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# Runway Overrun During Landing

## Peninsula Aviation Services Inc. d.b.a. PenAir flight 3296

### Saab 2000, N686PA

Unalaska, Alaska

October 17, 2019

**Abstract:** This report discusses the October 17, 2019, accident involving a Saab SA-2000 airplane, operated by Peninsula Aviation Services Inc. d.b.a. PenAir flight 3296, which overran the end of runway 13 at Unalaska Airport, Unalaska, Alaska. The airplane was substantially damaged during the runway overrun; as a result, of the 3 crewmembers and 39 passengers aboard, 1 passenger sustained fatal injuries, and 1 passenger sustained serious injuries. Eight passengers sustained minor injuries, most of which occurred during the evacuation. Safety issues identified in this report include the potential for cross-wiring of airplane antiskid brake systems; insufficient Federal Aviation Administration (FAA) guidance to identify safety risks for air carriers experiencing significant organizational changes, including bankruptcy, acquisition, and merger; lack of FAA consideration of runway safety area dimensions during the process of authorizing an air carrier to operate its aircraft at a specific Title 14 Code of Federal Regulations Part 139 certificated airport, and the benefits of safety management systems for design, manufacturing, and maintenance organizations. As a result of this investigation, the National Transportation Safety Board makes six new safety recommendations to the FAA, three new safety recommendations to the European Union Aviation Safety Agency, and one new recommendation to the Saab Group.

# Contents

**Figures .....iv**

**Tables ..... v**

**Acronyms and Abbreviations.....vi**

**Executive Summary.....viii**

    What Happened.....viii

    What We Found .....viii

    What We Recommended .....x

**1. Factual Information ..... 1**

    1.1 History of Flight ..... 1

    1.2 Personnel Information ..... 12

        1.2.1 The Captain -----12

        1.2.2 The First Officer-----13

        1.2.3 The Flight Attendant-----15

    1.3 Airplane Information..... 15

        1.3.1 Maintenance Program and Records -----16

        1.3.2 Brake System and Tires -----17

        1.3.3 Antiskid System-----20

    1.4 Meteorological Information ..... 31

    1.5 Airport Information ..... 33

        1.5.1 Runway Safety Area -----34

        1.5.2 Airport Master Plan Update -----37

    1.6 Wreckage and Impact Information ..... 38

    1.7 Medical and Pathological Information ..... 39

    1.8 Flight Recorders ..... 40

    1.9 Survival Factors..... 40

---

1.9.1	Cabin Condition After Accident-----	42
1.9.2	Evacuation and Emergency Response-----	43
1.10	Tests and Research–Aircraft Performance Study .....	45
1.10.1	Saab 2000 Landing Performance Capability-----	46
1.10.2	Accident Airplane Deceleration Times and Rates-----	50
1.10.3	Study Summary-----	51
1.11	Organizational and Management Information .....	51
1.11.1	Company Procedures-----	52
1.11.2	Pilot Training-----	62
1.11.3	Safety Program-----	64
1.11.4	Federal Aviation Administration Oversight-----	68
<b>2.</b>	<b>Analysis .....</b>	<b>71</b>
2.1	Introduction .....	71
2.2	Accident Summary .....	72
2.2.1	Preflight Planning-----	72
2.2.2	Accident Sequence-----	73
2.2.3	Evacuation and Emergency Response-----	79
2.3	Brake System .....	81
2.3.1	Left Main Landing Gear Outboard Tire-----	81
2.3.2	Antiskid Brake System-----	82
2.3.3	Effect of Left Main Landing Gear Outboard Tire Skid-----	83
2.3.4	Design of Wheel Speed Transducer Wire Harnesses-----	85
2.4	Operational Factors .....	91
2.4.1	Pilot-in-Command Airport Qualification Policy-----	91
2.4.2	PenAir Safety Management System-----	94
2.5	Federal Aviation Administration Oversight .....	96

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- 2.5.1 Certificate Management Team Oversight of PenAir -----96
- 2.5.2 Authorization Process for Scheduled Air Carrier Operations  
at Airports -----98
- 3. Conclusions ..... 102**
- 3.1 Findings..... 102
- 3.2 Probable Cause ..... 103
- 4. Recommendations ..... 105**
- 4.1 New Recommendations ..... 105
- Appendixes ..... 108**
- Appendix A: Investigation ..... 108**
- Appendix B: Consolidated Recommendation Information ..... 109**
- Appendix C: Cockpit Voice Recorder Transcript ..... 113**
- Appendix D: Comments from the Swedish Accident Investigation  
Authority and the United Kingdom Air Accidents Investigation Branch ..... 180**
- References..... 183**

## Figures

Figure 1. Front door and back door paths to DUT..... 3

Figure 2. Airplane in its final resting location (Source: Unalaska Department of Public Safety)..... 9

Figure 3. Left side of accident airplane (Source: Unalaska Department of Public Safety)..... 10

Figure 4. Airplane ground track overlaid on a Google Earth image. .... 11

Figure 5. Worn area and hole in left outboard tire. .... 18

Figure 6. Additional worn area on the left outboard tire. .... 19

Figure 7. Routing for wheel speed transducer wire harnesses (Source: APPH)..... 23

Figure 8. Wheel speed transducer wiring as designed..... 27

Figure 9. Cross-wiring of left MLG wheel speed transducers. .... 27

Figure 10. Airplane interior configuration and location of fatal and serious injuries. . 41

Figure 11. Impact area of left propeller blade..... 42

Figure 12. Forward view of cabin from row 6. .... 43

Figure 13. Aircraft performance study calculations for various landing configurations. .... 48

## Tables

Table 1. Captain’s sleep opportunities during the 72 hours before the accident. .... 13

Table 2. First officer’s sleep opportunities during the 72 hours before the accident. 14

Table 3. Tire replacements on accident airplane. .... 17

Table 4. Faults recorded during landing rollout. .... 21

Table 5. Wind reports transmitted by the DUT weather observer. .... 33

Table 6. Evacuation and emergency response timeline. .... 45

## Acronyms and Abbreviations

AAC	aircraft approach category
AC	advisory circular
ADG	airplane design group
ADOT	Alaska Department of Transportation and Public Facilities
agl	above ground level
ANC	Ted Stevens Anchorage International Airport
ARFF	airport rescue and firefighting
ATC	air traffic control
AWOS	automated weather observing system
CFM	company flight manual
CFR	<i>Code of Federal Regulations</i>
CG	center of gravity
CMT	certificate management team
CRM	crew resource management
CVR	cockpit voice recorder
DUT	Unalaska Airport
EASA	European Union Aviation Safety Agency
EICAS	engine indicating and crew alerting system
EMAS	engineered materials arresting system
FAA	Federal Aviation Administration
FDR	flight data recorder
FLM	frontline manager
MDC	maintenance diagnostics computer
METAR	meteorological aerodrome report
MLG	main landing gear

NOTAM	notice to airmen
NTSB	National Transportation Safety Board
PIC	pilot-in-command
POI	principal operations inspector
psi	pounds per square inch
RNAV	area navigation
RSA	runway safety area
SB	service bulletin
SMS	safety management system
VFR	visual flight rules
V <sub>ref</sub>	reference speed



## Executive Summary

### What Happened

On October 17, 2019, a Saab SA-2000 airplane, operated by Peninsula Aviation Services Inc. d.b.a. PenAir flight 3296, overran the end of runway 13 at Unalaska Airport (DUT), Unalaska, Alaska. The flight crew executed a go-around during the first approach to runway 13; the airplane then entered the traffic pattern for a second landing attempt on the same runway. Shortly before landing, the flight crew learned that the wind at midfield was from 300° at 24 knots, indicating that a significant tailwind would be present during the landing. Because an airplane requires more runway length to decelerate and stop when a tailwind is present during landing, a landing in the opposite direction (on runway 31) would have favored the wind at the time. However, the flight crew continued with the plan to land on runway 13.

Our postaccident calculations showed that, when the airplane touched down on the runway, the tailwind was 15 knots. The captain reported after the accident that the initial braking action after touchdown was normal but that, as the airplane traveled down the runway, the airplane had “zero braking” despite the application of maximum brakes. The airplane subsequently overran the end of the runway and the adjacent 300-ft runway safety area (RSA), which was designed to reduce airplane damage during an overrun, and came to rest beyond the airport property. The airplane was substantially damaged during the runway overrun; as a result, of the 3 crewmembers and 39 passengers aboard, 1 passenger sustained fatal injuries, and 1 passenger sustained serious injuries. Eight passengers sustained minor injuries, most of which occurred during the evacuation. The crewmembers and 29 passengers were not injured.

### What We Found

Postaccident examination of the airplane’s antiskid brake system found that the wire harnesses for the left main landing gear (MLG) wheel speed transducers were incorrectly routed; the harness that should have been routed to the left inboard wheel was instead routed to the left outboard wheel (and vice versa). As a result of the incorrect (crossed) wiring, the antiskid system performance was substantially compromised. Specifically, during most of the landing rollout, the left outboard tire was in a skid. However, because of the crossed wiring, the antiskid system perceived that the left inboard wheel was skidding and released the brake pressure to that wheel and the right inboard wheel (due to the paired-wheel design of the antiskid system). The system also perceived that the left outboard wheel was operating

properly, even though the tire was skidding. As a result, the left outboard tire continued to skid and then burst, causing an additional loss of MLG wheel braking.

The incorrect wheel speed transducer wiring most likely occurred during the overhaul of the left MLG at the landing gear manufacturer's facility in January 2017, more than 2.5 years before the accident. This cross-wiring condition was not discovered until after the accident in part because the airplane was not in revenue service between the time of left MLG overhaul and PenAir's first revenue flight in June 2019. Also, the antiskid system does not generate a fault based on incorrect wiring. For a cross-wiring condition to potentially be detected, a significant skid event would have to occur for more than 2 seconds (based on the antiskid system's logic) and not be relieved. Saab's design of the wheel speed transducer wire harnesses did not consider that the harnesses could be incorrectly installed during maintenance and overhaul. In addition, three incidents that we investigated showed the potential for cross-wiring of antiskid system components in other airplane types.

The airplane should have had the landing performance capability to stop within the landing distance available on runway 13 or the RSA distance given the airplane's energy state, MLG touchdown location, environmental conditions, and runway surface conditions. However, the Saab 2000 could not tolerate the loss of MLG wheel braking in excess of 50%. Thus, the combined loss of left and right inboard and left outboard MLG wheel braking prevented the flight crew from stopping the airplane on the runway.

During postaccident interviews, the flight crewmembers stated that they were aware of the airplane manufacturer's 15-knot tailwind limit but thought that the reported wind direction and speed (300° at 24 knots) did not warrant a change of the runway for landing. The flight crew's continuation with the planned landing on runway 13 despite the knowledge of a tailwind that exceeded the manufacturer's limit was inappropriate and was consistent with plan continuation bias, which is an unconscious cognitive bias to continue with an original plan despite changing conditions.

Further, we found that PenAir designated DUT as an airport that required a company specific qualification for pilots-in-command (PICs) because of the surrounding terrain and complex approach and departure procedures. At the time that PenAir qualified the accident captain as a PIC to operate at DUT (about 2 months before the accident), he did not meet the total flight time in the Saab 2000 that the company's PIC airport qualification policy required. Because PenAir allowed the captain to operate at DUT without gaining the experience that the company's policy intended, the captain might not have fully understood the challenges associated with landing the Saab 2000 at the airport.

In addition, we found that the Federal Aviation Administration (FAA) approved PenAir's use of the Saab 2000 on DUT runway 13/31 without considering whether the RSA at the airport was suitable, according to FAA guidance, for an airplane with the approach speed and size of the Saab 2000. No evidence indicated that either PenAir or the FAA was aware of the RSA standards for the Saab 2000 or the inconsistency between the standards and the existing RSA dimensions at DUT. Further, neither PenAir nor the FAA considered potential mitigations to ensure that the Saab 2000 could safely operate at the airport.

We determined that the probable cause of this accident was the landing gear manufacturer's incorrect wiring of the wheel speed transducer harnesses on the left MLG during overhaul. The incorrect wiring caused the antiskid system not to function as intended, resulting in the failure of the left outboard tire and a significant loss of the airplane's braking ability, which led to the runway overrun. Contributing to the accident were (1) Saab's design of the wheel speed transducer wire harnesses, which did not consider and protect against human error during maintenance; (2) the FAA's lack of consideration of the RSA dimensions at DUT during the authorization process that allowed the Saab 2000 to operate at the airport; and (3) the flight crewmembers' inappropriate decision, due to their plan continuation bias, to land on a runway with a reported tailwind that exceeded the airplane manufacturer's limit. The safety margin was further reduced because of PenAir's failure to correctly apply its company-designated PIC airport qualification policy, which allowed the accident captain to operate at one of the most challenging airports in PenAir's route system with limited experience at the airport and in the Saab 2000 airplane.

## **What We Recommended**

As a result of this investigation, we recommended that the FAA and the European Union Aviation Safety Agency identify system safety assessments for landing gear systems on currently certificated transport-category airplanes to determine whether the assessments evaluated and mitigated human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and then require transport-category airplane manufacturers without such assessments to perform them and then implement mitigations. We also recommended that the FAA and the European Union Aviation Safety Agency require system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs; the certification should ensure that the system safety assessments evaluate and mitigate the potential for human error that can lead to a cross wiring error. Further, we recommended that Saab redesign the wheel speed transducer wire harnesses for the Saab 2000 to prevent the harnesses from being installed incorrectly during maintenance and

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overhaul and that the FAA and the European Union Aviation Safety Agency require organizations that design, manufacture, and maintain aircraft to establish a safety management system.

We also recommended that the FAA notify certificate management team personnel about the circumstances of this accident and emphasize the importance of detecting and mitigating the safety risks that can result when certificate holders experience significant organizational change, such as bankruptcy, acquisition, and merger, all of which PenAir was experiencing for more than 2 years before the accident. We further recommended that the FAA revise agency guidance to include a formalized transition procedure to be used during a changeover of certificate management team personnel responsible for overseeing a certificate holder that is undergoing significant organizational change to ensure that incoming personnel are fully aware of potential safety risks.

In addition, we recommended that the FAA include the runway design code for runways of intended use among the criteria assessed when authorizing a scheduled air carrier to operate its airplanes on a regular basis at an airport certificated under Title 14 *Code of Federal Regulations* Part 139.

# 1. Factual Information

## 1.1 History of Flight

On October 17, 2019, about 1740 Alaska daylight time, Peninsula Aviation Services Inc. d.b.a. PenAir flight 3296, a Saab SA-2000, N686PA, was landing at Unalaska Airport (DUT), Unalaska, Alaska, when the airplane overran the end of the runway, passed through the airport perimeter fence, crossed a road, and pitched down over shoreline rocks with its nosewheel coming to rest at the edge of Dutch Harbor.<sup>1</sup> The captain, first officer, flight attendant, and 29 of the 39 passengers were not injured. Of the remaining 10 passengers, 1 sustained fatal injuries, 1 sustained serious injuries, and 8 sustained minor injuries. The airplane was substantially damaged. The airplane was operating as a regularly scheduled passenger flight from Ted Stevens Anchorage International Airport (ANC), Anchorage, Alaska, under the provisions of Title 14 *Code of Federal Regulations (CFR)* Part 121. Visual meteorological conditions prevailed at the time of the accident.

The accident occurred during the airplane's third flight leg of the day. The airplane had been flown by another flight crew from ANC to DUT and back; the return flight arrived at ANC at 1302.

At 1355, the accident flight crew reported for duty at ANC; the airplane was scheduled to depart at 1510. During a postaccident interview, the captain stated that he and the first officer performed a preflight inspection of the airplane, during which the first officer noticed "a slight bald spot" on the left main landing gear (MLG) outboard tire.<sup>2</sup> The first officer took a photograph of that area on the tire and showed the photograph to the captain (who was in the cockpit at the time). The captain stated

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<sup>1</sup> (a) Additional information can be found in the public docket for this National Transportation Safety Board accident investigation (case number DCA20MA002) by accessing the [Accident Dockets link](#) at [www.nts.gov](http://www.nts.gov). For information about our safety recommendations, use the [CAROL Query for Safety Recommendations](#) at the same website. (b) All times in this report are Alaska daylight time.

<sup>2</sup> According to postaccident interviews with company pilots, the preflight inspection of airplane tires included checking the general condition of the tires; determining if the tires were properly inflated and showing tread; and examining the tires for issues such as plies showing through the rubber, missing pieces of rubber, and the formation of flat spots. The first officer of the first two flight legs in the airplane on the day of the accident stated that he conducted a walk-around check of the airplane at ANC and DUT and noted no anomalies.

that the tire “wasn’t showing cord” and was thus not a concern.<sup>3</sup> PenAir procedures did not require the flight crew to take any further action regarding the tire.

Part of the flight crew’s preflight planning included an initial assessment of the runway conditions at DUT. The weather packet that the crew received before departure included a notice to airmen (NOTAM) issued at 0826 on the day of the accident, which indicated that the runway was damp with no standing water. The captain stated that the dispatcher briefed him about the NOTAM and other flight planning information, which the captain shared with the crewmembers afterward.

The airplane left the gate at 1515 and departed for DUT at 1523. The captain was the pilot flying, and the first officer was the pilot monitoring. The taxi, takeoff, climb, and en route portions of the flight were uneventful. While en route to DUT, the captain briefed the planned RNAV (area navigation) approach to runway 13. Between 1624:05 and 1624:42, the captain stated, “we can either go straight in if not we can make an early decision...to go through the back door off of this approach if we have to.”<sup>4</sup> As shown in figure 1, the straight-in, or “front door,” path involved approaching the airport from the west side of Mount Ballyhoo and landing on runway 13; the “back door” path involved approaching the airport from the east side of Mount Ballyhoo and landing on runway 31 if the wind favored that direction for landing.<sup>5</sup> At 1626:28, the captain commented that the wind was from 310° at 6 knots. At 1627:30, the captain stated that the unfactored landing distance would be 3,058 ft.<sup>6</sup>

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<sup>3</sup> “Cord” is the term commonly used to describe reinforcing plies on tires. The National Transportation Safety Board’s examination of the first officer’s photograph of the tire found that the flat spot had not exposed any of the tire’s reinforcing plies.

<sup>4</sup> During a postaccident interview, the first officer stated, “once we got down there, if we had visual conditions, we would make the determination based off of the current observed winds, if we were going to continue with RNAV 1-3 or if I would switch back off over to center frequency and request a visual 3-1 so we could land with the best winds. The plan was to always to land with whatever winds favored the best runway.”

<sup>5</sup> Figure 1 is based on an image from a PenAir pilot training presentation. In that image, “front door” and “back door” were informal terms to describe the final visually flown leg of the RNAV 13 and 31 approaches to runway 13 and 31, respectively.

<sup>6</sup> According to Federal Aviation Administration Advisory Circular 91-79A, Mitigating the Risks of a Runway Overrun Upon Landing, the unfactored landing distance is the landing distance demonstrated during certification (according to 14 CFR 25.125) without any safety margin additives. This landing distance is based on a dry runway and does not account for the effects of reverse thrust or autobrakes.



**Figure 1.** Front door and back door paths to DUT.

Note: The missed approach point for the RNAV approach to runway 13, which the accident airplane flew, was about 1.5 miles north-northeast of Eider Point, which is about 5 miles northwest of DUT.

At 1657:41, the captain noted that the updated weather information indicated that the wind was from 310° at 11 knots. About 7 seconds later, the captain stated that the wind was “startin’ to favor the back door a little more,” to which the first officer responded, “we’ve done that before.”<sup>7</sup>

At 1705:57, the first officer contacted the DUT weather observer to obtain the latest weather conditions at the airport.<sup>8</sup> Seven seconds later, the weather observer advised the flight crew that the wind was from 210° at 6 knots with gusts to 14 knots. The first officer acknowledged the weather information and stated that the airplane was about 25 minutes from the airport. At 1707:38, the first officer contacted Anchorage Center to request the RNAV approach to runway 13; the first officer also mentioned that he had the current weather. The controller then told the flight crew to expect that approach. At 1708:23, the captain stated, “pretty much a direct crosswind there.”

At 1709:01, the captain called for the in-range checklist, which the flight crew completed less than 1 minute later. At 1715:26, the controller cleared the airplane for

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<sup>7</sup> PenAir records showed that, on October 8 and 9, 2019, the captain and the first officer flew together from ANC to DUT and back to ANC.

<sup>8</sup> During postaccident interviews, the captain and the first officer stated that they called the DUT weather observer when approaching the airport to learn the current weather conditions there. The captain explained that it was important to talk to an observer on the ground at DUT because the weather conditions at each end of the airport could differ, which would not be apparent on the automated weather observing system broadcast.



the RNAV approach to runway 13, and the first officer acknowledged this instruction. Between 1715:45 and 1715:49, the captain stated, "if there's any major changes in wind then we'll just...call [the controller] back," and the first officer stated, "we'll switch [runways]." At 1717:42, the captain called for the descent checklist, which the flight crew completed at 1718:02.

The cockpit voice recorder (CVR) recording indicated that the flight crew overheard the pilot of another airplane in the area (N546LM, a King Air operated by Life Med) requesting a weather check. At 1720:48, the DUT weather observer told the King Air pilot that the wind was from 180° at 7 knots and that showers were in the vicinity of the airport.

At 1732:09, the captain called for 20° of flaps and the before landing checklist, and the first officer called the checklist complete about 16 seconds later. At 1732:34, the captain requested a wind check. The first officer then contacted the DUT weather observer, who reported at 1732:44 that the wind was from 270° at 10 knots. The first officer provided the wind condition to the captain, and they discussed whether to make an approach to runway 13 or 31. At 1733:05, the captain stated, "we'll go straight," indicating an approach to runway 13.

Flight data recorder (FDR) data indicated that, at 1733:30, the airplane began descending from 950 ft above ground level (agl). Five seconds later, the first officer announced that the airplane was at the missed approach point, which was 4.7 nautical miles from runway 13; about 6 seconds later, the captain announced that the runway was in sight. At 1734:56, the captain stated, "if it gets too sheer-y [referring to wind shear] just say go around and we'll go out the back door." About 1735:27, the captain stated, "whad'ya think?"; in response, the first officer stated, "go around," and the captain stated, "goin' around." Three seconds later, the FDR recorded maneuvers consistent with a go-around.<sup>9</sup>

At 1735:41, the captain asked the first officer to announce that the airplane was "coming around for a visual," which he did. Between 1736:05 and 1736:49, the CVR recorded the flight crew discussing the visual approach; at 1736:19, the captain

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<sup>9</sup> During postaccident interviews, the captain stated that, when the airplane was on final approach and about 300 ft above the runway, he reached up to turn off an engine anti-ice switch (located on the panel above the captain's head); at that point, the airplane "got out of position," and the approach became unstabilized. The first officer stated that, as the captain was turning off the anti-ice switch, the airplane became "slightly destabilized" and went off course; afterward, the first officer called for the go-around. Section 21.6.11.1 of the PenAir *General Operations Manual* provided the company's policy for a stabilized approach. The manual stated that, for a visual approach, the airplane must be "established on proper vertical and course guideline" by 500 ft above the airport elevation, but the manual did not provide any guidance on the actions to take when an approach was not stabilized.



stated, "we're gonna go out here and do a one eighty and come back in."<sup>10</sup> At 1736:51, the pilot of the nearby King Air airplane asked the flight crew whether the flight had landed. The first officer responded, "negative we're circling around to come back in for a visual [approach]." The King Air pilot continued his conversation with the first officer until 1737:13 to determine the airplane's altitude. The King Air pilot also asked, "gonna land on three one?"; the first officer responded, "comin' back around for...the visual one three." During that time, the DUT weather observer reported that the wind was from 290° at 16 knots with gusts to 30 knots. The CVR recording showed that the flight crew did not discuss this updated wind information.

At 1737:15, the captain stated "three one" twice, and the first officer questioned "three one?" The captain then questioned "back door?" and the first officer stated, "I thought we were doin' one three." The captain responded, "oh okay...sure...we'll try again." At 1737:41, the first officer asked the captain if he was "okay" with a landing on runway 13, and the captain responded, "I was thinking about going the other way" and "shear." During a postaccident interview, the first officer stated that the wind check information did not indicate that the planned runway for landing needed to change.

At 1737:49, the King Air pilot asked the DUT weather observer about weather conditions for a landing on runway 31. At 1737:55, the DUT weather observer replied, "there's showers just moving through...right at the moment it is perfect for three one but I'm thinking that it might switch back...once this shower moves through."<sup>11</sup> Also at 1737:55, the flight crew began performing the before landing checklist for the second approach and confirmed that the flaps were set to 20° and the gear was down. (It is unknown whether the flight crew was aware of the above-referenced conversation between the King Air pilot and the DUT weather observer given that the crew was executing the before landing checklist at the same time.)

At 1738:25, the captain asked the first officer to get a wind check. The first officer contacted the DUT weather observer 8 seconds later, and she stated that the

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<sup>10</sup> During this timeframe, the CVR recorded the captain instructing the first officer to reduce power, the first officer asking about the engine setting, and the captain stating, "just bring it back to about fifty." The CVR also recorded the captain stating that the altitude setting should be 1,000 ft mean sea level and the first officer indicating that the altitude was set. In addition, the CVR recorded an altitude alert, the first officer stating that the airplane's altitude was 1,200 ft mean sea level (200 ft above the altitude setting), and the captain acknowledging this information and then stating, "slow me up...back off on power." FDR data showed that power decreased 1 second later and that the airplane responded to the decrease in power with an immediate reduction in longitudinal acceleration.

<sup>11</sup> During postaccident interviews, the flight crew recalled a King Air pilot on the radio but did not remember specifics about any weather discussions.

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midfield wind was from 300° at 24 knots. The first officer stated "oh God" to the captain, and the captain stated an expletive. At 1738:45, the first officer asked the captain, "do you wanna...back out...do it again?" Six seconds later, the captain told the first officer to "keep talking to weather"; afterward, the first officer stated, "we'll try again," and the captain replied, "last try."

FDR data showed that, while descending through an altitude of about 350 ft agl, the airplane began a turn to align with the runway and became established on the runway heading at an altitude of about 100 ft. At 1739:45 and 1739:46, the CVR recorded sink rate warnings from the enhanced ground proximity warning system. FDR data showed that, at the time of the warnings, the airplane was at an altitude of about 100 and 60 ft, respectively, and that the airplane's descent rate reached a peak of almost 1,300 ft per minute about this time. The captain began arresting the sink rate when the airplane was at an altitude of 90 ft. At that time, the airplane's indicated airspeed was about 135 knots (the speed bug was set at 136 knots), and its groundspeed was about 149 knots.

The CVR and FDR showed that the airplane touched down on the runway at 1739:54. According to FDR data, the groundspeed at MLG touchdown was about 142 knots. Vertical acceleration data indicated that nose gear touchdown occurred 1.5 seconds later.<sup>12</sup> During a postaccident interview, the captain stated that there were no puddles or standing water on the runway. The captain also reported that he applied reverse power after the nose gear touched down and that the initial braking action was normal. The captain further reported that, at that point, the airplane was slowing down as expected. FDR data showed that the rate of deceleration increased during the 3 seconds after MLG touchdown and reached a peak of -0.48g.

A video taken by a passenger aboard the airplane recorded what appeared to be a puff of smoke near the left MLG during the initial landing rollout (about 5 to 6 seconds after touchdown).<sup>13</sup> Evidence from the crash site showed that the puff of

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<sup>12</sup> During postaccident interviews, the captain and the first officer reported that the airplane touched down about 1,000 ft beyond the runway 13 threshold. On the basis of FDR accelerometer data, the MLG touchdown point was about 1,100 ft beyond the runway threshold, and the nose gear touchdown point was about 1,470 ft beyond the threshold.

<sup>13</sup> This video was one of two passenger videos from the accident flight that the National Transportation Safety Board received. The video showed intermittent views of the left MLG strut and inboard and outboard wheels (among other structures). The other passenger video showed the right wing, right engine cowl, right side of runway 13, and related runway markings. That video also showed that the midfield wind cone was fully extended but did not show the wind cone at the approach or departure ends of runway 13. According to Federal Aviation Administration (FAA)

smoke was related to the left MLG outboard tire, which burst during the rollout (as discussed in section 1.3.2).

During postaccident interviews, the flight crew reported a decrease in deceleration, and the FDR showed that the deceleration had decreased to  $-0.29g$  at 1739:59. Two seconds later, the antiskid inboard fault caution became active.<sup>14</sup> Also at 1740:01, the first officer made the 80-knot callout. At that time, the airplane's groundspeed was about 100 knots. Less than 1 second later, the CVR recorded a sound similar to the master caution.<sup>15</sup>

At 1740:03, the engines transitioned from ground idle to maximum reverse power. At 1740:04, the first officer stated, "brakes," to which the captain replied, "I got em all the way." During postaccident interviews, the captain stated that, after he applied maximum brakes, the airplane was slowing but "not at a rate that was normal anymore...nil braking...zero braking," and the first officer stated that he put his feet on the pedals to verify that full braking had been applied.<sup>16</sup> Between 1740:08 and 1740:11, the CVR recorded the captain stating, "hang on"; the sound of two thumps; and the captain stating, "I'm sliding." By 1740:11, the airplane's longitudinal deceleration had decreased to  $-0.17g$ , and its groundspeed was 54 knots.<sup>17</sup>

According to the FDR, at 1740:13, the antiskid inboard fault caution became inactive. For the next few seconds, the engine power lever angles were about  $1^\circ$ , which was consistent with maximum reverse power, and the deceleration remained steady between  $-0.16$  and  $-0.2g$ . At 1740:17, the antiskid inboard fault caution became active again; the airplane's groundspeed at the time was 34 knots. Between 1740:18 and 1740:21, the engine power lever angles increased from about  $1^\circ$  to about  $35^\circ$ , which was consistent with flight idle power; at 1740:19, changes in pitch,

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Advisory Circular 150/5345-27E, FAA Specification for Wind Cone Assemblies, a windsock must be designed to fully extend when exposed to a 15-knot wind.

<sup>14</sup> The FDR samples this parameter once every 4 seconds.

<sup>15</sup> The CVR recorded four additional sounds similar to the master caution—at 1740:06, 1740:12, 1740:17, and 1740:22. A master caution is intended to alert flight crews to a non-normal airplane system or operational condition that does not require immediate crew action. According to the PenAir Saab flight manual, a master caution is indicated by an amber, flashing illuminated pushbutton on the glareshield panel, an amber message on the primary engine indicating and crew alerting system, and an aural single chime sound.

<sup>16</sup> During postaccident interviews, the captain stated that there were no writeups in the airplane's logbook on the day of the accident and that none of the previous writeups pertained to the brakes; the first officer stated that the "brake checks were good."

<sup>17</sup> At 1740.12, the longitudinal acceleration parameter had increased momentarily to  $-0.31g$ .

roll, and vertical and longitudinal accelerations occurred, which were consistent with the airplane having departed the runway surface. At that time, the airplane's groundspeed was 23 knots, and the CVR recorded the sound of multiple low-frequency thumps and thuds.

About 1740:20, the landing gear weight on wheels and the left MLG down and locked parameters no longer detected that the left MLG was down and locked, which was consistent with damage to the left MLG. About 1 second later, the left engine gas generator speed dropped to 0%, which was consistent with damage to the left engine.

During a postaccident interview, the first officer stated that, as the airplane was sliding, he advised the captain to go to the right and toward a road to avoid Dutch Harbor, which was located beyond the end of the runway. The first officer also stated that he "pushed as hard as [he] could on that right brake, trying to make that airplane turn" toward the road, which was parallel to the runway 13 overrun area. The captain stated that he "was trying to get [the airplane] to go in that direction" and was "pushing on the brakes still just trying to get [the airplane] to stop" because only the engines and brakes were available at that point.<sup>18</sup>

Witness marks from the MLG wheels (discussed later in this section) indicated that the airplane departed the end of runway 13 and traveled through the 300-ft runway safety area (RSA) and the 150-ft blast pad while the airplane's track deviated to the right of the extended runway centerline.<sup>19</sup> The airplane crossed a 15-ft section of grass and traveled through a 4-ft (in height) chain-link airport perimeter fence. Curled and twisted wires were found along the top 8 inches of the perimeter fence and in the travel path of the left engine propeller and left MLG. The left MLG also impacted a ditch.

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<sup>18</sup> The captain stated that the airplane "could not go around with the distance remaining [on the] runway. We wouldn't have made it."

<sup>19</sup> (a) In this report, witness marks refer to evidence of any contact made by the airplane's MLG, tires, and propellers. (b) According to the Federal Aviation Administration, an RSA is a "surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway," and a blast pad is a "surface adjacent to the ends of runways provided to reduce the erosive effect of jet blast and propeller wash."

Video from two off-airport security cameras showed that the left engine shed propeller blade fragments and two propeller blades either before or as the airplane traveled across an off-airport road.<sup>20</sup> In addition, either the left wing or the left engine propeller struck a 7-ft vertical signal post. The left engine propeller then struck an 8-ft road sign mounted on a metal post, and the left engine shed propeller blade fragments and one propeller blade after contacting the road sign.<sup>21</sup> The security camera video also showed that the airplane overrun stopped at 1740:29. The airplane came to rest with its nose pitched downward, the nose gear in shallow water at the edge of Dutch Harbor, the left MLG embedded in rocks, and the right MLG on the shoulder of a road intersection, as shown in figure 2.



**Figure 2.** Airplane in its final resting location (Source: Unalaska Department of Public Safety).

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<sup>20</sup> The two off-airport security cameras captured portions of the accident sequence, evacuation, and emergency response. The two propeller blade shedding paths were not visible in the videos. Thus, the blade shedding could have been due to contact with the airport perimeter fence, a large rock in the road shoulder area between the perimeter fence and an off-airport road, and/or the ground. Further, witness marks in the road shoulder and off-airport road area were obscured by bulk material added to the road shoulder to enable local road traffic to maneuver around the airplane in its final position after the accident.

<sup>21</sup> For more information about the damage to the left engine propellers, see section 1.6.



Figure 3 shows a hole and impact damage on the left side of the airplane located near the fifth passenger window on that side. Section 1.9.1 provides additional details about the damage to the airplane in this area.



**Figure 3.** Left side of accident airplane (Source: Unalaska Department of Public Safety).

At 1740:40, the captain used the public address system to command an evacuation. During postaccident interviews, the captain indicated that he commanded the evacuation from the right side because the left engine fire light had illuminated as he was shutting down the airplane.<sup>22</sup> The captain also indicated that he heard the flight attendant immediately commanding an evacuation.

Security camera video showed that the right overwing exit opened at 1740:40 and that the aft service door (on the right side of the airplane) opened at 1740:52.

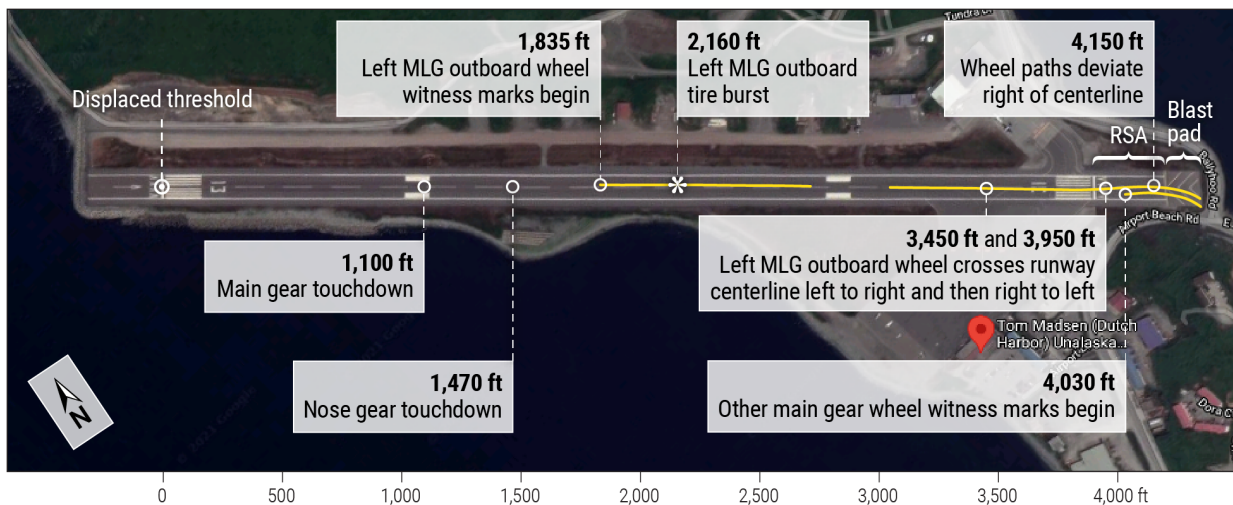
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<sup>22</sup> The captain stated that he then shut down the fuel and activated the fire bottle; afterward, the engine fire light was no longer illuminated. The first officer also stated that the left engine fire indication had annunciated.

Between 1740:52 and 1741:29, the captain contacted DUT operations and stated that the airplane was off the runway and that crash, fire, and rescue were needed.

According to the security camera video, the DUT airport rescue and firefighting (ARFF) vehicle arrived on scene at 1742:42, and the first mutual aid vehicle arrived at 1745:37. Additional information about the evacuation and emergency response is discussed in section 1.9.2.

A postaccident GPS survey of runway 13 documented the witness marks associated with the accident airplane's ground track. Witness marks associated with the left MLG outboard tire began about 1,835 ft beyond the runway 13 displaced threshold.<sup>23</sup> The left MLG outboard tire path began on the left side of the runway centerline, crossed over to the right side of the centerline, returned to the left side, and crossed over again to the right side before the airplane overran the blast pad surface. The airplane was estimated to be about 2,160 ft beyond the runway 13 displaced threshold at the time of the tire burst captured on the passenger video. Witness marks associated with the left MLG inboard tire and the right MLG inboard and outboard tires began about 4,030 ft beyond the runway 13 displaced threshold and near the midpoint of the 300-ft RSA. Figure 4 shows the airplane's ground track from the time of the landing rollout to the blast pad departure, including the approximate location where the tire burst.



**Figure 4.** Airplane ground track overlaid on a Google Earth image.

<sup>23</sup> According to the Federal Aviation Administration's *Aeronautical Information Manual*, a displaced threshold is "located at a point on the runway other than the designated beginning of the runway. Displacement of a threshold reduces the length of runway available for landings. The portion of runway behind a displaced threshold is available for takeoffs in either direction and landings from the opposite direction."

## 1.2 Personnel Information

### 1.2.1 The Captain

The captain, age 56, held an airline transport pilot certificate with a multiengine land rating. He received a type rating for the SA-2000 on July 8, 2019, and for the De Havilland Canada DHC-8 on September 20, 1991. The captain also held a first-class medical certificate dated June 25, 2019, with a limitation that required him to possess glasses for near vision.<sup>24</sup> The captain reported that he did not wear his glasses during the accident flight.

The captain had been employed by PenAir since May 2019 as a line pilot and the director of training. He became a captain on the SA-2000 on July 25, 2019. Before his employment with PenAir, the captain flew the DHC-8-100 for Era Aviation (which later became Corvus Airlines). He upgraded to captain in June 2015 and was an instructor and a check airman for the DHC-8-100 while working for Corvus Airlines.

According to PenAir records, the captain had accumulated 14,761 total flight hours, 11,811 hours of which were as pilot-in-command (PIC), including 131 hours in the SA-2000.<sup>25</sup> He had flown 120, 27.8, and 2.6 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. The captain's last line check occurred on July 25, 2019, and his last training event (line-oriented flight training) occurred on July 10, 2019.<sup>26</sup> Federal Aviation Administration (FAA) records for the captain showed no previous accident or incident history or enforcement actions.

PenAir flight logs showed that, before the accident, the captain flew to DUT nine times between July 15 and October 11, 2019 (including the flights on October 8 and 9 with the accident first officer). Five of these flights (all of which occurred between July 15 and 22) were conducted during the captain's operating experience

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<sup>24</sup> The captain held a special issuance medical certificate with a nonstandard validity period; the certificate was not valid for any class after June 30, 2020.

<sup>25</sup> Most of the captain's total flight time and PIC time was accumulated while he was employed at Era Aviation.

<sup>26</sup> A line check is a flight along an air carrier's route that each captain must make annually with an FAA-designated check airman, who evaluates the captain's ability to perform duties and responsibilities in one of the types of airplanes that the captain operates. The FAA requires line checks only for captains; PenAir also conducted line checks for first officers.



and were thus flown with a check airman.<sup>27</sup> The captain estimated that, before his employment with PenAir, he had flown to DUT about 20 times.

The captain reported going to sleep on October 14, 2019, about 2230. On October 15, the captain awoke about 0630 to fly a round trip from ANC to King Salmon Airport, King Salmon, Alaska, and back, and he went to sleep about 2230. On October 16, the captain awoke about 0900 to fly a round trip from ANC to Fairbanks International Airport, Fairbanks, Alaska, and back, and he went to sleep about 2300. On October 17, the day of the accident, the captain awoke about 0900; he reported feeling “great” that day. Table 1 shows the captain’s sleep opportunities between October 14 and 17.

**Table 1.** Captain’s sleep opportunities during the 72 hours before the accident.

Date	Bedtime	Awakening time	Sleep opportunity
October 14 to 15, 2019	2230	0630	8.0 hours
October 15 to 16, 2019	2230	0900	10.5 hours
October 16 to 17, 2019	2300	0900	10.0 hours

The captain reported that he normally needed about 7.5 hours of sleep to feel rested. He had been diagnosed with sleep apnea and used a continuous positive airway pressure machine consistently. The captain also reported that he had one alcoholic drink per day and that his last drink was on the day before the accident. In addition, the captain reported no issues with medication (including his prescription medication for hypertension) during the 72 hours before the accident that would have affected his performance during the flight.

### 1.2.2 The First Officer

The first officer, age 39, held an airline transport pilot certificate with a multiengine land rating. He received a type rating for the SA-2000 on July 26, 2019. The first officer also held a first-class medical certificate dated April 24, 2019, with no limitations.

The first officer had been employed by PenAir since May 2019. Before his employment with PenAir, the first officer provided flight instruction at two flight schools in Colorado (until May 2018). In August 2018, he began providing flight instruction at the University of Alaska in Anchorage.

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<sup>27</sup> Operating experience comprises a mandated period after completion of flight training (in this case, a minimum of 20 hours) during which a newly qualified pilot must fly with a check airman. After completion of operating experience, the pilot receives a line check.

According to PenAir records, the first officer had accumulated 1,447 total flight hours, 138 hours of which were logged in the SA-2000. He had flown 138, 60, and 2.3 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. The first officer's last line check occurred on August 4, 2019, and his last training event (line-oriented flight training) occurred on July 28, 2019. FAA records for the first officer showed no previous accident or incident history or enforcement actions.

PenAir flight logs showed that, before the accident, the first officer flew to DUT 15 times between August 2 and October 13, 2019 (including the flights on October 8 and 9 with the accident captain). Two of the flights (on August 2 and 3) were flown with a check airman as part of the first officer's operating experience.

On October 15, 2019, the first officer was off from work; he reported going to sleep that day about midnight. On October 16, the first officer awoke about 0700 and flew two round trips. The first trip was from ANC to Sand Point Airport, Sand Point, Alaska, and back. After a 2-hour layover, the first officer flew from ANC to Fairbanks International Airport and back. He went to sleep about midnight. On October 17, the first officer awoke about 0700 and took a nap from 0800 to 1100. He reported feeling "fine" after he awoke from his nap and leaving for the airport about 1330. Table 2 shows the first officer's sleep opportunities between October 15 and 17.

**Table 2.** First officer's sleep opportunities during the 72 hours before the accident.

Date	Bedtime	Awakening time	Sleep opportunity
October 14 to 15, 2019	Unknown	Unknown	Unknown
October 15 to 16, 2019	0000	0700	7 hours
October 16 to 17, 2019	0000	0700	10 hours (including 3-hour nap)

The first officer reported that he needed 7 hours of sleep to feel rested and that he kept a consistent bedtime and awakening schedule and napped as needed. The first officer also reported that he did not take any prescription medication and that he drank alcohol occasionally; his last drink was about 2 to 3 days before the accident. In addition, the first officer reported that he had no issues with his eyesight and that he did not take any medication that would have affected his performance in the 72 hours before the accident.

During a postaccident interview, the accident captain stated that the first officer "does a good job" and that he would speak up if he had any concerns. The first officer stated that he and the captain were "working as a team" during the flight.

### 1.2.3 The Flight Attendant

The flight attendant had worked for PenAir since April 2011. According to company records, she completed initial training on April 18, 2011. The flight attendant was qualified on the Saab 2000 and 340 and completed Saab 2000 initial ground training in May 2016. The flight attendant's last recurrent training occurred on February 28, 2019, and her last company evaluation occurred on May 24, 2019. She worked for several years as a flight attendant for Era Aviation before her employment with PenAir.

### 1.3 Airplane Information

The Saab Group manufactured the accident airplane, serial number 2000-017, on June 9, 1995.<sup>28</sup> The airplane was owned by several operators before PenAir leased it from Jet Stream Leasing in 2016. The airplane was added to PenAir's operations specifications in June 2019, and the airplane's first revenue flight with PenAir occurred on June 26, 2019.<sup>29</sup> At the time of the accident, the airplane had accumulated 12,617 total flight hours and 9,455 total flight cycles. The airplane had accumulated 638 flight hours and 521 cycles between its first revenue flight and the accident flight.

The airplane was equipped with two Rolls-Royce AE2100A dual-spool turbopropeller engines. At the time of the accident, the left and right engines had accumulated 19,271 and 26,215 total flight hours and 20,813 and 30,152 total flight cycles, respectively. The airplane was also equipped with two Dowty R381/6-123F/5 six-bladed, constant-speed, variable-pitch propellers that were hydraulically actuated. At the time of the accident, the left and right propellers had accumulated 19,513 and 35,820 total flight hours, respectively.

According to the Swedish Accident Investigation Authority, Saab 2000 production ended in 1999, and about 45 Saab 2000 airplanes were in operation worldwide as of September 24, 2021.

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<sup>28</sup> The Saab Group is headquartered in Stockholm, Sweden, and the Saab 2000 was designed and manufactured in Linköping, Sweden. The Joint Aviation Authorities (which represented several European civil aviation regulatory authorities and was the predecessor to the European Union Aviation Safety Agency) certified the Saab 2000 in March 1994, and the FAA certified the Saab 2000 in April 1994.

<sup>29</sup> The airplane was in storage for most of the time between January 2017 (when the left MLG was overhauled, as discussed later in this section) and June 2019 because PenAir had declared bankruptcy (as discussed in section 1.11).

### 1.3.1 Maintenance Program and Records

PenAir maintained its Saab 2000 airplanes using a continuous airworthiness maintenance program that was developed from the Saab 2000 maintenance review board document. The PenAir continuous airworthiness maintenance program manual provided inspection descriptions, schedules, and general procedures. All the inspections were based on flight hours, landing cycles, or calendar time. The main part of the PenAir Saab 2000 inspection program consisted of 10 inspections that were performed sequentially at 400-hour intervals; thus, the complete sequence of 10 inspections would be performed every 4,000 hours.

The PenAir Saab 2000 inspection program also included line checks that were to be accomplished outside of the 400-hour inspections.<sup>30</sup> The following line check tasks were related to the landing gear:

- Check left and right MLG and nose landing gear tire pressures and inspect tires for wear and damage.
- Check left and right MLG brake wear.

These line checks were required to be performed every 50 flight hours or 7 days (which was consistent with the interval in Saab's maintenance planning document). The line checks were most recently performed on October 13, 2019 (4 days before the accident).<sup>31</sup> The Saab 2000 *Aircraft Maintenance Manual* stated that the tires were to be examined for signs of damage, wear, and other deterioration and that a tire was to be removed "when tread has worn to the base of any groove or if any plies are exposed." The accident airplane flew 16 flight legs between the October 13 line checks and the accident.

PenAir reviewed maintenance records for the airplane to determine the tire replacements that occurred on the accident airplane between July 1 and October 16, 2019. Table 3 provides the information that PenAir reported.

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<sup>30</sup> A line check consists of routine and nonroutine maintenance to support day-to-day airplane operations. PenAir's maintenance program included line checks performed every 25 or 50 hours. The accident airplane's most recent maintenance before the accident was a line check performed on the day before the accident. During that line check, the only tasks related to the landing gear, hydraulics, or flight control systems were to ensure that the hydraulic reservoir quantity was correct and to fill the hydraulic systems with hydraulic fluid if necessary.

<sup>31</sup> The line check tasks were assigned on October 13, 2019, and were completed just after 0300 on the morning of October 14.

**Table 3.** Tire replacements on accident airplane.

Date	Tire	Reason for replacement
July 31, 2019	Outboard tire on left MLG	Tire had a crack in the grooves with fabric exposed
August 15, 2019	Inboard tire on left MLG	Tire was worn to its limit
August 28, 2019	Outboard tire on right MLG	Tire was worn to its limit
August 30, 2019	Inboard tire on right MLG	Tire was worn to its limit
September 2, 2019	Outboard tire on left MLG	Tire had a bald spot with threads cut
September 15, 2019	Outboard and inboard tires on left MLG	Inboard tire pressure was 90 pounds per square inch (psi), which necessitated replacement of both tires

A review of the accident airplane's flight logs from March 13 to October 17, 2019, showed that routine servicing and checks of the airplane were conducted. The flight logs also showed no significant entries regarding the landing gear, hydraulics, or flight control systems. In addition, none of the service difficulty reports and mechanical interruption summary reports that were on file from June to October 2019 were related to issues involving the airplane's landing gear, hydraulics, or flight control systems. According to the manufacturer of the landing gear, the left and right MLG were overhauled in January 2017.

### 1.3.2 Brake System and Tires

The airplane's left and right MLG had outboard and inboard wheels. The MLG tires, which were mounted on the wheels, were bias tires manufactured by Michelin Air.<sup>32</sup> The Saab 2000 brake system applies braking separately to the outboard and inboard wheels on each MLG. The primary components of the brake system are the brake pedals, the power brake valve, the outboard and inboard brakes (which transmit braking force to the wheels and tires), and the antiskid system (discussed in section 1.3.3).

The captain's and first officer's brake pedals operate independently. A control cable from each pedal transmits the inputs of the pedal to the power brake valve, which is mounted on a bulkhead in the nose gear wheel well. The power brake valve converts the pedal inputs into hydraulic pressure for the antiskid control valves, which determine the amount of pressure for each brake. The No. 1 hydraulic system powers the outboard brakes, and the No. 2 hydraulic system powers the inboard brakes.

<sup>32</sup> For a Michelin bias airplane tire, the main structure (casing) is constructed of overlapping nylon fabric plies that are laid at angles to the centerline (direction of rotation) of the tire.

### 1.3.2.1 Postaccident Examinations

The power brake valve, which was manufactured by Tactair, was examined on site after the accident and at the manufacturer's facility in Liverpool, New York. No conditions were noted that would have affected the power brake valve's operation.

The left outboard tire was found deflated and had an oval-shaped worn area that corresponded with the area on the tire where the first officer documented the flat spot. The worn area measured about 11 inches in length and had a hole in the middle, as shown in figure 5. The left outboard tire also had another oval-shaped worn area that measured about 15 inches in length and had intact tread in the middle, as shown in figure 6. This worn area was about 180° from the flat spot area.



**Figure 5.** Worn area and hole in left outboard tire.





**Figure 6.** Additional worn area on the left outboard tire.

The left outboard tire was examined at Michelin’s testing facility in Charlotte, North Carolina. The results of this examination are discussed in the next section. In addition, visual searches of the runway after the accident identified two 2-to-3-inch strips and four 3-to-5-inch strips of tacky rubber, a small screw, and a polygonal piece of non-tacky rubber that was the size of a quarter. One of the rubber fragments was found near the end of a dark skid mark on the runway.

The left inboard tire and the right outboard and inboard tires were intact. The left inboard tire pressure was 135 psi, and the right outboard and inboard tire pressures were at the maximum reading of the gauge: 160 psi. A placard on the landing gear doors indicated that the allowable tire pressure was between 165 and 173 psi. All three tires had numerous abrasions and cuts but did not have any flat spots, and all had significant tread remaining.

The brake wear pins on the left and right outboard tires had about 1 inch or more showing above the measuring plate, which indicated that most of the brakes’ service life remained. The brake wear pins on the left and right inboard tires had between about 1/8 and 1/2 inch showing above the measuring plate; these measurements indicated that the brakes were still usable. Visual inspection of the brake on the left outboard tire (after removal of the wheel) revealed no damage other than ingested dirt and debris.

### **1.3.2.2 Tire Analysis**

Michelin provided the National Transportation Safety Board (NTSB) with a tire analysis report. The report indicated the following regarding the left outboard tire:

- The oval-shaped flat spot in the tire (the same area where the first officer noticed a flat spot) represented a skid pattern from the initial skid. The

tapered and oval shape of the plies in the tire indicated that it was initially inflated during the skid but that, as the tire skidding action wore into the plies, the tire was unable to maintain pressure because of the reduction in the plies (casing strength), resulting in a complete loss of tire pressure. After this loss of pressure, the tire collapsed, and the skid pattern extended into the sidewall area.

- The rubber fragments found on the runway appeared to be from the area of the initial skid. The small screw found on the runway was not from the tire.
- At some point later in the landing rollout, the tire and wheel assembly rotated, and the airplane skidded again, as indicated by the oval-shaped worn area about 180° from the flat spot area. This skid pattern also extended into the sidewall area, indicating that the tire was deflated during the skid.
- The large cut on the tire tread extended through the casing and inner liner. This cut appeared to have occurred after the tire deflated; there was no bias rupture of the casing to indicate a pressurized blowout. Debris (pieces of gravel, rock, and concrete) was found inside this cut.

### **1.3.3 Antiskid System**

The antiskid system was manufactured by Crane Aerospace and Electronics. The antiskid system controls the hydraulic pressure applied to the brakes. The power brake valve provides brake pressure for the four MLG wheels to the antiskid system, which reduces the commanded brake pressure if an excessive skid is sensed.<sup>33</sup> The system controls the antiskid function in pairs; specifically, the outboard wheels on the left and right MLG are one pair, and the inboard wheels on the left and right MLG are the other pair. The primary system components are the antiskid control unit, the antiskid control valves, and the wheel speed transducers (sensors), which are discussed in the sections that follow and are shown in figure 8 (in section 1.3.3.5).

#### **1.3.3.1 Antiskid Control Unit**

The antiskid control unit was installed under the floor panels in the forward cabin. The unit contains identical outboard and inboard channels. The outboard

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<sup>33</sup> A skid occurs when a tire slides, instead of rolls, on a surface. A skidding tire provides less stopping force and can sustain damage quickly. An antiskid system monitors a tire's rotational speed and reduces brake pressure to the tire to prevent an excessive skid.



channel controls the outboard brakes, and the inboard channel controls the inboard brakes. Both antiskid channels receive signals from their respective wheel speed transducers. Each channel compares the average of the two wheel speeds to a calculated airplane groundspeed; when the difference between the average wheel speed and the groundspeed exceeds a certain threshold, the antiskid control unit commands the channel's antiskid control valve to reduce brake pressure to that pair of wheels.

The antiskid control unit also has a locked-wheel protection function that compares the speed of one outboard or inboard wheel with the speed of the other outboard or inboard wheel. When the speed of one of the outboard and/or inboard wheels is 40% or less than the speed of the paired wheel, the antiskid control unit commands the corresponding antiskid control valve to reduce the brake pressure in both wheels to the minimum pressure value that the valve can command.

The antiskid control unit monitors system components continuously through (1) a valve dump detector, which detects a full release of brake pressure to a wheel pair longer than 1.5 seconds; (2) a valve monitor, which detects a short or an open connection between the antiskid control unit and an antiskid control valve; and (3) a transducer monitor, which detects a short or an open connection between the antiskid control unit and a wheel speed transducer. If a fault occurs, the signal is sent to the left and right data concentrator units, which contain logic that determines whether the fault will be displayed on the engine indicating and crew alerting system (EICAS) in the cockpit, will be recorded on the maintenance diagnostics computer (MDC), or both. (The data concentrator units' logic includes a 0.5-second delay in displaying an EICAS message related to a fault for the inboard antiskid channel.) Faults recorded on the MDC are presented as either a maintenance message or a maintenance message source. Table 4 provides information about the faults that were recorded by the MDC during the accident landing rollout.<sup>34</sup>

**Table 4.** Faults recorded during landing rollout.

Fault message	System component monitor	MDC information
32# ANTI SKID CTL (recorded twice)	Valve dump detector	Maintenance message
INBD A-SKID (recorded twice)	Fault for inboard antiskid channel	Maintenance message source
32# L WHEEL SPD XDCR	Transducer monitor for left MLG	Maintenance message
OUTBD A-SKID	Fault for outboard antiskid channel	Maintenance message source
INBD A-SKID	Fault for inboard antiskid channel	Maintenance message source

Note: Each maintenance message was recorded at the same time as the related maintenance message source(s).

<sup>34</sup> Collins Aerospace (the MDC manufacturer) performed a download of the MDC circuit card fault data and provided the information to the NTSB.

FDR data showed that the inboard and outboard antiskid faults were recorded during a landing on October 13, 2019. The MDC recorded a maintenance message but not a maintenance source for these faults. The MDC fault should have been displayed on the EICAS (based on the data concentrator units' logic), but the airplane's logbook did not show any related entries.<sup>35</sup>

### **1.3.3.2 Antiskid Control Valves**

The primary components of the antiskid outboard and inboard control valves are an electrohydraulic servo valve and two slide and sleeve assemblies. The operation of each valve controls brake pressure.

The servo valve has a torque motor with an arm that extends between a pressure nozzle and a return nozzle. The position of the arm between the nozzles is determined by the amount of electrical current applied to the servo valve. With no electrical current, the arm is positioned against the return nozzle.

Each slide moves back and forth inside of a sleeve, and the position of the slide within the sleeve is determined by control pressure from the servo valve. Check valves in the antiskid control valve body enable pressure to be applied to the servo valve. With no electrical current, pilot-applied pressure pushes the slide to one end of the sleeve, which routes the applied pressure directly to the brakes.

When wheel braking exceeds the skid level, the antiskid system increases electrical current to the servo valve, causing the arm to move toward the pressure nozzle, which decreases pressure against the slide. This operation enables brake pressure feedback to push the slide in the opposite direction so that pressure is routed away from the brakes and to the return port, thereby stopping the wheel from skidding.

### **1.3.3.3 Wheel Speed Transducers**

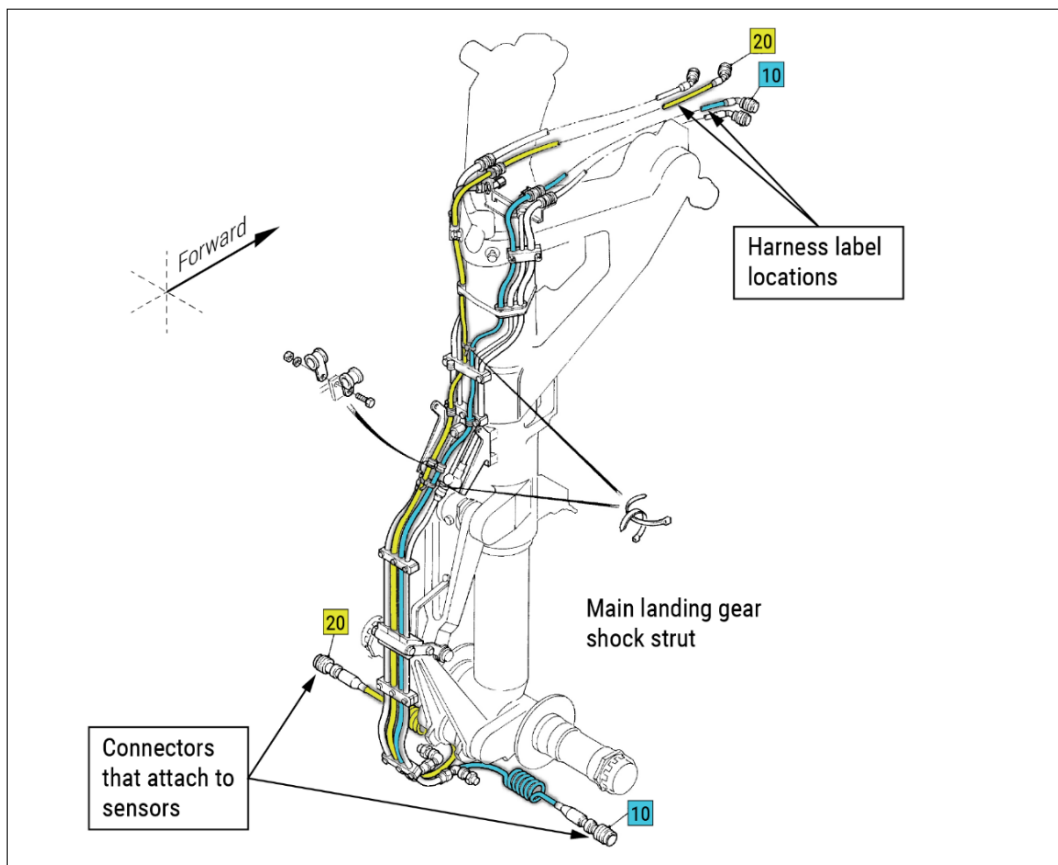
The wheel speed transducers provide signals to the inboard and outboard antiskid channels that are proportional to the speed of the wheel. These signals are provided through wheel speed transducer wire harnesses. Both the left and right

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<sup>35</sup> PenAir's *General Operations Manual*, section 21.10.2.1.2, required pilots to enter maintenance items in an airplane's logbook. Specifically, the manual stated that the PIC was responsible for ensuring that "an entry is made in the Aircraft Log of all mechanical irregularities that occur during flight. This entry...includes all reported or observed safety critical failures or malfunctions of an airframe, engine, propeller, or appliance [that is, system]."

MLG and the wheel speed transducer wire harnesses were manufactured by APPH Limited, also known as Héroux-Devtek UK. (APPH Limited became a subsidiary of Héroux-Devtek Inc. in February 2014.)

The wire harnesses have connectors at their top ends that attach to bulkhead fittings in each MLG wheel well. These connectors are keyed differently, so each connector can be attached to only one of the bulkhead fittings. The bottom ends of each wire harness are inserted through a hole in the base of each MLG shock strut, routed to the appropriate axle opening, and attached to the wheel speed transducers in the axles, as shown in figure 7. There is no distinguishing feature at the bottom ends of the harnesses to indicate which harness should be routed to the inboard wheel and which harness should be routed to the outboard wheel.



**Figure 7.** Routing for wheel speed transducer wire harnesses (Source: APPH).

Note: The wheel speed transducer wire harness with illustrated parts list item No. 10 indicates right wheel routing (the left MLG inboard wheel and the right MLG outboard wheel), and item No. 20 indicates left wheel routing (the left MLG outboard wheel and the right MLG inboard wheel). Wheel speed transducer wire harness item No. 10 has two labels near the upper connector (not shown); one indicates 5/6 GA-P4 (the component identifier), and the other indicates AIR134484 (the manufacturer part number). Wheel speed transducer wire harness item No. 20 also has two labels near the upper connector (not shown); one indicates 5/6 GA-P5 (the component identifier),

and the other indicates AIR134485 (the manufacturer part number). Section 1.3.3.4 further discusses the component identifiers.

The APPH component maintenance manual, the Saab illustrated parts catalog, and APPH wire harness drawings showed that one wheel speed transducer wire harness (part number AIR134485) is routed to the left wheel for each MLG—the outboard wheel for the left MLG and the inboard wheel for the right MLG. The other wheel speed transducer wire harness (part number AIR134484) is routed to the right wheel for each MLG—the inboard wheel for the left MLG and the outboard wheel for the right MLG.<sup>36</sup>

### **1.3.3.4 Postaccident Examinations**

The antiskid control unit and antiskid control valves were in good condition with no evidence of damage. The left MLG wheel speed transducer wire harnesses and the bulkhead fittings in the wheel well were damaged as a result of the MLG's impact with a ditch and a large rock beyond the fenced airport property. Both wire harnesses were fractured at the top of the MLG shock strut with the connectors still attached to the bulkhead fittings at the top end. In addition, the wire harness for the outboard wheel was fractured in two pieces near the top, and the wire harness for the inboard wheel was fractured near the midpoint and top of the strut; this piece was not recovered. Further information about the postaccident examination of each antiskid system component appears below.<sup>37</sup>

#### **Antiskid Control Unit**

Examination of the electrical connectors at Crane's facility in Burbank, California, showed that one of the connector pins was partially broken; only a stub remained, which was bent at the fracture location. Saab wiring diagrams indicated that this pin was connected to a left outboard wheel speed transducer signal.

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<sup>36</sup> The APPH component maintenance manual at the time of the landing gear overhaul (version 11, dated July 2015) illustrated the correct routing of the wheel speed transducer harnesses but contained discrepancies related to the nomenclature for the harnesses in the illustrated parts list. Specifically, the name for part number AIR830134484 was shown as "harness subassembly, anti skid right hand," but that part number was for the left wheel. Similarly, the name for part number AIR830134485 was shown as "harness subassembly, anti skid left hand," but that part number was for the right wheel. The most recent version of the APPH component maintenance manual (version 12, dated February 2020) removed the discrepancies by deleting "right hand" and "left hand" in the nomenclature.

<sup>37</sup> Crane reviewed the repair history of all antiskid system components. According to Crane's records, the only parts returned for repair were the inboard antiskid control valve (in May 2015) and the left outboard wheel speed transducer (in July 2009).

The antiskid control unit passed all functional tests except for the locked-wheel crossover test for the outboard wheels. (As stated in section 1.3.3.1, the locked-wheel protection function releases the brake pressure to the outboard and/or inboard wheels if one outboard and/or inboard wheel speed drops to less than 40% of the paired wheel speed.) The antiskid control unit cover was opened, and the unit was inspected. No anomalies were noted to the unit or the wheel speed/built-in test card circuit cards. The positions of the two cards within the unit were swapped; the cover was reinstalled; and some of the functional tests, including the locked-wheel crossover test, were performed again. The unit passed all of the tests. The two cards were then returned to their original positions, and the tests were repeated. The unit passed all of the tests again. The cause of the initial failed locked-wheel crossover test was not determined.

The results of the testing showed that the broken pin stub was in good contact with the test electrical connector during all of the repeated tests and did not affect any test outcomes. Additional continuity tests were performed at the NTSB's Materials Laboratory in Washington, DC, to determine if the broken pin stub would also make good contact with the electrical connector from the accident airplane. These tests showed that the broken pin stub was making solid contact with the connector and would not have affected system operation.

### **Antiskid Control Valves**

Both antiskid control valves (as well as other antiskid system components) were shipped in the same box from Anchorage to NTSB headquarters in Washington, DC, for further examination at Crane's facility. At some point during the shipping process, the box was damaged; upon arrival at NTSB headquarters, the box had water damage and had been retaped. When the box was opened, it was missing the outboard antiskid control valve. The NTSB contacted the shipper about the missing part, but the part was not subsequently located.

The inboard antiskid control valve was tested according to established procedures.<sup>38</sup> First, resistance checks were performed. Next, the valve pressure ports were connected to the test bench, and three hydraulic fluid samples were taken. Afterward, a functional test and other electrical tests were performed. The inboard antiskid control valve passed all tests except for an internal leakage test, which produced a result that was higher than the allowable measurement for that part. The

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<sup>38</sup> The NTSB hand carried this and the other shipped components to Crane's facility.

fluid samples were then filtered and examined under a microscope by a Crane technician, and the particle count was found to be acceptable.

### **Wheel Speed Transducers**

The four wheel speed transducers were tested at Crane's facility according to established procedures. The wheel speed transducers passed all tests.

### **Wheel Speed Transducer Wire Harnesses**

The NTSB, Saab, and the accredited representative from the Swedish Accident Investigation Authority examined the recovered wheel speed transducer wire harnesses. During the examination, the participants noted that the left MLG wheel speed transducer wiring harnesses had been constructed differently. Specifically, the left outboard harness was constructed with one filler wire (a nonconducting wire with a fiberglass center used to fill space in the conduit and increase the strength), and the left inboard harness had two filler wires. As a result, the left outboard harness segment could be matched with a short wire segment (about 6.5 inches long) that had a label identifying the harness as 5/6 GA-P4. The short wire segment was also matched with the upper electrical connector with part number MS 27467T9B35P.<sup>39</sup> According to the installation instructions, this harness should have been routed to the left inboard wheel and not the left outboard wheel.<sup>40</sup> Thus, the examination showed that the left MLG wheel speed transducer wire harnesses were incorrectly installed. The examination also showed that the right MLG wire harnesses were correctly installed.<sup>41</sup>

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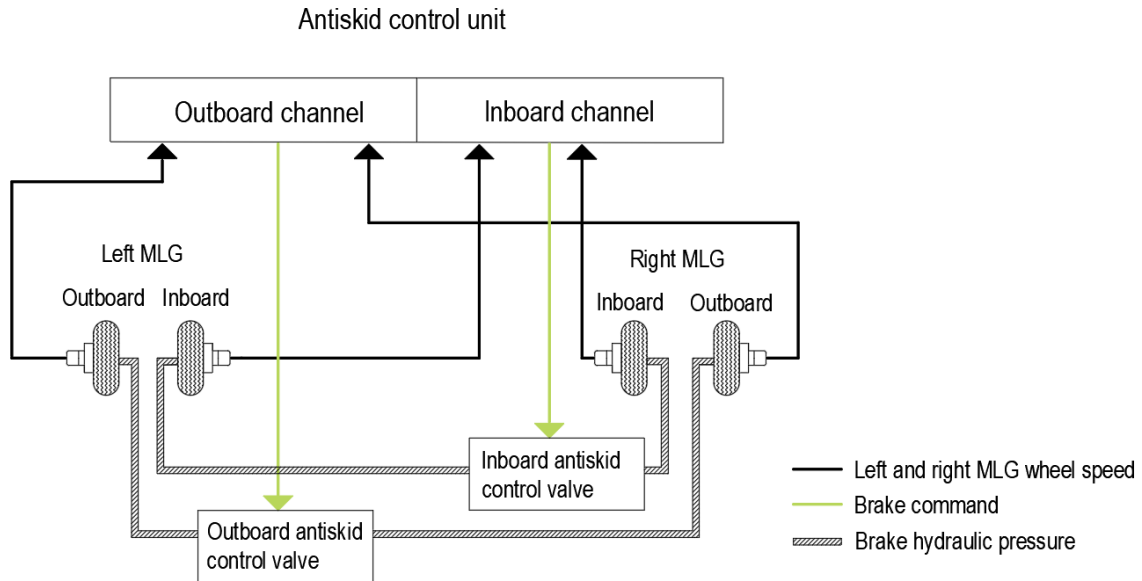
<sup>39</sup> The wire numbers for the recovered airplane wires to both the antiskid control unit electrical connectors and the inboard antiskid control valve electrical connectors were compared with those on the respective wiring diagrams, and the numbers for the recovered airplane wires were determined to be correct.

<sup>40</sup> According to APPH's component maintenance manual and wire harness drawings and Saab's illustrated parts catalog, the correct wheel speed transducer wiring harness routing to the left outboard wheel has a label identifying the harness as 5/6 GA-P5, and the upper electrical connector part number is MS 27467T9B35PA. The correct wheel speed transducer wiring harness routing to the left inboard wheel has a label identifying the harness as 5/6 GA-P4, and the upper electrical connector part number is MS 27467T9B35P.

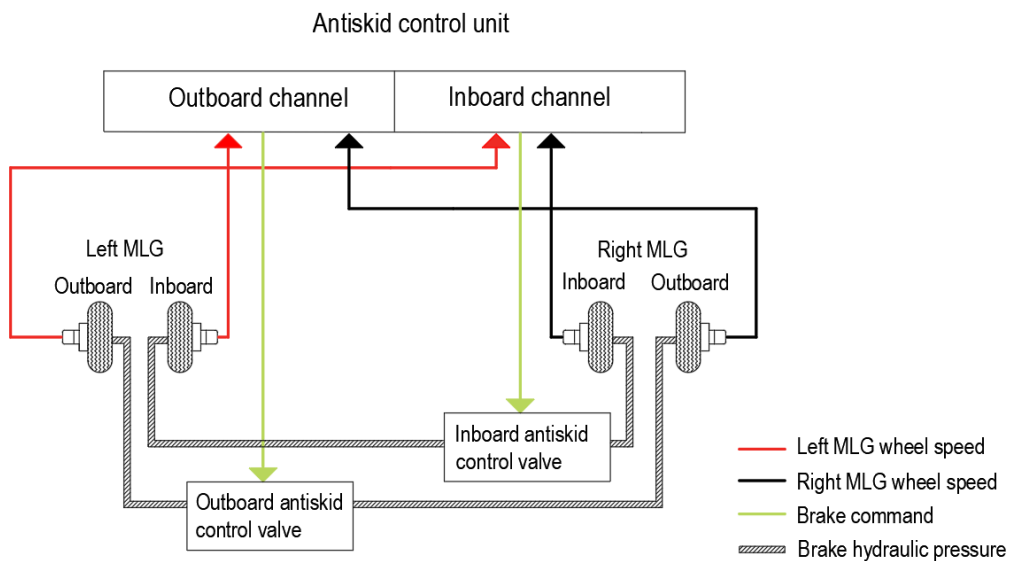
<sup>41</sup> The label information for the right inboard wire harness could not be read after the heavy dark residue found on the label was cleaned. The label on each harness is placed at the top end of the harness.

### 1.3.3.5 Wheel Speed Transducer Cross-Wiring

Figure 8 shows the correct wiring for the left MLG wheel speed transducer. The crossed wiring of the left MLG wheel speed transducers, as described in the previous section, is shown in figure 9; the crossed wiring is shown in red.



**Figure 8.** Wheel speed transducer wiring as designed.



**Figure 9.** Cross-wiring of left MLG wheel speed transducers.



The NTSB asked Crane, as the manufacturer of the antiskid system, about the system's response to crossed left MLG wheel speed transducer wiring and the left outboard tire in a skid condition. Crane stated that the following would be expected:

- If the left outboard tire were in an excessive skid, the inboard circuit would sense the skid and quickly reduce brake pressure to the left and right inboard wheels to near zero.
- The right outboard wheel would still have skid protection, but the wheel speed would be compared with the speed for the left inboard wheel (the right wheel on the left MLG).
- Some skid protection for the left outboard tire could occur if the right outboard tire started to skid. The outboard circuit would sense the skid and reduce the brake pressure to the left and right outboard wheels.

On March 8, 2021, Héroux-Devtek UK provided a root cause and corrective action report to the Air Accidents Investigation Branch (the NTSB's counterpart agency in the United Kingdom) in support of this accident investigation. The report recognized the possibility that the left MLG could have been assembled with the wheel speed transducer wiring harnesses in the opposite positions. The report noted that the MLG had been overhauled at the manufacturer's facility in Runcorn, England, in 2017 and stated that "it is at this overhaul that there is a potential for the...Anti-Skid Harnesses to have become inverted."<sup>42</sup>

The report further stated that, "due to the time since overhaul...the actual root cause of this incident cannot be determined." The report identified potential root causes involving the environment, material, personnel, equipment, and methods. Héroux-Devtek UK's internal investigation determined that "the only potential contributing factors" for the incorrect harness wiring were "unclear harness part numbers and the [equipment] operator following the process incorrectly."

### **1.3.3.6 Saab 2000 System Safety Assessment**

According to Saab, its system safety assessment for the Saab 2000 landing gear was conducted using *Federal Aviation Regulation/Joint Aviation*

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<sup>42</sup> PenAir records showed no evidence of any maintenance that would have required altering the position of the wheel speed transducer wiring on the left MLG.

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*Requirement 25.1309, Equipment, Systems, and Installations.*<sup>43</sup> This requirement included considering possible failure modes, the probability of multiple failures, a system's capability to detect faults, flight crew warning cues, corrective actions to mitigate the failure mode, and the effects of the failure modes on the airplane and its occupants. FAA Advisory Circular (AC) 25.1309 described various acceptable means for showing compliance with the requirements of *Federal Aviation Regulation/Joint Aviation Requirement 25.1309*.<sup>44</sup> The AC included guidance on the fail-safe design concept, including error-tolerant designs that consider adverse effects of foreseeable errors during the airplane's operation and maintenance.

The NTSB's review of the system safety assessment for the Saab 2000 found that the assessment did not analyze potential hazards related to the cross-wiring of wheel speed transducer harnesses during maintenance or overhaul and the effects that this failure mode could have on the flight crew and the airplane during landing.

The FAA has recognized the importance of mitigating the potential for human error during an airplane's design. For example, in 2016 the FAA published human factors design standard HF-STD-001B, which addressed, among other things, how manufacturers could design systems to preclude human error during maintenance. Similar to AC 25.1309, the FAA's human factors design standard provided several objectives, including (1) incorporating system safety factors to minimize human error in the operation and maintenance of a system, (2) providing a fail-safe design for systems in which a failure could cause catastrophic damage, and (3) ensuring that personnel are protected from making errors to the maximum possible extent.

### **1.3.3.7 Postaccident Actions**

On April 14, 2020, Saab issued Service Bulletin (SB) 2000-32-083, Landing Gear - Anti-Skid - Inspection for Correct Installation of the Anti-Skid Harness. This SB, which was issued to operators of the Saab 2000, provided inspection instructions to ensure that the antiskid harnesses were correctly installed. The SB indicated that, with an incorrect connection between the harnesses and the wheel speed transducers, a reduction in braking capabilities would occur if the antiskid function activated

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<sup>43</sup> (a) System safety assessments comprise several analyses, including a functional hazard assessment. The intent of a functional hazard assessment is to determine potential system failures that could lead to hazards that could affect the airplane and its occupants. (b) The Joint Aviation Authorities were responsible for publishing regulations, known as the *Joint Aviation Requirements*, which addressed, among other things, aircraft certification and design standards.

<sup>44</sup> European Union Aviation Safety Agency Acceptable Means of Compliance 25.1309 is the equivalent document to FAA AC 25.1309.

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because the system would receive wrong inputs. The SB described corrective actions that operators should take to ensure the proper functioning of the antiskid system. Saab added the new inspection procedure to its *Aircraft Maintenance Manual* procedures for MLG replacement.

On June 18, 2020, the European Union Aviation Safety Agency (EASA) issued Airworthiness Directive (AD) 2020-0137 (EASA 2020b).<sup>45</sup> This AD required a one-time inspection of the Saab 2000 antiskid system harnesses within 5 months of the effective date of the AD (July 2, 2020) and the accomplishment of applicable corrective actions (if necessary) before the next flight. The FAA issued AD 2021-02-02, which became effective on March 29, 2021, to address inadvertently reversed connections of the outboard and inboard channel harnesses of the wheel speed transducers (FAA 2021).

The FAA's AD required compliance with EASA's AD to prevent incorrect inputs to the antiskid system, which could lead to reduced braking capability. Saab stated that, as of October 15, 2021, a total of 45 Saab 2000 airplanes were in service. The inspection that the ADs mandated was reportedly performed for 30 of these airplanes. For the remaining 15 airplanes, Saab has not received information indicating whether the mandated inspection had been performed.

In addition, APPH stated that it completed the following "containment" actions in January 2021 to prevent incorrect wiring of the wheel speed transducers:

- A "quality alert" was issued to ensure that all equipment operators and certifying staff at the company's Runcorn manufacturing facility are aware of the potential to incorrectly install the Saab 2000 wiring harnesses.<sup>46</sup>
- A "quality alert" was issued to remind all equipment operators to ensure the legibility of harness labels.
- The company's quality control inspection checklist was updated to include a photograph of the harnesses and a signoff step to validate correct installation.

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<sup>45</sup> According to EASA's website, EASA "was founded in 2002 and was initially known as the European Aviation Safety Agency. The name was changed to European Union Aviation Safety Agency in 2018, when its responsibilities were also widened."

<sup>46</sup> APPH also issued a "global quality alert" to ensure that all twin-axle landing gear assemblies were checked for incorrect harness installation.

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- An “operator duplicate inspection” was added to the work order/job card to ensure that the harnesses were correctly installed during assembly.
- All equipment operators were reminded about the importance of following assembly instructions.

As a result of its internal investigation to identify potential root causes for the incorrect harness wiring, APPH implemented the following corrective actions:

- A clear tubing sleeve was installed to cover and protect the harness part identification numbers.
- A process failure mode effects analysis of critical potential failures was conducted for the Saab 2000 MLG to identify other manufacturing risks, and actions were implemented to reduce the risk priority number score.<sup>47</sup>
- An engineering team updated the original equipment drawing to ensure that the harness installation information was clearly depicted.
- The assembly tooling test equipment was changed to prevent assembly errors and enable more in-depth testing of the wheel speed transducer antiskid harnesses. The changes included test fittings that, according to APPH, would allow “instant detection” of crossed wire harnesses.
- Additional testing procedures per the engineering instructions were added to the component maintenance manual.

## 1.4 Meteorological Information

DUT has an automated weather observing system (AWOS) at an elevation of about 25 ft mean sea level. The AWOS reports were augmented by a weather observer. The AWOS hourly reports (referred to as meteorological aerodrome reports, or METARs) surrounding the accident time were as follows:

- At 1656 (44 minutes before the accident), the wind was from 310° at 11 knots, visibility was 10 statute miles or greater, few clouds were at 3,400 ft agl, a broken ceiling was at 4,700 ft agl, broken clouds were at 6,000 ft agl, the temperature was 7°C, the dew point was 1°C, and the altimeter setting was 29.50 inches of mercury.

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<sup>47</sup> In addition, APPH indicated that it reviewed other twin-wheel landing gear harness installation instructions to identify potential risks and took preventive actions as necessary.

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- At 1756 (16 minutes after the accident), the wind was from 300° at 21 knots with gusts to 27 knots, visibility was 5 statute miles, light rain was occurring, a broken ceiling was at 3,900 ft agl, the temperature was 6°C, the dew point was 2°C, and the altimeter setting was 29.53 inches of mercury. The remarks indicated that a peak wind from 300° at 27 knots occurred at 1754, rain began at 1741, and 0.02 inch of precipitation had fallen since 1656.

The automated 1-minute observations from the DUT AWOS for the times surrounding the accident included the following conditions:

- At 1740, the wind was from 310° at 20 knots with gusts to 25 knots, visibility was 9 statute miles, a broken ceiling was at 3,900 ft agl, the temperature was 7°C, the dew point was 2°C, and the altimeter setting was 29.52 inches of mercury.
- At 1741, the wind was from 310° at 19 knots with gusts to 25 knots, visibility was 9 statute miles, light rain was occurring, a broken ceiling was at 3,900 ft agl, the temperature was 7°C, the dew point was 2°C, and the altimeter setting was 29.52 inches of mercury. The remarks indicated that rain began at 1741 and that a trace amount of precipitation had fallen since 1656.<sup>48</sup>

The NTSB conducted a postaccident interview with the weather observer who was on duty at DUT at the time of the accident flight. The weather observer, who had been in that position for 18 years, stated that, in addition to observing weather and updating weather information, she communicates via radio with flight crews of arriving aircraft about weather conditions. The weather observer stated that flight crews usually make initial contact with her when they are 20 to 30 minutes away from the airport.<sup>49</sup> The weather observer also stated that she provides additional weather information if conditions change as well as wind information when airplanes are on final approach. She thought that flight crews likely do not listen to the AWOS

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<sup>48</sup> The time periods that the trace amount of precipitation had accumulated since 1656 could not be determined. Also, the AWOS 1-minute observation at 1744 reported that 0.01 inch of precipitation had fallen since 1656, indicating that, at some time during the previous 1 minute, the amount of accumulated precipitation collected since 1656 had reached 0.01 inch.

<sup>49</sup> According to the DUT weather observer, she provides flight crews with initial wind information from the AWOS. When airplanes are on approach to runway 13 or 31, the DUT weather observer provides crews with wind information from the midfield anemometer. She also provides wind information from the anemometer located near the runway 31 threshold for airplanes landing on that runway.

broadcasts for DUT because the crews know that the weather observers will update them about weather conditions.

The weather observer stated that she provided wind information to the accident flight crew when the airplane was 2 to 3 miles away from the airport during both approaches. The weather observer also stated that she was “surprised” to see the flight crew attempt to land the airplane on runway 13 during the second approach. She saw the airplane touch down and did not recall if the runway was wet or dry, but she did recall no standing water or puddles on the runway. The weather observer also recalled that a storm was coming in about the time of the landing.

According to the CVR, the DUT weather observer transmitted the wind reports shown in table 5 while the accident airplane was en route to DUT.

**Table 5.** Wind reports transmitted by the DUT weather observer.

Time	Reported wind
1706	210° at 6 knots gusting to 14 knots
1720	180° at 7 knots
1732	270° at 10 knots
1735	300° at 8 knots
1737	290° at 16 knots gusting to 30 knots
1738	300° at 24 knots

Note: The wind directions transmitted by the weather observer were referenced along a magnetic heading, whereas the AWOS wind directions noted earlier in this section were referenced to true north.

## 1.5 Airport Information

DUT is located on Amaknak Island and serves the city of Unalaska (located about 800 miles southwest of Anchorage) as a regional transportation hub for the western Aleutian Islands. The airport is owned and operated by the State of Alaska Department of Transportation and Public Facilities (ADOT), Southcoast Region. The airport is surrounded by Mount Ballyhoo to the north, Dutch Harbor and Iliuliuk Bay to the east, industrial and residential development to the south, and Unalaska Bay to the north and west. Runway 13/31 is 4,500 ft long and 100 ft wide, with 3,900 ft available for landing. The runway is constructed of grooved asphalt.

DUT was certificated under 14 *CFR* Part 139, and the FAA assigns each Part 139 certificate holder with an ARFF index based on the length of air carrier airplanes operating at the airport and the average number of daily departures. That index determines the required number of ARFF vehicles at the airport. DUT was assigned a class A index; 14 *CFR* 139.315 required a class A index airport to have one ARFF vehicle. DUT met this requirement with one E-1 Titan HPR 4x4-P501 ARFF vehicle.

### 1.5.1 Runway Safety Area

Airport design standards consider the size of airplanes that currently use (or are expected to use) an airport. The FAA categorized the runway at DUT as runway design code B-II.<sup>50</sup> FAA AC 150/5300-13A, Airport Design, specified that RSAs for such runways were to extend 300 ft beyond each runway end and were to be 150 ft wide.<sup>51</sup>

Before ADOT completed an airport improvement project at DUT in 2016, the runway at the airport was designated 12/30, and the RSAs measured 200 ft in length at the approach end of runway 12 and 100 ft in length at the approach end of runway 30. Because these RSAs did not meet the FAA's 300-ft RSA length for a B-II runway, ADOT contracted for an RSA practicability study, which was completed in October 2010. At that time, PenAir was operating a Saab 340B airplane at DUT and expected that the Saab 340B would most likely remain in service beyond 2016.

The RSA study determined that it would not be practical or feasible to construct full standard RSAs beyond the runway ends. The study found that declared distances could be used to meet the B-II RSA design standard at DUT by displacing the landing threshold at the approach end of each runway by 300 ft; the displaced pavement could then serve as the required RSA for arriving aircraft.<sup>52</sup> The study considered the installation of an engineered materials arresting system (EMAS) as part of the RSAs, but it was found not to be practical (due in part to cost) given that

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<sup>50</sup> The runway design code helps determine the design standards that apply to a specific runway. The three components that comprise the runway design code are the aircraft approach category (AAC), the airplane design group (ADG), and the approach visibility minimums. The first component of the runway design code is depicted by a letter that relates to an aircraft's approach speed (that is, the AAC). The second component is depicted by a Roman numeral and relates to either the aircraft's wingspan or tail height (whichever is more restrictive) of the largest aircraft expected to operate on the runway (that is, the ADG). The third component (the approach visibility minimums) is not applicable to the discussion about RSAs and is thus not presented in this report. In addition, each airport has an airport reference code (used for planning and design) that signifies the airport's highest runway design code. DUT had one runway, so its airport reference code was B-II.

<sup>51</sup> The FAA's 150-series ACs are primarily directed toward airport design and operations, and the standards and recommendations in AC 150/5300-13A for use in the design of civil airports are "mandatory for all projects funded with federal grant monies through the Airport Improvement Program...and/or with revenue from the Passenger Facility Charges...Program."

<sup>52</sup> FAA AC 150/5300-13 permitted declared distances if it was not practicable to provide a standard RSA. The AC defined declared distances as "the distances the airport owner declares available for a turbine powered aircraft's takeoff run, takeoff distance, accelerate-stop distance, and landing distance requirements."



full RSAs could be provided within the overall runway footprint through declared distances.<sup>53</sup>

The only declared distance option that was determined to be operationally viable involved (1) extending the end of pavement at the northwest end of the runway (the runway 12 approach end) by 200 ft to the northwest, (2) moving the runway 12 landing threshold 200 ft to the northwest, (3) extending the southeast end of the runway (the runway 30 approach end) to provide an additional 200 ft for an RSA, and (4) including a 150-ft blast pad (as recommended for a B-II runway) to provide additional separation from an adjacent road. (The road would be rerouted around the end of the runway and the new blast pad.) Because the RSA pavement at each runway end would be displaced, the runway pavement could also be used by departing airplanes and would increase the runway available for takeoff (4,500 ft) without increasing the pavement length. The use of declared distances met the operational needs of the Saab 340B.

The DUT airport improvement project began in 2012, and the actions discussed in the previous paragraph were implemented. When the project was completed in 2016, the runway was redesignated as 13/31. Also in 2016, PenAir began providing scheduled air carrier service at DUT with Saab 2000 airplanes. Afterward, PenAir began to phase out the Saab 340B from DUT operations.

According to the *DUT Airport Certification Manual*, at the time of the accident, the overall runway area measured 4,650 ft by 150 ft and included 300-ft RSAs at each runway end (marked as displaced thresholds) and a 150-ft blast pad at the approach end of runway 31. The 300-ft-long by 150-ft-wide RSA was consistent with the requirements in FAA AC 150/5300-13A for airplanes with an aircraft approach category (AAC) and an airplane design group (ADG) designation of B-II, including the Saab 340B. The Saab 2000's characteristics resulted in an AAC-ADG designation of C-III.<sup>54</sup> For a runway to accommodate airplanes with an AAC-ADG designation of C-III, the AC required an RSA that extended 1,000 ft beyond the departure ends of the

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<sup>53</sup> An EMAS is an FAA-approved aircraft arresting system intended for use where standard RSAs are impractical and when other alternatives are not feasible. EMAS consists of a bed of cellular concrete material blocks with a strength appropriate for the types of aircraft expected to use the airport. The blocks crush under the weight of an aircraft and bring it to a controlled stop within a short distance.

<sup>54</sup> On the basis of their approach speeds, the Saab 340B's AAC was B, and the Saab 2000's AAC was C. On the basis of their size (primarily their wingspan), the Saab 340B (a 70-ft wingspan) had an ADG of II, and the Saab 2000 (an 81-ft wingspan) had an ADG of III. In response to an NTSB request, the FAA provided an e-mail on May 18, 2020, that stated that the AAC-ADG for the Saab 2000 was C-III. Section 1.5.2 further discusses the AAC designation for the Saab 2000.

runway and was 500 ft wide. Thus, the runway 13/31 RSAs at the time of the accident did not meet the AC's length and width criteria for the Saab 2000.

AC 150/5300-13A states that the operation of an aircraft that exceeds the design criteria of an airport may result in either an unsafe operation or a lesser safety margin unless "air traffic control (ATC) Standard Operating Procedures" are in place for those operations.<sup>55</sup> The AC also states, "aircraft operations cannot be prevented, regulated, or controlled simply because the airport or runway does not meet the design standards for a particular aircraft type."

In addition, AC 150/5000-17, Critical Aircraft and Regular Use Determination, addresses operations of aircraft exceeding the design criteria of an airport.<sup>56</sup> For example, for scheduled revenue aircraft that exceed the design standards of an airport but do not meet the definition of regular use (500 or more annual operations), the AC states that the airport sponsor with responsibilities for airport safety should work with the FAA "to determine potential measures to mitigate any risk to the air transportation system.... However, the airport sponsor cannot restrict airport access based on design standards without an FAA determination (from [the Office of Airports] and the Flight Standards Service.") This exceedance concept does not apply to regularly scheduled Part 121 operations that meet the definition of regular use, but it is noteworthy that the FAA has guidance stating that an FAA determination is needed before aircraft that exceed an airport's design standards can be restricted from operating at that airport.

On June 10, 2020, and in response to NTSB questions to clarify the decision-making process involving the RSA construction process at DUT, ADOT stated that it had no role in the selection of aircraft that land at airports that the department owned and operated. Specifically, ADOT stated, "we publish the airport information and the rest is between the carrier and the FAA" and, similarly, "we don't dictate who or what airframe utilizes our airport system, that is between the carrier and the FAA." Further, ADOT did not recall and could not find any documentation regarding PenAir's decision to operate the Saab 2000 at DUT.

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<sup>55</sup> According to the AC, these procedures would apply to the "faster and/or larger aircraft that use the airport occasionally." PenAir conducted regularly scheduled flights at DUT.

<sup>56</sup> The critical aircraft (also referred to as the design aircraft) is an aircraft or a composite of several aircraft used to determine the airport reference code and the corresponding airport design standards in AC 150/5300-13A. The critical aircraft is typically the most demanding aircraft (in terms of size and speed) that regularly uses, or is expected to regularly use, the airport.

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The NTSB asked the FAA to provide any records or documentation regarding the authorization that allowed PenAir to operate the Saab 2000 at DUT. The FAA responded with a data collection tool titled "Aircraft Performance Operating Limitations, Design Assessment, Operations," which was completed for PenAir in January 2016. The FAA determined that PenAir had the necessary policies and procedures in place to meet the objective of the tool, which was to determine if the certificate holder would be able to comply with regulations and operate aircraft within performance limitations. During a postaccident interview, the FAA's principal operations inspector (POI) at the time that the FAA authorized Saab 2000 operations at DUT stated that he had no recollection of any consideration of the DUT airport reference code or the Saab 2000 AAC-ADG. In addition, during an April 2021 meeting with FAA Flight Standards Service staff members, the NTSB learned that they do not consider runway design codes or the corresponding RSA dimensions when authorizing a certificate holder to operate specific airplanes at an airport.

PenAir stated that the personnel who could provide information about the authorization process that allowed the Saab 2000 to operate at DUT were no longer with the company. PenAir provided the names of the individuals who were the director of operations and the assistant director of operations at that time. The NTSB contacted both individuals, but neither recalled the airport reference code or the AAC-ADG designation as considerations during the Saab 2000 authorization process. In addition, PenAir stated that any documents that the company might have had regarding the Saab 2000 authorization process would have been lost because of a cyberattack on the company in December 2019.

### **1.5.2 Airport Master Plan Update**

During fall 2020, ADOT began updating the DUT airport master plan.<sup>57</sup> This process involved an assessment of existing conditions, an evaluation of aviation forecasts and future needs, and a determination of the critical aircraft for the airport. As part of the process, the Saab 2000 and the DHC-8 were identified as the critical

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<sup>57</sup> An airport master plan helps identify development objectives to enhance safety and capacity at an airport during the next 20 years. The plan is required to maintain eligibility for federal funding of improvements. (For more information, see AC 150/5070-6B, Airport Master Plans.) The FAA recommends that airport master plans be updated every 7 to 10 years; the airport master plan for DUT was last updated in 2008.

aircraft and were determined to have a B-III AAC-ADG designation.<sup>58</sup> As a result, a focus of the master plan update process was to review options to accommodate B-III airplanes at the airport. Among the areas examined was the practicability of expanding the RSA.

AC 150/5300-13A required a 600-ft-long RSA for B-III aircraft. The airport master plan presented multiple options for consideration, which included providing a full-length 600-ft RSA at both runway ends, extending the runway and providing a full-length RSA at both runway ends by creating an embankment 971 ft into Dutch Harbor, installing an EMAS at both ends of the runway, or installing an EMAS at the approach end of runway 31 and using a displaced threshold at the approach end of runway 13.

[ADOT's website](#) (accessed October 18, 2021) indicated that the third of three public meetings to discuss the DUT master plan was scheduled for October 28, 2021, which was to be followed by a public comment period through November 11, 2021.

## 1.6 Wreckage and Impact Information

This section documents the postaccident condition of the airplane's structures, including flight control surfaces, and engines.<sup>59</sup> The fuselage had a hole and impact damage near the fifth passenger window on the left side (see figure 3). Scrape marks and dirt were observed in an area of the lower aft fuselage, and another scrape mark was seen just forward and to the left of this area. The right side of the fuselage had an impact mark forward of the wing. The impact mark, which was shallower at the top

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<sup>58</sup> A *Forecasts of Aviation Activity* report, dated January 15, 2021, was prepared for the master plan update by an engineering consultant for the project. According to the report, FAA traffic flow management system counts for 2019 (when the system was last updated) were used to make the critical aircraft determination for DUT. The data showed traffic involving 2,652 aircraft with B-II characteristics and 1,729 aircraft with B-III characteristics. The report stated, "based upon information provided by Ravn [Alaska], future chartered flights of the Dash 8 [37-seat airplane] may also occur. Future of larger aircraft by Ravn is not known, however, deployment and use of the larger 45-seat Saab 2000 airliner formerly serving DUT is not anticipated." (Ravn Alaska was formerly Ravn Air Group.) In an August 9, 2021, e-mail to the NTSB, ADOT confirmed that its engineering consultant used data from the FAA's traffic flow management system counts for 2019 indicating that the Saab 2000 had an AAC of B.

<sup>59</sup> The location and orientation of the airplane where it came to rest and the witness marks observed on the runway were documented in section 1.1. The postaccident condition of the brakes and MLG tires was documented in section 1.3.2.1. The postaccident condition of the antiskid system components was documented in section 1.3.3.4.

and deeper toward the bottom, was in line with the trajectory of the propeller blades. The fuselage skin in this area had three punctures and numerous small dents.

The left MLG had collapsed and was pushed aft and inboard, and its linkages were bent and broken. The right MLG was intact and in the down and locked position. The nose gear was intact, its left tire was punctured and deflated, and its right tire appeared to be partially inflated.

The left wing was intact and had minor impact marks on the leading edge. The right wing was intact and had no apparent damage. The aileron and aileron trim surfaces on both wings were intact. The flaps on both wings were intact and partially extended. The inboard portion of the flap on the left wing had an impact mark that began at the bottom and extended to the top. The vertical stabilizer, rudder, horizontal stabilizer, and elevators were intact and undamaged.

The left and right engines were in place. The left propeller was found sagging as a result of a 360° fracture of the reduction gear box. Three of the left engine's propeller blades fractured at the base of the airfoils. One of the blades was found hanging outside of the left-side fuselage near seat 4A. Another blade was found on the right side of the cabin near seat 4F. (See section 1.9 for the location of these seats within the cabin.) The other blade was recovered from the water near the airplane's resting location. No preexisting conditions were noted that could have affected normal operation of the engines and propellers.

## **1.7 Medical and Pathological Information**

Urine toxicological tests (mandated by the Department of Transportation) were performed on specimens that the captain and the first officer provided on the day after the accident at an unknown time. The results were negative for tested-for substances.<sup>60</sup>

The passenger who received fatal injuries (seat 4A) was struck by a propeller blade that entered the cabin. The State of Alaska Medical Examiner's Office reported that the cause of death for this passenger was "blunt impacts of head, trunk and extremities with multiple skeletal and visceral injuries."

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<sup>60</sup> Post-2018 Department of Transportation urine drug testing identifies the following urinary metabolites: amphetamine, methamphetamine, cocaine, codeine, morphine, heroin, phencyclidine, methylenedioxymethamphetamine, methylenedioxyamphetamine, methylenedioxyethylamphetamine, tetrahydrocannabinol, oxycodone, oxymorphone, hydrocodone, and hydromorphone.

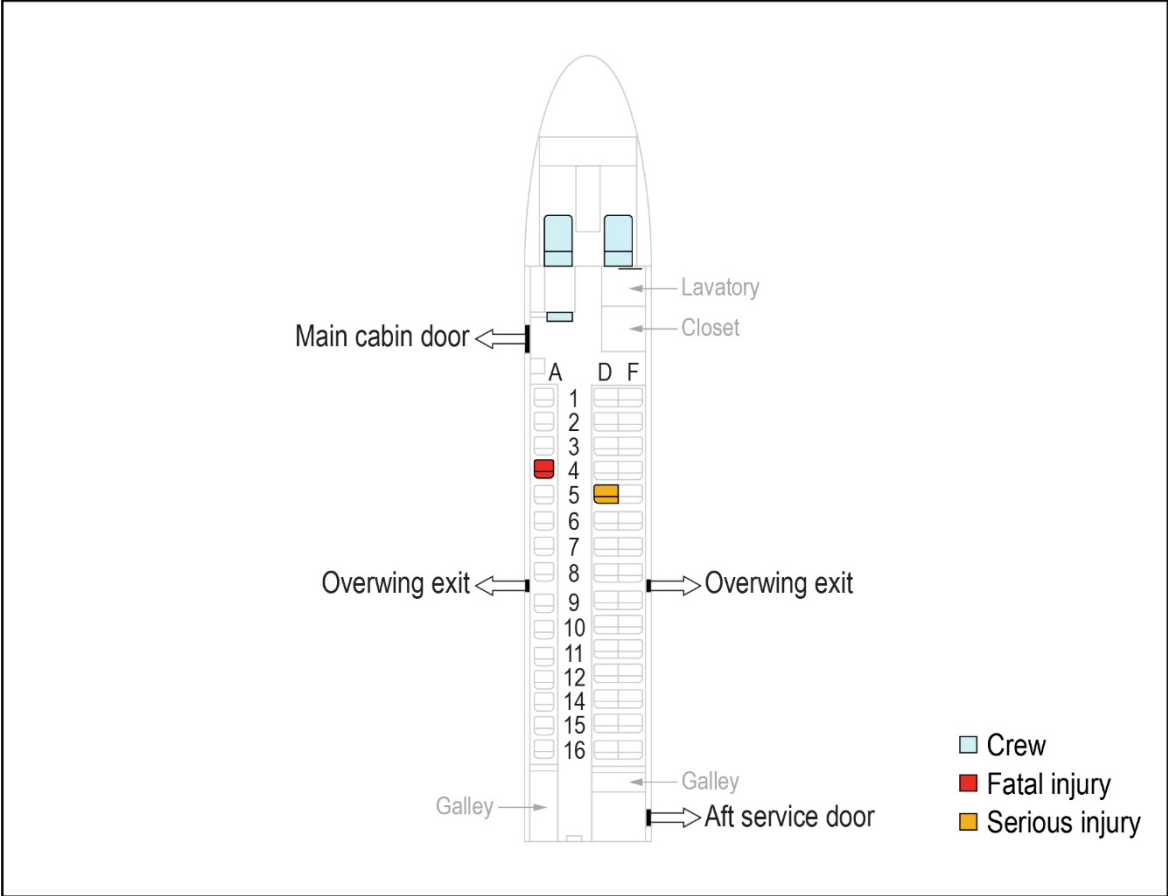
## 1.8 Flight Recorders

The airplane was equipped with a Honeywell 6022 solid-state CVR. The CVR contains a two-channel digital audio recording of at least the last 2 hours of operation. One channel combines three audio panel sources—the captain, the first officer, and the observer—and the other channel is the cockpit area microphone. The CVR also contains a three-channel digital audio recording of the last 30 minutes of operation. The three channels comprise the individual audio panels for the captain, the first officer, and the observer. Each of the CVR channels contained either excellent- or good-quality audio information, and the data were extracted normally. A transcript was prepared of the recording, which began at 1536:30 (when the airplane was near the top of climb) and ended at 1741:37. Appendix C contains the CVR transcript.

The airplane was also equipped with a L3/Fairchild F1000 solid-state FDR. The recorder was in good condition, and the data were extracted normally. About 43 hours of operational data were retained on the recording medium, including about 2 hours 24 minutes of data from the accident flight, from about 1516:04 to 1740:31.

## 1.9 Survival Factors

The accident airplane cabin was configured with a center aisle and 15 rows of passenger seats, numbered 1 through 12 and 14 to 16 (there was no row 13). A single seat on the left side of the cabin was designated A, and the two seats on the right side of the cabin were designated D (aisle) and F (window). The cabin had one aft-facing flight attendant jumpseat that was forward of the main cabin door on the left side of the airplane. In addition to the main cabin door, an aft service door was located on the right side of the airplane, and two overwing emergency window exits were located at row 9. Figure 10 shows the cabin configuration and the seating positions of the crew and the passengers who were fatally and seriously injured.



**Figure 10.** Airplane interior configuration and location of fatal and serious injuries.

Note: This figure does not show the seating positions of the eight passengers who received minor injuries because most of those injuries occurred during the evacuation, as discussed in section 1.9.2.



### 1.9.1 Cabin Condition After Accident

A left propeller blade impacted the left side of the cabin, as shown in figure 11, and damaged the cabin interior in the area between seats 3A and 6A, with extensive damage next to the seat 4A seatback and window. The overhead compartment in that area partially separated from its mounts and descended about 6 to 12 inches. The wall panel separated near seat 3A and was displaced aft and inboard. The wall panel and fuselage skin infringed about 10 inches into the seat 4A area at the lower seatback cushion. The 4A window fuselage frame was located on the cabin floor at row 2.



**Figure 11.** Impact area of left propeller blade.

Seat 4A sustained substantial damage. The seatback was displaced inboard toward the center aisle, as shown in figure 12, and the seatback structure was fractured on the left side. The headrest cushion was partially torn away from the seatback, and the left side of the seatback (forward facing) had an 8-inch vertical cut through the foam and cover starting about 4 inches from the top of the seatback. The bottom seat cushion was askew. The right armrest was fractured at the forward mount and displaced inboard about 4 inches. The seat belt was not damaged and was functional. Another propeller blade had entered the left-side fuselage, traversed the cabin, and was in place vertically on the right side of the cabin in front of seat 4F, which can also be seen in figure 12. The blade was wedged between the overhead bin and the floor. There was no damage or scrape marks to the overhead bin, floor, or seats 4D and 4F except for a fracture and slight displacement of the inboard armrest of seat 4D. Seat 5D had a superficial x-shaped tear in the seat cushion.



**Figure 12.** Forward view of cabin from row 6.

### 1.9.2 Evacuation and Emergency Response

PenAir's flight attendant manual discussed the duties for unplanned evacuations. The manual indicated that the flight attendant was "solely responsible for the organization and evacuation of the passengers" and that it was critical for the flight attendant to "respond immediately and accurately to the emergency situation." The manual also stated that an evacuation should begin "as soon as the airplane

stops completely” and that the flight attendant “[should] not wait for a signal from the PIC to evacuate in an unplanned emergency situation.”

According to a postaccident interview, the flight attendant looked outside of passenger windows and determined that her exit (the main cabin door on the left side of the airplane) was unusable, so she immediately ordered an evacuation through the right-side exits. Interviewed passengers did not specifically recall evacuation orders from the flight attendant or the flight crew but recognized that an evacuation was necessary and opened the right overwing exit and the right service door in the aft cabin. Passengers who evacuated from the aft service door encountered a significant drop to the ground due to the airplane’s attitude. The passenger who opened the door helped other passengers to the ground from that exit. Passengers who evacuated from the right overwing exit encountered a slippery wing due to rain that began about that time (as discussed in section 1.4). Most of the eight passengers who sustained minor injuries had slipped and fallen on the wing. Afterward, towels were placed on the wing to provide friction, and passengers reached the ground via a ladder that was brought (most likely by firefighters) to the wing.

Passengers who were seated in and aft of row 5 evacuated immediately. Passengers seated in and forward of row 4 (including the three crewmembers) could not initially evacuate because the passenger in seat 4A had been moved by other passengers from his seat to the aisle immediately after the airplane stopped (thus blocking the egress path) so that they could tend to the passenger’s injuries. After most of the passengers in and aft of row 5 had evacuated, a local doctor (who witnessed the accident) boarded the airplane through the right overwing exit and began providing medical assistance to the injured passenger. Afterward, emergency medical technicians boarded the airplane and removed the injured passenger, who was then transported via ambulance to a local medical clinic.<sup>61</sup> The remaining passengers and the three crewmembers subsequently exited the airplane, and all airplane occupants were off the airplane about 19 minutes after the accident.

One ADOT airport operations employee was on duty at the time of the accident. The employee stated that, after the second approach, the airplane touched down and appeared to be traveling faster than normal. As the airplane traveled past the airport operations office (which was near the ARFF station), the employee heard a

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<sup>61</sup> Nine other passengers were transported to the local medical clinic. One of these passengers received a serious injury and was subsequently flown via medevac to Anchorage for treatment. The other passengers were treated and released; several days later, one of the passengers had a surgical procedure related to the minor injury that he sustained in the accident.

“boom” that “sounded like a misfire.” Shortly afterward, he saw the airplane off the end of the runway and in the water. The employee immediately donned his firefighting gear and called 911 to report that an airplane was in the water off the end of the runway. He then drove the ARFF vehicle to the accident site and called the airport manager while en route.

The DUT *Airport Certification Manual* included a mutual aid agreement with the city of Unalaska. Thus, in addition to the airport response, the Unalaska Fire Department and the Unalaska Police Department responded to the accident site. The NTSB received digital video files and computer-aided dispatch reports from the Unalaska Police Department. The NTSB reviewed the video files and dispatch reports along with the video from the two off-airport security cameras (which captured portions of the accident, evacuation, and emergency response) to determine the evacuation and emergency response timeline, as shown in table 6.

**Table 6.** Evacuation and emergency response timeline.

Time	Event
1740:29	Airplane came to a stop
1740:40	Right overwing exit opened; passengers began exiting shortly afterward
1740:52	Right aft service door opened; passenger evacuations through this door could not be observed
1742:36	End of initial passenger flow from right overwing exit
1742:42	DUT ARFF vehicle arrived on scene
1745:37	First mutual aid fire vehicle (a sport utility-style vehicle) arrived
1748:39	First mutual aid fire truck arrived
1750	Medic 1 and Medic 2 ambulances arrived
1754	Passenger in seat 4A was carried off airplane
1759	All occupants were off airplane
1800	Medic 1 left for medical clinic with passenger in seat 4A
1802	Medic 1 arrived at medical clinic

## 1.10 Tests and Research—Aircraft Performance Study

The NTSB conducted an aircraft performance study to determine the Saab 2000 landing performance capability and identify factors that might have affected the accident airplane’s stopping performance. The study was based on available factual evidence as well as the Saab 2000 airplane flight manual and supplemental aerodynamic, engine, and brake system data. The study was primarily focused on the airplane’s configuration and energy state from MLG touchdown to the airplane’s departure from the paved surface comprising runway 13, the RSA at the departure end of runway 13, and the blast pad beyond the RSA.

### **1.10.1 Saab 2000 Landing Performance Capability**

The aircraft performance study considered whether the accident airplane had adequate stopping performance to land at DUT on runway 13 with the accident conditions—a flaps 20 configuration, a landing weight of 46,000 pounds, an MLG touchdown groundspeed of 142 knots, an altimeter setting of 29.50 inches of mercury, a temperature of 8°C, a dry pavement surface, and a 15-knot tailwind.<sup>62</sup> The runway 13 surface was considered to be dry given that the two passenger videos (which documented the accident airplane’s touchdown) and the two security camera videos (which recorded the airplane’s departure from the blast pad) indicated that condition during the touchdown and landing rollout.<sup>63</sup> The supporting Saab 2000 landing performance data (developed for FAA certification and use by Saab 2000 operators to comply with airplane dispatch requirements) assumed that the airplane was equipped with automatic flap retraction after touchdown (in this case, from 20° to 15°) to increase MLG loading, a fully functional wheel brake and antiskid system, one engine at ground idle power during the landing rollout, and the other engine inoperative.

#### **1.10.1.1 Saab 2000 Normal Unfactored Landing Distance**

The aircraft performance study examined 18 normal unfactored landing distance scenarios to quantify the performance of various airplane configurations and wind conditions. These scenarios were based on a flap setting of either 20° or 35°; a 15-knot tailwind, no wind, or a 15-knot headwind; and nominal and alternate forward center-of-gravity (CG) limits.<sup>64</sup> The unfactored landing distance included the air distance from a 50-ft displaced threshold crossing height to MLG touchdown, the distance for nose gear touchdown and transition to the selected deceleration device configuration, and the airplane rollout distance to a complete stop.

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<sup>62</sup> Some of the data used in this study were slightly more conservative than the accident conditions. For example, the 46,000-pound assumed landing weight was almost 800 pounds higher than the accident airplane’s landing weight (which was estimated to be 45,213 pounds). Also, the temperature was assumed to be 8°C; the recorded temperature was 7°C. The 15-knot tailwind condition was derived from FDR airspeed and groundspeed data.

<sup>63</sup> The videos showed no water on the passenger windows, no water displaced by the MLG wheels, no rainfall on the pavement, and no rainfall on the Dutch Harbor surface before the airplane reached its final resting position.

<sup>64</sup> An alternate forward CG limit is an airplane loading criterion that allows increased landing weights that meet the FAA’s landing performance requirement in 14 *CFR* 121.195 (which is discussed in section 1.11.1.2). PenAir had two different alternate forward CG limits, referred to as I and II.



The calculations for all scenarios showed that the normal unfactored landing distance ranged from 2,165 to 3,625 ft, which corresponded to remaining runway lengths (relative to the 3,900-ft landing distance available) that ranged from 1,735 to 275 ft.<sup>65</sup> One of the scenarios involved the accident airplane configuration and the wind condition at MLG touchdown (a 15-knot tailwind). The results for the accident scenario indicated that, with the flight crew accomplishing MLG touchdown near the target touchdown point (about 1,000 ft down the runway), timely nose gear touchdown (within 2 seconds after MLG touchdown), manual wheel brake application, and both engines in ground idle to maximum reverse power during the landing rollout, the airplane would stop with about 445 ft (11%) of runway remaining before the RSA.<sup>66</sup>

Another scenario considered the flight dispatch calculation for the accident flight, which indicated that the airplane had the landing performance capability to make a flaps 35 landing with no wind, at the estimated arrival weight, and with an alternate forward CG loading.<sup>67</sup> (See section 1.11.1.2 for information about PenAir flight dispatch calculations.) The Saab 2000 airplane flight manual data for this scenario indicated that the airplane would stop with about 1,560 ft (40%) of runway remaining before the RSA.

#### **1.10.1.2 Saab 2000 Non-Normal Unfactored Landing Distance**

The accident airplane's actual transition and rollout distances exceeded the expected stopping performance margin for a dry, grooved runway with no credit for the stopping performance of reverse power. As a result, the NTSB requested that Saab engineering staff calculate unfactored transition and rollout distances for non-normal landing configurations, and Saab provided calculations for 20 non-normal landing scenarios. The non-normal landing configurations comprised one engine inoperative, one or both antiskid circuits inoperative (that is, no braking for two or all four MLG wheels, respectively), automatic flap retraction (from flaps 20 to 15) inoperative, and/or wheel brakes not applied. An additional landing performance

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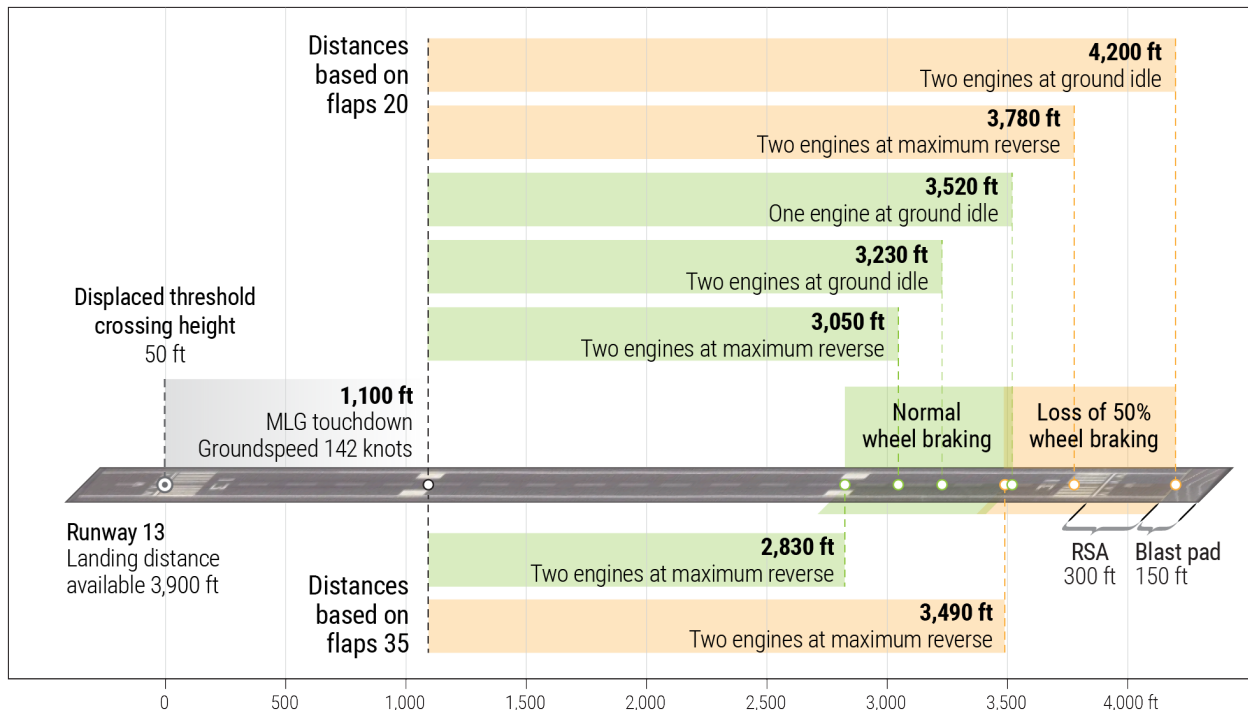
<sup>65</sup> The distance remaining values in this section did not include the runway 13 RSA or runway 31 blast pad pavement lengths.

<sup>66</sup> The actual runway distance remaining would exceed 445 ft because the accident engine configuration provided more deceleration than the calculation assumed.

<sup>67</sup> The NTSB's review of the load manifest for the accident flight showed that the airplane's CG was within the alternate forward CG limit included in the flight dispatch calculation.

variable for the non-normal landing configurations was the use of ground idle or maximum reverse power on the operative engine(s).

Further, a flaps 35 landing scenario was calculated for four different wheel brake configurations to determine additional Saab 2000 landing performance capabilities. The initial conditions for all flaps 35 scenarios were the same as the flaps 20 initial conditions except that airspeed was adjusted for the lower landing reference speed ( $V_{ref}$ ) and touchdown speed for the flaps 35 configuration. Figure 13 shows some of the results from the aircraft performance study regarding non-normal unfactored landing distances.



**Figure 13.** Aircraft performance study calculations for various landing configurations.

For the flaps 20 configuration, the calculations indicated that the accident airplane should have had adequate performance capability to stop within the landing distance available on runway 13 for all cases in which both antiskid circuits were operating and for the case in which one antiskid circuit was inoperative (no braking for two of the four wheels) and both engines were operating at maximum reverse power. Also, the airplane should have been able to stop on the paved surface near the RSA/blast pad transition point with one antiskid circuit inoperative and both engines operating at ground idle power. The landing distance required for the accident airplane to stop (based on the average deceleration it demonstrated from MLG touchdown to RSA departure) with a flap setting of 20° was 4,490 ft, which exceeded the landing distance available.



For the flaps 35 configuration, the calculations indicated that the accident airplane should have had adequate performance capability to stop within the landing distance available on runway 13 for the case in which both antiskid circuits were operating and for the case in which one antiskid circuit was inoperative and both engines were operating at maximum reverse power. The calculated flaps 35 stopping distances were several hundred feet less than the similar cases with a flaps 20 configuration. The landing distance required for the accident airplane to stop (based on the average deceleration it demonstrated from MLG touchdown to RSA departure) with a flap setting of 35° was 4,080 ft, which indicated that the airplane would have stopped within the runway 13 RSA.

The average aircraft deceleration value during the transition and rollout segments was calculated for each scenario. With two antiskid circuits active, the average aircraft deceleration at flaps 20 (which becomes flaps 15 due to automatic flap retraction after MLG touchdown) was between about 7 and 9 knots per second for all engine power settings evaluated. The accident airplane's groundspeed as it departed the paved surface (after overrunning the runway, RSA, and blast pad) was about 28 knots. Thus, the average deceleration required to match this groundspeed was calculated to be about 5 knots per second. The FDR-based average deceleration for the airplane during the transition and rollout segments on the paved surface was about 4.7 knots per second.

### **1.10.1.3 Saab 2000 Flight Test Data**

The aircraft performance study examined time history data from 10 flight test conditions related to the Saab 2000 deceleration capability on a dry runway. The examination considered airplane loading (weight and CG), configuration (flap position and engine power setting), and deceleration device configuration (maximum wheel braking with or without automatic flap retraction for landing).<sup>68</sup> The data were based on normal landing, accelerate-stop, and rejected takeoff flight test conditions, which were flown to support Saab 2000 development and certification efforts.

The flight test data for each of the 10 cases included plots of airplane groundspeed as a function of time. The slope of this line yielded the demonstrated Saab 2000 average deceleration on a dry runway. The deceleration value for each flight test case was calculated from the time that the airplane transitioned to the full deceleration device configuration through the rollout to a complete stop. The results

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<sup>68</sup> The cases included flap settings at 0°, 15°, 20°, and 35°; both engines operating or one engine inoperative; and maximum reverse or ground idle power.

indicated that a fully functional Saab 2000 could generate average deceleration values ranging from about 6 to 9 knots per second during the rollout with maximum wheel braking and an operating antiskid system. The variation of 3 knots per second was a function of the landing flap configuration, number of operating engines, engine power setting, and automatic flap retraction configuration.

### **1.10.2 Accident Airplane Deceleration Times and Rates**

The accident airplane's MLG touched down about 1,100 ft beyond the runway 13 threshold at a groundspeed of about 142 knots. Thus, given the 3,900-ft landing distance available on runway 13, 2,800 ft of runway stopping distance remained. According to constant acceleration equations for position and speed, the maximum time available for the airplane to stop on runway 13 would have been 23.4 seconds. The average deceleration that would have allowed the accident airplane to stop within the 2,800-ft remaining runway distance (with a fully functional wheel brake and antiskid system) was determined to be 6.1 knots per second.<sup>69</sup>

The timeframe available for the flight crew to configure the airplane for full deceleration was estimated by considering hypothetical time delays for wheel brake application that ranged from 1 to 4 seconds. At an initial groundspeed of 142 knots, the average deceleration for the airplane to stop within 2,800 ft ranged from 6.7 knots per second (for a 1-second delay) to 9.3 knots per second (for a 4-second delay).<sup>70</sup>

The deceleration required to stop within the landing distance available after MLG touchdown (2,800 ft) plus the RSA (300 ft) and the blast pad (150 ft) distances, which totals 3,250 ft, was also calculated. (The RSA distance would have been used for emergency stopping. Although the blast pad was not intended for that purpose, it could also have been used for emergency stopping.) At an initial groundspeed of 142 knots, the airplane required an average deceleration of 5.3 knots per second to stop within the 3,250-ft total distance. With hypothetical wheel brake application delay times that ranged from 1 to 4 seconds, the average deceleration for the airplane to stop within 3,250 ft ranged from 5.7 knots per second (for a 1-second delay) to 7.5 knots per second (for a 4-second delay).

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<sup>69</sup> The accident airplane's deceleration was initially higher than 6.1 knots per second and was less than 6.1 knots per second after the left MLG outboard tire burst.

<sup>70</sup> These decelerations (as well as other hypothetical wheel brake application delay times presented in this section) were consistent with the Saab 2000 flight test deceleration capabilities demonstrated with maximum wheel braking and a fully operational antiskid system.

Compared with the deceleration values required to stop within the landing distance available after MLG touchdown (2,800 ft), the deceleration values required to stop within the total 3,250-ft distance decreased because of the lower average deceleration required to dissipate the airplane's energy along the RSA and blast pad distances. According to Saab 2000 airplane flight manual, non-normal configuration, and flight test data, the accident airplane should have had the performance capability to stop within the total distance comprising the landing distance available on runway 13 plus the RSA and the blast pad distances.

### **1.10.3 Study Summary**

The aircraft performance study found that the airplane should have had the landing performance capability to stop within the landing distance available on runway 13 or the RSA distance given the documented airplane energy state, MLG touchdown location, environmental conditions, and runway pavement and surface conditions along with two of the four wheel brakes inoperative. The study also found that the airplane's initial deceleration was consistent with an ability to stop on the runway but that the deceleration decreased substantially after the left MLG outboard tire burst. In addition, the study found that the burst tire by itself (that is, without the cross-wired left MLG wheel speed transducer harnesses) would not have caused the airplane to depart the paved surface because the airplane could have stopped even if 50% of MLG wheel braking was inoperative.

## **1.11 Organizational and Management Information**

Peninsula Aviation Services Inc. d.b.a. PenAir was headquartered in Anchorage, Alaska. The company's Part 121 operating certificate was initially issued by the FAA on July 31, 1979, and was reissued on June 1, 2010. At the time of the accident, PenAir had six Saab 2000 airplanes in its fleet (including the accident airplane).

Peninsula Airways was founded in Pilot Point, Alaska, in 1955 and became incorporated 10 years later. By 1973, the company began providing charter service to DUT. In 1991, the company began doing business as PenAir.

In 1996, PenAir began operating some flights under Part 121 while continuing to operate others under 14 CFR Part 135. In 1998, PenAir relocated its headquarters to Anchorage. By 2005, PenAir was Alaska's largest commuter airline, operating a fleet of 40 airplanes (under Part 121 and Part 135) and providing scheduled service to 36 communities in the southwest part of the state.

PenAir also operated routes outside of Alaska. Between 2012 and 2016, the company began operations from Boston, Massachusetts; Portland, Oregon; and Denver, Colorado. Also in 2016, the company received delivery of four Saab 2000 airplanes, which were primarily used for routes in Alaska, including ANC to DUT.

In August 2017, PenAir filed for chapter 11 bankruptcy and announced that the company would be ending operations from Denver and Portland. According to a bankruptcy court filing dated August 6, 2017, the company's financial performance deteriorated partly because the Denver and Portland hubs "have not lived up to expectations." In June 2018, PenAir announced the suspension of operations from Boston, citing a loss of mechanics and pilots who accepted positions with other air carriers. In October 2018, a court overseeing the bankruptcy proceedings approved the acquisition of PenAir by Peninsula Aviation Services Inc. (Peninsula Aviation Services made its bid through a company that owned Ravn Air Group Inc.) The Department of Transportation approved the acquisition in December 2018.

According to the FAA, the process of merging PenAir with Corvus Airlines, a Ravn Air Group air carrier, began in April 2019. The FAA issued Operations Specification A502, Air Carrier Merger and/or Acquisition, to Peninsula Aviation Services with an effective date of August 28, 2019. The operations specification authorized Peninsula Aviation Services to conduct operations during the merger transition period, which began on June 14, 2019, and would continue until all required training and qualifications were accomplished (or 5 years had elapsed).

In April 2020, Ravn Air Group filed for chapter 11 bankruptcy due to the COVID-19 pandemic; at that time, operations at PenAir and Corvus Airlines ceased. On October 15, 2020, the PenAir air carrier certificate was voluntarily surrendered to the FAA.

### **1.11.1 Company Procedures**

#### **1.11.1.1 Pilot-in-Command Airport Qualification**

Section 21.2.6 of PenAir's *General Operations Manual* contained a list of four airports, including DUT, that required a company-designated PIC airport qualification. A pilot could not act as PIC on a flight to one of these airports unless the

pilot met specific company requirements.<sup>71</sup> According to the manual, to be eligible for the company-designated PIC airport qualification, a pilot must have either (1) 300 hours as PIC in PenAir airplanes (the Saab 2000 was the only airplane that PenAir operated as of March 2019) or (2) 100 hours as PIC in PenAir airplanes along with an e-mail or letter of recommendation from a company check airman who flew with the pilot and an e-mail or letter of approval from the company chief pilot.<sup>72</sup> Eligible pilots then began the qualification process detailed in section 22.11.1.12 of the PenAir *Flight Operations Training Manual*.

The qualification module in the training manual contained the following elements: briefing, including special considerations for the designated airport; preflight planning; normal takeoff, en route, and landing procedures; abnormal considerations; and debrief. The qualification process involved at least one round-trip flight with a check airman to the company-designated airport; a separate qualification flight was required for each airport on the list. According to the training manual, the PIC was to demonstrate “the skills and knowledge required to operate in and out of the company designated airport on regularly scheduled flights.”

The *General Operations Manual* stated that, once the company-designated PIC airport qualification process was completed, the PenAir crew scheduling program would reflect a PIC’s qualification for that airport. Crew scheduling personnel would receive an alert from the program if they attempted to assign a flight to a company-designated airport to a PIC who had not completed the qualification process for that airport.

### **Captain’s Related Training Records**

The captain’s training records included *Flight Operations Training Manual* form 116, Saab 2000 Company Designated PIC Airport Qualification, which was signed by a company check airman on August 1, 2019. By signing the form, the check airman

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<sup>71</sup> The company-designated PIC airport qualification requirements were separate from the FAA’s PIC airport qualification requirement for special airports. According to 14 *CFR* 121.445, certain airports with surrounding terrain, obstructions, or complex approach or departure procedures are considered special airports that require special qualifications (including DUT). For special airports, the FAA requires either the PIC or the second-in-command to have flown to the airport within the last 12 months or the PIC to have familiarity with the airport via pictorial means. A review of PenAir crew scheduling records logs showed that both accident pilots met the FAA’s 12-month special airport requirement.

<sup>72</sup> The PenAir *General Operations Manual* stated that the company-designated PIC airport qualification was aircraft specific. Thus, to be eligible for the qualification in the Saab 2000, company pilots needed the required number of PIC hours in that airplane (and not in any other airplane that PenAir had operated).

certified that the captain achieved the prerequisites for the qualification and demonstrated the skills and knowledge to operate at DUT. The PenAir manager of flight standards signed the form on August 5, 2019.<sup>73</sup>

Form 116 indicated that the completion date for the captain's DUT qualification flight was July 20, 2019. The company flight log indicated that the check airman flew with the accident captain during one round-trip flight from ANC to DUT on that date. Crew flight time and duty log records from PenAir showed that, as of July 20, the captain had accumulated 20 hours 36 minutes of flight experience in the Saab 2000 (4 hours 50 minutes of which were accumulated during the round-trip flight). During a postaccident interview, the check airman stated that the captain had "a lot of [previous] experience" at special airports and that he had seen the captain operating at DUT before he began working for PenAir, so he "based a lot of [the] evaluation on his experience level and how he performed and how he handled himself." The check airman also noted that he had made several flights with the captain to DUT during his operating experience.<sup>74</sup>

The records also indicated that the captain had accumulated 95 hours 57 minutes of flight experience in the Saab 2000 on August 24, 2019, the date of his first trip to DUT as a PIC without a check airman. Although form 116 had been signed before this flight (indicating that the captain met the company-designated PIC airport qualifications for DUT), PenAir flight logs indicated that the accident captain had not logged a sufficient number of hours in the Saab 2000 to be eligible for the PIC airport qualification. The check airman who signed the captain's form 116 stated that he knew that the captain did not have 100 hours as a PIC in the Saab 2000 but that "there was a push to get people who were experienced to be signed off for Dutch Harbor."

During a postaccident interview, the PenAir chief pilot at the time of the accident stated that she was aware of the 300-hour PIC requirement for eligibility for the company-designated PIC airport qualification but waived the requirement for the

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<sup>73</sup> During a postaccident interview, the PenAir employee who was responsible for pilot records recalled entering the accident captain's DUT qualification into the crew scheduling program after receiving his form 116 and verifying that the form had the required signatures.

<sup>74</sup> This check airman also signed the form indicating that the accident captain had completed his operating experience on July 25, 2019, which was 5 days after the PIC airport qualification flight.

accident captain.<sup>75</sup> The chief pilot also stated that, at the time of the accident, she was not aware that a pilot needed to accumulate 100 hours of PIC time in PenAir airplanes before the 300-hour requirement could be waived. She was also unaware of the requirement for letters or e-mails from a check airman and the chief pilot for PICs with only 100 hours of PIC flight time in company airplanes (even though those prerequisites were listed on form 116).

Senior company pilots stated that the 100-hour waiver was intended for pilots that might be new to PenAir but had substantial flight experience either in the Saab 2000 or at a company-designated airport (or both). The former chief pilot of PenAir (from September 2017 to March 2019) stated that a pilot who had “10 years flying Saab 2000s” or “10 years of flying in and out of Dutch Harbor every day” might be eligible to have the 300-hour requirement waived to 100 hours. The waiver was also appropriate for PenAir Saab 2000 first officers upgrading to captain who had accumulated a sufficient level of experience in the airplane (as second-in-command) and at the designated airport.

### **Proposed Changes to PIC Airport Qualification**

Company pilots indicated that, during a pilot meeting in early summer 2019, the PenAir chief pilot at the time of the accident and the Ravn Air Group senior vice president of flight operations (who was involved with PenAir’s operations during the acquisition and merger) discussed the possibility of changing the 300-hour PIC experience requirement for operating at company-designated airports.<sup>76</sup> The pilots recalled that such a change could involve reducing the requirement to 100 hours (without a waiver), replacing the requirement with a check airman recommendation, or keeping the requirement at 300 hours but allowing that time to be accumulated as either a captain or a first officer.

During a postaccident interview, the Ravn senior vice president stated that he was not convinced that the 300-hour minimum requirement was necessary, especially

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<sup>75</sup> The former chief pilot stated that she waived the requirement for the accident captain because “he had 1,000 hours of turboprop Alaska time. I had flown with him in a Dash-8...I was confident he could go into Dutch safely.” During a postaccident interview, the captain stated that the Dash-8 is a “highly maneuverable airplane” that “can fly a lot slower” during final approach than the Saab 2000, which he described as “a high speed airplane” that is “more of your airliner type.” (The captain had flown the Dash-8 model DHC-8-100 airplane before his employment with PenAir.)

<sup>76</sup> Before assuming her role at PenAir in February 2019, the chief pilot worked at Ravn Air Group with the senior vice president of flight operations.



for a small air carrier such as PenAir.<sup>77</sup> The PenAir chief pilot stated that she “didn’t disagree” with the Ravn senior vice president’s idea to reduce the 300-hour requirement. (The FAA was not involved in discussions about changing this company-designated PIC airport qualification requirement because PenAir had not officially proposed a change to the requirement.)

The check airman who signed the captain’s form 116 (before he had logged the required number of hours in the Saab 2000) stated that the chief pilot had told him that the company was in the process of changing requirements for the PIC airport qualification. Another company check airman stated that “there was obviously a need for us to get more pilots qualified” to operate at company-designated airports and that, in late July and early August 2019, the chief pilot met him after training flights to such airports to ask if the pilots had been signed off for the airports.<sup>78</sup> A company pilot who became a captain in June 2019 stated that the chief pilot “took the first step” to get her training to become qualified to fly into DUT, even though she had not yet accumulated 300 hours as a PIC in the Saab 2000. The pilot declined this training so that she could first gain more experience as a captain.

Several PenAir senior pilots and check airmen had concerns about the potential change to the PIC qualification requirement for company-designated airports. One of the check airmen was concerned that pilots would not receive the training that they needed to fly into those airports. One of the pilots stated that a question arose during a meeting regarding the number of landings that a pilot needed to accomplish to become proficient in operations at company-designated airports. The pilot thought that a set number of landings would not necessarily indicate proficiency because those landings might not have included all the environmental and operational conditions that a pilot would need to experience at the airports.

Even though they were aware of the pilots’ concerns, the PenAir chief pilot and the Ravn senior vice president continued pursuing a revised PIC airport qualification

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<sup>77</sup> During a postaccident interview, the PenAir director of flight training stated that the 300- and 100-hour requirements were implemented in 2015 to have experienced pilots operating at more challenging airports, but he was not aware “how or why they [the company] came up with those numbers.”

<sup>78</sup> Several pilots indicated that the period surrounding PenAir’s bankruptcy was stressful for flight crews and that many senior pilots left PenAir during that time because of the company’s uncertain future and the hiring opportunities at major airlines. One pilot stated that, about the time that the accident captain received his PIC qualification for DUT (July 2019), there were “four or five” captains qualified for DUT.

requirement, but the 300-hour minimum requirement ultimately remained in place. The 100-hour waiver requirement remained in place until a *General Operations Manual* revision, dated March 2, 2020, eliminated the waiver option.

### **1.11.1.2 Preflight Planning**

#### **Wind Chart**

PenAir used a wind chart created by the Medallion Foundation for 18 airports that the company served, including DUT.<sup>79</sup> The wind chart provided the maximum wind limits recommended for dispatch. According to the PenAir *Dispatch Procedures Manual*, when the forecast wind approaches the wind chart recommendations, dispatch is not authorized unless “the dispatcher and the PIC agree that the flight can be conducted safely” and an alternate airport is listed on the dispatch release.<sup>80</sup>

The wind chart for DUT (dated May 1, 2019) indicated that 30 knots was the maximum wind allowed in the chart sector that comprised 170° to 280°, which included the forecast wind direction for DUT (270°). The chart also indicated that the maximum wind for that sector should be reduced by 10 knots for PICs with less than 300 hours in the aircraft type. The accident captain had 131 hours of PIC time in the Saab 2000; thus, the wind limit for the sector was 20 knots.

According to the weather information included in the dispatch release package, the forecast wind was from 15 knots with gusts to 25 knots.<sup>81</sup> The wind chart indicated that, for wind gusts of 10 knots or greater, one-half the gust value should be added to the steady-state wind to determine if the wind would be within the limit for any sector on the chart. According to this formula, the steady-state wind limit would be 20 knots.<sup>82</sup>

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<sup>79</sup> According to its website, the Medallion Foundation was an Alaska-based nonprofit foundation that promoted aviation safety in the state. The foundation began its work in 2001 and ceased operations in September 2019.

<sup>80</sup> The alternate airport for the accident flight was Dillingham Airport, Dillingham, Alaska, which is 408 nautical miles to the northeast of DUT.

<sup>81</sup> The dispatch release package also included the 1356 METAR, which indicated that the wind was from 250° at 8 knots with gusts to 22 knots.

<sup>82</sup> The gust value is the difference between the reported steady-state wind and the reported wind gusts. In this case, the gust value was 10 knots, one-half of this value was 5 knots, and that value added to the 15-knot steady-state wind was 20 knots.

The DUT wind chart also included a runway risk factor of +8.<sup>83</sup> According to the PenAir director of safety, the runway risk factor on a wind chart was to be entered on the company's flight risk assessment form (discussed later in this section), which PICs were expected to complete before certain flights.

### **Landing Weight Limitations**

As part of preflight planning, dispatchers had to consider the requirements of 14 *CFR* 121.195, which addressed landing limitations at destination airports for turbine engine-powered airplanes. The regulation states that an aircraft should depart at a weight that, after considering the expected fuel burn during the flight, would allow the aircraft to stop within 60% of the effective length at the destination airport. To meet this requirement, PenAir dispatchers used landing performance tables from the company manual titled *Airport Analysis Saab 2000 Alaska*. The tables provided maximum landing weights for various conditions and airplane configurations to meet the 60% requirement.

According to section 26.8.3 of the PenAir *Company Flight Manual* (CFM) for the Saab 2000, the dispatch release informed pilots of the maximum allowable planned landing weight for the destination airport and included remarks about the flap setting, airplane loading, wind, and runway length used in the calculation. The CFM also stated that, before departure, the PIC had to ensure that the calculation for the planned landing weight and the information in the remarks section were accurate (per 14 *CFR* 121.195).

The dispatch release for the accident flight showed that the airplane's maximum allowable planned landing weight was 46,114 pounds. The remarks section of the dispatch release indicated that the planned landing weight was calculated using no wind, a flap setting of 35°, an alternate forward CG limit, and a landing on runway 31. According to load manifest documents, the captain calculated that the planned landing weight would be 45,213 pounds; thus, the flight met the 14 *CFR* 121.195 requirement for departure. (This calculation was completed before departure and after all the passengers had boarded and the fuel and baggage had been loaded on the airplane.) Upon arrival at the destination airport, the landing

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<sup>83</sup> Eleven airports that PenAir served had a runway risk factor of zero, five airports had a runway risk factor between +3 and +7, and DUT and one other airport had a runway risk factor of +8. (The wind chart did not show whether a runway risk factor higher than +8 could be assigned.) Higher runway risk factor numbers indicated more challenging airport operations. Thus, DUT was considered one of the most challenging airports that PenAir served.

weight limit that was calculated before departure (for the purpose of meeting the 14 CFR 121.195 requirement) no longer applied to the flight.

Even though the maximum allowable planned landing weight at the time of departure was based on a flaps 35 setting, the captain could choose to use a different flap setting for landing. According to the *Airport Analysis Saab 2000 Alaska* company manual, the maximum allowable landing weight at the time of departure for a planned flaps 20 landing would have been 40,628 pounds. Although this maximum allowable landing weight was less than the planned landing weight that the captain calculated, the 40,628-pound maximum allowable landing weight would only have applied to the dispatch requirements of 14 CFR 121.195 for a planned flap setting of 20° for landing.

During a postaccident interview, the captain stated that the standard flap setting was 20° and that a setting of 35° was considered to be nonstandard, but he did not provide a reference for these statements.<sup>84</sup> The captain also stated that he decided to land with 20° instead of 35° of flaps because the latter could lead to floating or ballooning and difficulty pinpointing the landing spot. In addition, the captain stated that “there is not that much performance difference” between the use of flaps 20 versus flaps 35 for landing.<sup>85</sup> Postaccident interviews with other company pilots found that some would regularly land at DUT with 35° of flaps and that others preferred to land at the airport with 20° of flaps, especially in gusty conditions, if the airplane’s performance would not be affected.

### **Flight Risk Assessment**

Section 21.5.8.1 of the PenAir *General Operations Manual* and section 24.5.15 of the PenAir *Dispatch Procedures Manual* stated that the PIC was to complete a flight risk assessment for certain flights before departure, including those to DUT. The PenAir risk assessment form, dated November 15, 2013, assigned points to various risk factors involving equipment, personnel, weather, and the destination airport. The

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<sup>84</sup> According to the CVR, at 1553:49, the captain told the first officer, “some guys actually do full flap landings into Dutch even though it’s not recommended.” The first officer replied that two company pilots he had flown with to DUT had used flaps 35 for landing and that one of the company pilots “asked me [the first officer] if I wanted to do it...and I was like...I’ll do twenty—I’m good.”

<sup>85</sup> During a postaccident interview, the captain stated that, with a flaps 20 landing, “maybe you might...roll an extra 150 feet.” In addition, the CVR recorded the captain stating that, with the unfactored landing distance of 3,058 ft that he calculated, a flaps 35 landing “saves” about 300 ft of that distance.

number of points for each of these risk factors were added together to determine a total number of points that corresponded to one of four risk factor categories:

- low (0 to 15 points)
- caution (16 to 25 points)
- medium (26 to 39 points)
- high (40 or more points)

If the form indicated that the risk factor category was low or caution, then pilot and dispatcher concurrences were required for the flight. If the form indicated that the risk factor was medium, the PIC had to receive approval from the director of flight operations, the chief pilot, or their designated representative to conduct the flight. If the form indicated that the risk factor was high, the flight was to be canceled.

The captain conducted a risk assessment for the accident flight and found that it would have low risk (10 points). The captain determined that the following risk factors applied to the flight: "Destination Runway <6000'," "Turbulence Forecast," "Cross Wind Component >15 Knots," "Landing VIS [visibility] 1-3 [miles] Above Minimums," "Mountainous Terrain," and "APP/DEP [approach/departure] Over Water." The captain did not include the following items in his risk assessment (which would have raised the point total to 17 and increased the risk category to caution): "Runway Risk Factor" (from the wind chart), "Less than 1 year with the Company," and "More Than 2 hours from Home Base."

### **1.11.1.3 Landing Performance**

PenAir did not require time-of-arrival landing performance calculations and did not have a procedure for these calculations in company manuals.<sup>86</sup> Nevertheless, during postaccident interviews, several company pilots stated that it was a common practice to check landing performance data during the approach to an airport after receiving the current weather conditions.

The PenAir *Saab 2000 Performance Binder* (an appendix of the CFM) provided the unfactored landing distances needed for the airplane to stop on a runway.<sup>87</sup>

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<sup>86</sup> FAA Safety Alert for Operators 19001, Landing Performance Assessments at Time of Arrival (dated March 11, 2019), states that "there is no specific regulation requiring operators to assess landing distance requirements at time of arrival, however the FAA encourages operators to adopt such procedures to ensure that a safe landing can be made."

<sup>87</sup> The information in this binder also appeared in the *Saab 2000 Quick Reference Handbook*.

Title 14 *CFR* 25.125 requires airplane manufacturers to determine this distance for certification. The unfactored landing distance is measured from the runway threshold (with an airplane crossing the threshold at a height of 50 ft agl and at  $V_{ref}$ ) to the point where the aircraft comes to a stop.

The PenAir *Saab 2000 Performance Binder* presented the distances in tables that considered the airplane weight and flap setting, the wind, and the airport pressure altitude. In addition, the information presented in the binder included landing distance correction factors due to various environmental conditions, such as a tailwind or headwind, which would either increase or decrease the unfactored landing distance.<sup>88</sup> According to the tables, the unfactored landing distances for the accident airplane at DUT were 3,536 ft (with a 15-knot tailwind and flaps 20) and 3,224 ft (with a 15-knot tailwind and flaps 35).<sup>89</sup>

#### **1.11.1.4 Approach Speed**

Section 26.7.2.1 of the CFM stated that visual approaches were to be flown at the appropriate  $V_{ref}$  (found in the PenAir *Saab 2000 Performance Binder*) plus a wind increment. The manual indicated that the wind increment was determined by adding one-half of the headwind component to the gust value (regardless of wind direction). The manual also indicated that the final approach speed ( $V_{ref}$  plus the wind increment) should be the nominal speed down to 50 ft above the landing surface (the expected height when crossing the runway threshold on a normal approach), at which time the pilot should begin decreasing the speed for landing. Similarly, section 26.7.5.1 of the CFM, which discussed normal landings, stated that this speed ( $V_{ref}$  plus the wind increment) should be held until crossing the runway threshold on final approach.

The *Saab 2000 Performance Binder* showed that, according to the planned flap setting and landing weight, the  $V_{ref}$  for this approach was 126 knots indicated airspeed. FDR data showed that the airplane's indicated airspeed was about

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<sup>88</sup> In the *Saab 2000 Performance Binder*, the highest tailwind provided for unfactored landing distances was 15 knots. According to section 26.2.1.4 of the CFM, the tailwind limitation for takeoffs and landings in the Saab 2000 was 15 knots.

<sup>89</sup> The captain's performance calculation for landing with 20° of flaps, 3,058 ft (as recorded by the CVR at 1627:30), did not match any information in the *Saab 2000 Performance Binder* tables. During a postaccident interview, the captain stated that, during the accident flight, he evaluated a "performance program" on his iPad that he was hoping to get PenAir and the FAA to approve. The captain also stated that the performance program "would tell you exactly...how many feet [the airplane is] going to use" for landing and that he had evaluated the program on other company flights.

127 knots as it crossed the runway 13 threshold at an altitude of 26 ft agl and was about 125 knots at the time of touchdown.

During a postaccident interview, the captain stated, "normally we run what's called REF plus 10. On approach I was REF plus 15. Right about 300 feet, I'm REF plus 10. Maybe right at the runway, I'm REF plus 5, and at touchdown I was on REF." During the first officer's postaccident interview, he recalled that the  $V_{ref}$  was 126 knots indicated airspeed and stated that "we bug REF plus 10. So 136 [knots]." The first officer also stated, "we didn't have gusting too much, so we just [stuck] with the plus 10." In addition, the first officer stated that, with a tailwind, he would still fly at a speed of  $V_{ref}$  plus 10 knots.

### **1.11.2 Pilot Training**

#### **1.11.2.1 Special Instrument Approach Procedures**

Four special instrument approach procedures existed for approaches to DUT in conditions that exceeded visual flight rules (VFR) weather minimums; the RNAV approach to runway 13 was one of those four procedures. The special approach procedures required FAA authorization, and PenAir's authorization was contained in an operations specification that required the company to provide its pilots with training on these approaches. According to PenAir, this training was accomplished through a computer-based presentation titled New DUT Special Approaches, which was provided during initial new hire training. This presentation reviewed the four special approaches at DUT, including the missed approach procedures, and included various aerial photographs of the airport area.

Training on the special approach procedures was also included in the *Flight Operations Training Manual* modules on flight crew operating experience. This training was conducted in the Saab 2000 airplane after pilots completed simulator training.

#### **1.11.2.2 Aircraft Performance and Airport Analysis**

According to the PenAir *Flight Operations Training Manual*, all new company pilots received training in aircraft performance and airport analysis during indoctrination ground training. The module addressing this topic was 1.5 hours in duration, and the objective was for the student to "have a thorough understanding of environmental effects on aircraft performance including weather, geography, and airport condition."



The training manual indicated that company pilots also received Saab 2000-specific aircraft performance training. The module addressing this topic was 3 hours in duration, and the objective was to “introduce performance characteristics and procedures” in the Saab 2000. A presentation used for this training, titled Saab 2000 Aircraft Performance, indicated that the airport analysis manual, which was located in each company airplane, was used to calculate takeoff and landing performance data for all airports that PenAir served. The presentation also included instruction on determining the maximum allowable landing weight before departure.

Training records indicated that the captain and the first officer completed PenAir ground training, which included these two modules, on or before June 20, 2019.

### **1.11.2.3 Crew Resource Management**

According to the *Flight Operations Training Manual*, PenAir provided pilots with crew resource management (CRM) training during initial new hire, recurrent, and upgrade training. The initial new hire and upgrade CRM training was provided during a 4-hour period, and recurrent CRM training was provided during a 1-hour period. The training consisted of PowerPoint slides and videos that addressed communication, attitudes and behavior, problem solving, human factors, situational awareness, conflict resolution, team building, and threat and error management.

### **1.11.2.4 Go-Around Experience**

Some PenAir pilots who were interviewed as part of this investigation reported that, during Saab 2000 initial and recurrent simulator training, they conducted go-arounds after receiving direction from ATC to go around because of obstacles, vehicles, or airplanes on the runway. The pilots did not recall any training on go-arounds because of weather conditions or without ATC direction. During a postaccident interview, the accident captain stated that he had simulator experience conducting a go-around in the Saab 2000 but had no in-flight experience conducting a go-around in the Saab 2000 before the accident flight.

The PenAir pilots stated that they often conducted missed approaches under instrument flight rules but that the missed approaches were rarely followed by a VFR traffic pattern for a landing on the same runway.<sup>90</sup> The pilots also stated that, if they

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<sup>90</sup> The traffic pattern at DUT was a flight around Mount Ballyhoo, either clockwise for runway 31 or counterclockwise for runway 13.

had to go around, they could easily return for a landing on the opposite runway. For DUT, several pilots had performed go-arounds and maneuvered to re-enter the traffic pattern for the opposite runway, but those pilots could not recall conducting a go-around and flying the VFR traffic pattern to the same runway.

A former chief pilot for PenAir stated that it would be appropriate to discuss the VFR traffic pattern as part of the PIC airport qualification flight for DUT. The company-designated PIC airport qualification module in the training manual included the category "abnormal considerations." Although a visual go-around would be covered by this category, the available evidence for this accident did not indicate whether the check airman had discussed that information with the captain during the PIC airport qualification flight for DUT.

### **1.11.3 Safety Program**

PenAir was required by 14 *CFR* Parts 5 and 121 to have a safety management system (SMS).<sup>91</sup> The four components of an SMS are safety policy, safety risk management, safety assurance, and safety promotion.<sup>92</sup> The company's SMS was discussed during indoctrination training (a 2-hour module) and recurrent training (a 30- to 60-minute module). The training highlighted the SMS structure, reporting options, and company culture.

The PenAir manager of safety was responsible for the company's SMS.<sup>93</sup> The manager of safety stated that the company conducted safety risk assessments to

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<sup>91</sup> The FAA and EASA are developing requirements for SMS for manufacturers, as discussed in section 2.3.4.2. That section also provides information about Saab's plan to implement an SMS.

<sup>92</sup> According to FAA AC 120-92B, *Safety Management Systems for Aviation Service Providers* (dated January 8, 2015), safety policy is "the certificate holder's documented commitment to safety, which defines its safety objectives and the accountabilities and responsibilities of its employees in regard to safety." Safety risk management is "a process within the SMS composed of describing the system, identifying the hazards, and analyzing, assessing, and controlling risk." Safety assurance is "processes within the SMS that function systematically to ensure the performance and effectiveness of safety risk controls and that the organization meets or exceeds its safety objectives through the collection, analysis, and assessment of information." Safety promotion includes "communication of safety information to support the implementation and operation of an SMS in an organization."

<sup>93</sup> During a postaccident interview (in December 2019), the PenAir manager of safety stated that she had been in that position for about 3 years, the last 2 months of which were as the manager of safety for Ravn Air Group. The PenAir manager of safety reported to the PenAir director of safety, who had been in that position from July 2017 to July 2019, at which time he became the managing director of safety for Ravn Air Group. The Ravn Air Group SMS manual, which applied to PenAir, stated that the

proactively determine hazards and risk factors and develop and implement controls. The manager of safety further stated that the company's safety assurance program included internal and external audits to "make sure we [the company] are doing what we are saying we are doing." The internal audits, which focused on company manuals, were conducted at least once per year for each of the company's departments. Internal audits of the flight operations department occurred periodically throughout the year, and each audit focused on a specific subject, such as pilot records, cockpit operations, and cabin operations. The external audits consisted of check rides or employee reviews.

In addition, the manager of safety stated that PenAir had an aviation safety action program as well as a confidential safety reporting system for pilots and other employees to report identified hazards within company operations.<sup>94</sup> Employees could provide safety reports using paper forms that were placed in locked drop boxes in the company's crew room and maintenance area. The safety reports could also be provided through an e-mail, a telephone call, or an in-person visit to the safety department or by calling the company's 24-hour safety and security hotline. The manager of safety indicated that the names of employees who submitted reports were removed because "we always have the philosophy of looking at processes and procedures rather than looking at individuals that are involved." She also indicated that reports were kept in an open status until a corrective action or mitigation plan had been identified.

The manager of safety estimated that the safety department received about 30 to 40 safety reports per month from December 2018 to December 2019. The manager of safety also estimated that, of those monthly reports, fewer than 10 per month were submitted by pilots.

Many PenAir pilots who were interviewed after the accident stated that they had no concerns reporting safety issues, but several pilots stated that they were not comfortable reporting concerns or thought that their concerns would not be addressed. For example, one pilot had a concern about management's response to

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"Accountable Executive" (the chief executive officer) had the "ultimate responsibility" for the SMS and that the following management personnel were responsible for all required items in 14 *CFR* 5.25(c): the Ravn senior vice president of safety, security, and compliance; the PenAir director of safety; and the PenAir manager of safety.

<sup>94</sup> According to FAA AC 120-92B, an aviation safety action program "is meant to encourage voluntary reporting of safety issues and events that come to the attention of participating certificate holders' employees." These programs "include processes for intake of data from employees, analysis of the data, and development of corrective actions within a confidential environment" and "can be used to satisfy some SMS requirements."

her decision to refuse a flight because of adverse weather conditions (discussed later in this section), but this pilot decided not to submit a safety report because she thought that the PenAir chief pilot and the Ravn senior vice president of flight operations would know who submitted the report. This pilot was concerned that submitting the report would affect her job at the company.

In addition, during a postaccident interview, the chief pilot at the time of the accident recalled a conversation with a pilot who had rejected a takeoff. The chief pilot stated that she called the pilot and advised him to submit a safety report. The chief pilot indicated that the pilot did not want to submit a safety report and that he said, "there've been problems if you write it up." The chief pilot stated that she told the pilot that safety reports are anonymous but that the pilot said, "no, they know. They always know." The chief pilot further stated that she submitted the safety report on behalf of the pilot (with his awareness) because she "always encouraged safety problems to be reported." The chief pilot added that "there was no recrimination for him after it [the safety report about the rejected takeoff] was written up" and maintained "there [was] never...retribution or recriminations if somebody wrote something up."

The PenAir director of safety stated that the company communicates safety information to pilots using a "safety flash" for the "most significant" issues as well as safety bulletins that are issued every 2 weeks to all company employees.<sup>95</sup> The director of safety added that the company wants to "always highlight something that's happened recently in the company, whether it comes to us via a safety report or something we discovered in an audit."

### **Safety Culture**

During a postaccident interview, the accident captain spoke positively about PenAir's safety culture and stated that managers took it "very seriously" and followed up on issues. Conversely, another PenAir captain (who started flying for the company in 1989) stated that he was "not impressed at all" with the company's safety culture and rated the culture before the accident as a 3 on a scale from 1 to 10 (with 10 being the highest score).

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<sup>95</sup> According to the PenAir manager of safety, a safety flash is issued "anytime something happens within the operation" to "raise awareness as to what happened, why it happened, and what we are doing to prevent that event from happening again." The PenAir director of safety stated that each safety flash includes a briefing sheet for supervisors to use during discussions with their staff about the situation that occurred. The manager of safety also stated that the safety bulletin "always consists of three articles [one of] which is SMS."

During postaccident interviews, some company pilots discussed management actions that affected the company's safety culture. For example, one captain who was interviewed after the accident recalled his decision to resign as a check airman and return to flying as a line pilot. This captain stated that he no longer wanted to be a check airman because he did not agree with the proposed changes to the policy for the company-designated PIC airport qualification (discussed in section 1.11.1.1). This captain reported that the chief pilot told him that she was "going to make [him] work a lot" and that he was "going to be [receiving] a pay cut," which he interpreted as a threat.

Senior captains and check airmen stated that they did not feel pressure from management to fly, but several of these pilots recalled that a recently upgraded captain was questioned for refusing a flight with weather conditions near minimums. This captain stated that the weather was "right at the edge of" what was needed and that, even though the flight would have been legal under FAA regulations, "that doesn't mean it's a smart or safe decision" to conduct the flight.<sup>96</sup> She relayed these concerns to the dispatcher, who subsequently canceled the flight because the weather conditions had not improved.

Later that same day, the PenAir chief pilot and the Ravn senior vice president of flight operations expressed concerns to the captain about her decision to reject the flight. The captain stated that the Ravn senior vice president told her that the decision was "unprofessional and immature" and that, if she had "a legal airplane, legal weather, and legal crew, then it was [her] job" to make the flight. The captain further stated that the Ravn senior vice president "didn't trust [her] decision-making" as a captain and "didn't think [she] deserved to be on the flight line anymore," which she perceived as a threat. The captain reported that the PenAir chief pilot did not take her off the flight schedule but considered the meeting to be a "counseling session."

During postaccident interviews, the NTSB asked the PenAir chief pilot and the Ravn senior vice president of flight operations about this event. The Ravn senior vice president stated that he was concerned about the "captain saying that she can't operate to approach minimums." The PenAir chief pilot stated that the captain's job was not in jeopardy and that she and the Ravn senior vice president wanted to

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<sup>96</sup> During the postaccident interview, this captain also stated that she had reported that "my crew and I don't really feel comfortable...showing up at work at 6:00 a.m., being here for 6 hours already and going out to Dillingham [Airport] and doing a non-precision approach down to minimums and probably going missed off of it...with where the weather was at."

counsel a “young, inexperienced line pilot” about the other options that were available that day.

The PenAir director of safety described the overall safety culture as “still good” but stated that, with the new Ravn management, pilots were “not as comfortable anymore...saying something or making a decision and being questioned on it.” The director of safety further stated that there had been “more openness” with the previous PenAir management. Several pilots reported that, during summer 2019, morale began to decline because of the efforts of the PenAir chief pilot and the Ravn senior vice president of flight operations to reduce the PIC airport qualification requirement and because of their counseling of the recently upgraded captain who declined a flight.

#### **1.11.4 Federal Aviation Administration Oversight**

FAA oversight of PenAir was conducted by the Denali certificate management office in Anchorage. The Denali certificate management office comprises certificate management teams (CMTs) with oversight responsibilities for specific air carriers based in Alaska. The CMT for PenAir was also responsible for overseeing Corvus Airlines, which, at the time of the accident, was in the process of merging with PenAir. The CMT for these two operators consisted of a POI, a principal maintenance inspector, a principal avionics inspector, a dispatch inspector, a cabin safety inspector, two aircrew program managers, and a frontline manager (FLM).

The FAA uses its safety assurance system to accomplish air carrier oversight.<sup>97</sup> FAA Order 8900.1, Flight Standards Information Management System, provides guidance to FAA inspectors for evaluating certificate holders undergoing change resulting from (among other things) financial distress and growth or downsizing. This guidance is found in volume 6, chapter 2, section 18, Safety Assurance System: Evaluation of a Certificate Holder’s Management of Significant Changes Parts 121, 135, and 91 Subpart K.<sup>98</sup>

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<sup>97</sup> According to the [FAA webpage discussing the safety assurance system](#) (accessed October 18, 2021), the system is “an oversight tool to perform certification, surveillance, and continued operational safety.” The website indicated that this system, among other things, helps FAA aviation safety inspectors “determine risk-based, data-supported oversight decisions.”

<sup>98</sup> The order mentioned indicators of change that could impact safety, including noticeable turnover of personnel, changes in experience or proficiency of personnel, declaration of bankruptcy, reduction in route structure or flight schedules, and merger or takeover.

The POI for PenAir at the time of the accident stated that he had no previous experience with an air carrier merger and that he had not encountered any unusual challenges resulting from the merger process for PenAir and Corvus Airlines. He also stated that there had been no increased surveillance of PenAir as a result of the merger process. Further, the POI stated that his transition to the position in July 2019 was effective and that, during the transition, he spoke with the outgoing POI, who mentioned no issues with PenAir and thought that the company was doing well.

The previous PenAir POI, who had been in that position from January 2014 to July 2019, described PenAir as “very transparent” and stated that he had good communication with the company. The previous POI stated that, because of PenAir’s bankruptcy and merger with Corvus Airlines, he had used a matrix tool to determine the health of the company.<sup>99</sup> The previous POI did not mention any revisions to the FAA’s surveillance plan for PenAir based on the results of the matrix tool, but he stated that some increased surveillance, including ramp inspections, had been performed. The previous POI also stated that the turnover among company pilots prompted him to provide additional surveillance of hiring, scheduling, and pairing of pilots. He thought that the safety culture at PenAir was “very healthy” (based on his interactions with the operator) and did not note any changes from when he started the POI position to when he left the position.

The previous POI stated that, when he left the position, he had some informal discussions with the incoming POI about PenAir, including the company’s manual system, the pilots, and the scheduling process. The previous POI indicated that he had no specific areas of concern to pass along to the incoming POI and that the transition was “normal.”

The FLM for the PenAir CMT had been in that position since June 2019 and was the immediate supervisor of the PenAir POI. The FLM stated that a professional relationship existed between PenAir and the FAA and that he had not encountered any challenges. The FLM noted that PenAir’s bankruptcy and its merger with Corvus Airlines were both risk indicators in the certificate holder assessment tool, which the CMT used to document risk and the follow-up actions taken in response. The FLM stated that the risk indicators in the assessment tool “were being adequately monitored through normal surveillance” and that no enhanced surveillance had been

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<sup>99</sup> During a postaccident interview, the POI did not specify whether the matrix tool was from one of the decision aids in FAA Order 8900.1 or whether the tool was the certificate holder assessment tool (discussed in this section).

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conducted before the accident. The FLM added that he had no previous experience overseeing an air carrier merger.

The NTSB requested that the FAA provide any records in its safety assurance system related to the agency's oversight of PenAir from August 2017 to October 2019. The FAA's response, dated March 26, 2020, noted that the FAA found no systemic or recurring safety issues or areas of concern regarding PenAir's operations, training, or safety before the accident.

## 2. Analysis

### 2.1 Introduction

This accident occurred after the flight crew landed the Saab 2000 airplane on runway 13 at DUT. The captain, who was the pilot flying, reported that the initial braking action was normal but that, as the airplane traveled down the runway, the airplane had “zero braking” despite his application of maximum brakes. The airplane subsequently overran the runway and came to rest beyond the airport property. The aircraft performance study for this accident found that the airplane should have had the landing performance capability to stop within the landing distance available on runway 13 or the RSA distance given the airplane’s energy state, MLG touchdown location, environmental conditions, and runway surface conditions.

The following analysis summarizes the accident (section 2.2) and evaluates the following:

- brake system issues (section 2.3), including the crossed wiring of the wheel speed transducer harnesses in the antiskid brake system;
- operational factors (section 2.4), including PenAir’s PIC airport qualification policy; and
- FAA oversight (section 2.5).

After completing a comprehensive review of the circumstances that led to this accident, the investigation established that the following factors did not contribute to the cause of the accident:

*Flight crew qualifications.* The flight crew was properly certificated and qualified in accordance with Part 121. Company qualification requirements are discussed in section 2.4.1.

*Flight crew medical conditions.* The flight crew held valid and current medical certificates. A review of the flight crew’s work and sleep schedules and FAA medical certificate records showed no evidence of factors that could have adversely affected the performance of either crewmember on the day of the accident. The captain had previously been diagnosed with sleep apnea, but he used a continuous positive airway pressure machine consistently during sleep periods before the accident flight.

*Airplane conditions.* The airplane was properly certificated, equipped, and maintained by PenAir in accordance with Part 121. No evidence indicated any structural or engine failures before the runway overrun occurred. Issues involving the antiskid brake system are discussed in section 2.3.

Thus, the NTSB concludes that none of the following were factors in this accident: (1) flight crew qualifications and airplane certification, which were in accordance with US regulations; (2) flight crew medical conditions; and (3) the airworthiness of the airplane's structures and engines.

## **2.2 Accident Summary**

### **2.2.1 Preflight Planning**

PenAir used a wind chart for certain airports, including DUT, so that the dispatcher and the captain of a flight could evaluate the wind conditions at the destination airport. The forecast wind for DUT, 270° at 15 knots with gusts to 25 knots, was at the recommended limit for the accident captain because he had less than 300 hours as PIC in the Saab 2000.<sup>100</sup> For the flight to be authorized, PenAir procedures required both the captain and the dispatcher to agree that the flight could be safely conducted with those wind conditions, and the dispatch release had to include an alternate airport; both of these stipulations were met. The required agreement with the dispatcher, as well as the wind information that was known at the time (the current and forecast wind conditions), should have alerted the captain that a significant westerly wind was expected at the time of arrival at DUT, and the captain should have recognized that the current and forecast wind favored a landing on runway 31.<sup>101</sup>

The captain was required to complete a flight risk assessment because the FAA considered DUT to be a special airport due to the surrounding mountainous terrain. (As shown in figure 1, runway 13/31 was located at the foot of Mount Ballyhoo.) The flight risk assessment form resulted in a risk number for the flight, and pilot and dispatcher concurrence was required for flights with either a low (0 to 15 points) or a caution (16 to 25 points) risk category. (Management approval was required for flights in the medium risk category—26 to 39 points—and flights with 40 points or more were considered high risk and were thus to be canceled.)

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<sup>100</sup> Given the wind direction, the maximum wind limit of 30 knots for that wind chart sector was reduced to 20 knots for pilots with less than 300 hours as PIC in the aircraft type. The wind chart also indicated that, for wind gusts of 10 knots or greater, one-half the gust value should be added to the steady-state wind to determine if the wind would be within the limit for any sector on the chart. According to this formula, the steady-state wind limit was 20 knots for flight's arrival at DUT on the day of the accident.

<sup>101</sup> The preflight paperwork included the 1356 METAR, which indicated that the wind at the time was from 250° at 8 knots with gusts to 22 knots.

The captain's risk assessment for the accident flight found that it would have low risk (10 points). However, the captain did not account for the following items included on the form: "Runway Risk Factor" (from the wind chart), "Less than 1 year with the Company," and "More Than 2 hours from Home Base." The correct calculation would have resulted in a risk number in the caution category (17 points).

Even though the increased point total would not have raised the risk of the flight to the level requiring management approval, the captain's discounting of applicable items on the flight risk assessment form was consistent with a diminished recognition of the challenges associated with the flight, including landing at an airport with one of the highest runway risk factors on the wind charts that PenAir used (as discussed in section 1.11.1.2). Additional evidence that was consistent with the captain's diminished recognition of the challenges associated with landing the Saab 2000 at DUT is presented in section 2.2.2.3.

## **2.2.2 Accident Sequence**

### **2.2.2.1 Decision to Land on Runway 13 and Execution of Go-Around**

The CVR showed that, while en route to DUT, the captain planned for a landing on runway 13. However, the DUT wind forecast (270° at 15 knots with gusts to 25 knots) indicated that a tailwind would be present on the runway at the time of landing. Any tailwind increases an airplane's touchdown groundspeed, requiring more runway length to decelerate and stop.

The flight crew received several updates during the flight about the wind conditions at DUT. For example, at 1657:41, the captain noted that the wind was from 310° at 11 knots.<sup>102</sup> At that point, the captain stated that the wind was starting to favor a landing on runway 31 (because of the tailwind that would be present on runway 13), and the first officer noted that they had previously flown the back door path (see figure 1) to runway 31. At 1706:04, the DUT weather observer advised the flight crew that the wind was from 210° at 6 knots with gusts to 14 knots.

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<sup>102</sup> The CVR recording did not indicate the source for this wind information. During a postaccident interview, the captain stated that he used the first officer's personal Stratus device for "general" weather information. (The Stratus is an automatic dependent surveillance-broadcast receiver.) Thus, it is possible that this wind information was gleaned from the 1656 METAR.

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At 1720:48, the DUT weather observer told the pilot of another airplane in the area that the wind was from 180° at 7 knots.<sup>103</sup> Both the 1706:04 and 1720:48 wind reports indicated that a small headwind would be present on runway 13. However, at 1732:44, the DUT weather observer reported that the wind was from 270° at 10 knots, indicating that a tailwind would be present on runway 13. The flight crew then discussed whether to make an approach to runway 13 or 31, and the captain decided to continue with the planned landing on runway 13.

At this point in the approach, the flight crew could have considered landing with 35° of flaps given the expected tailwind on runway 13. If the flight crew had configured the airplane with 35° of flaps, the airplane would have had a lower approach speed and a shorter stopping distance on runway 13.<sup>104</sup> No evidence on the CVR indicated that the flight crew considered changing the flap setting from 20° to 35°. Postaccident interviews with company pilots found that some pilots would regularly land at DUT with 35° of flaps but that others preferred landing there with 20° of flaps, especially in gusty conditions, if the airplane's performance would not be affected.

At 1733:35, the first officer announced that the airplane was at the missed approach point; flight crews fly visually from the missed approach point to the runway, which was 4.7 miles away. About 6 seconds later, the captain announced that the runway was in sight.

During a postaccident interview, the captain stated that, when the airplane was on final approach, he reached up to turn off an anti-ice switch on the overhead panel, which caused the approach to become destabilized. According to the CVR, the first officer (the pilot monitoring) stated "go around," and the captain confirmed that the

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<sup>103</sup> Even though the captain and the first officer could not recall this wind information during postaccident interviews, it is possible that they heard the wind information during the flight because the CVR recorded a discussion between the crewmembers about the time of the wind report regarding the other airplane in the area.

<sup>104</sup> The aircraft performance study found that, with 35° of flaps, the airplane should have been able to stop within the landing distance available on runway 13 with one antiskid circuit inoperative and both engines operating at maximum reverse power. The calculated stopping distances for a flaps 35 configuration were several hundred feet less than similar cases with a flaps 20 configuration.

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airplane was “goin’ around.” The flight crew then conducted a go-around and re-entered the VFR traffic pattern.<sup>105</sup>

The CVR also showed that the crewmembers did not adequately discuss how to manage the flightpath in the VFR traffic pattern. For example, the captain did not maintain the altitude setting, as evidenced by a flight deck altitude alert and the first officer’s statement noting that the airplane was 200 ft above the 1,000-ft setting. Also, after the first officer increased throttle power for the go-around, the captain instructed the first officer to “slow me up...back off on power.”

The NTSB notes that, for a visual approach to runway 13 that results in a go-around, pilots fly along the back door path to Unalaska Bay and then re-enter the traffic pattern for either runway 13 or 31. Thus, after the accident go-around, the flight crew could have decided to re-enter the traffic pattern in the opposite direction for a landing on runway 31. However, the captain conducted the second landing attempt at DUT using the front door path to runway 13.

#### **2.2.2.2 Second Approach and Landing**

While the airplane was on the base leg of the VFR traffic pattern for runway 13, the captain asked the first officer to request a wind check from the DUT weather observer, which he did about 1 minute 20 seconds before touchdown.<sup>106</sup> The weather observer reported that the wind was from 300° at 24 knots; CVR statements indicated that the flight crew was surprised to learn about this significant tailwind for runway 13.

The PenAir CFM, which was based on manufacturer information, indicated that the Saab 2000 had a 15-knot tailwind limitation. During postaccident interviews, the flight crewmembers stated that they were aware of the tailwind limitation but thought that the wind direction and speed did not warrant a change of the runway for landing. The flight crew’s continuation with the planned landing on runway 13 despite the knowledge of a tailwind that exceeded the manufacturer’s tailwind limitation was consistent with plan continuation bias, which is an unconscious cognitive bias to

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<sup>105</sup> At 1735:29, the DUT weather observer reported that the wind was from 300° at 8 knots. The flight crew did not request this wind report and likely did not pay attention to the report because it was transmitted when the flight crew would have been focused on the increased workload associated with the go-around.

<sup>106</sup> About 1.5 minutes before the first officer’s wind check request, another pilot in the area was communicating with the first officer. At that time, the weather observer reported that the wind was from 290° at 16 knots with gusts to 30 knots. The CVR recording showed that the flight crew did not discuss this wind information.

continue with an original plan despite changing conditions. With plan continuation bias, the closer a pilot gets to a destination, the stronger the bias becomes (Woods 2020).<sup>107</sup>

After receiving the weather report indicating a 24-knot tailwind, the first officer asked the captain, “do you wanna...back out...do it again?” With no definitive response from the captain, the first officer stated, about 10 seconds later, “we’ll try it again.” The captain then responded, “last try,” even though he had earlier commented about a possible landing on runway 31.<sup>108</sup> Thus, the NTSB concludes that the flight crew’s decision to land on a runway with a reported tailwind that exceeded the airplane manufacturer’s limit was intentional, inappropriate, and indicative of plan continuation bias.

PenAir’s *Saab 2000 Performance Binder* contained unfactored landing distance tables that listed the distances for various landing weights, flap settings, and wind conditions, and several company pilots stated that they would check landing performance data before an approach and after receiving the most recent weather information. PenAir procedures did not require pilots to conduct a time-of-arrival landing assessment, and no evidence indicated that the accident flight crew used the performance binder tables at that point to verify the landing distance required based on the tailwind and airplane flap setting.

Earlier in the flight (while the airplane was en route to DUT), the CVR recorded the captain stating that the unfactored landing distance would be 3,058 ft, but that distance did not match any information in the *Saab 2000 Performance Binder* tables.<sup>109</sup> At the airplane’s planned landing weight and with 20° of flaps (the

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<sup>107</sup> Plan continuation bias is known to negatively affect aeronautical decision-making; as a result, the subject is addressed in FAA guidance, training, and testing materials for pilots.

<sup>108</sup> For example, about 50 seconds after the go-around, the captain stated that the airplane would go back out, do a 180° turn, and come back in, which indicated that the airplane would be returning to land on runway 31. About 1 minute later, after the first officer told a pilot in the area that the airplane was coming back around for the visual approach to runway 13, the captain stated “three one” twice. When the first officer stated that he thought that the airplane would be landing on runway 13, the captain responded, “oh okay...sure...we’ll try again.” Section 2.2.2.3 discusses this information further.

<sup>109</sup> The captain stated, “unfactored landing distance would be five...three thousand fifty-eight feet,” but the NTSB notes that the captain had apparently misspoken when he stated “five” given that the runway was 3,900 ft. The 3,058-ft distance was likely from a performance application that the captain was testing on his iPad. The CVR appeared to have captured the captain demonstrating the application to the first officer earlier in the flight. Further, some of the company pilots who were interviewed as part of this investigation mentioned that the captain (as the PenAir director of training)



configuration decided by the captain) and a 15-knot tailwind (the maximum tailwind value in the tables, consistent with the tailwind limit in the CFM), the performance binder tables indicated that the unfactored landing distance would be 3,536 ft.<sup>110</sup> The landing distance available at DUT was 3,900 ft; thus, with a tailwind of 15 knots or less, sufficient landing distance should have been available for the flight. However, if the flight crewmembers had considered landing performance data based on the reported 24-knot tailwind, they could have realized that the tailwind exceeded the maximum tailwind in the performance binder tables and might have reconsidered the decision to land on runway 13.

FDR data showed that the flight crew had not aligned the airplane with the runway heading until the airplane was below an altitude of 500 ft agl, which was inconsistent with the company's stabilized approach guidance indicating that, for a visual approach, the airplane must be established on the correct course by 500 ft above the airport elevation. However, before the second landing attempt, the airplane was operating in the airport traffic pattern and not from an approach, so the company's stabilized approach criteria would be difficult to correlate to this portion of the flight. In addition, constraints associated with the airport (the surrounding terrain and the nonalignment of the instrument approaches with the runways) might have presented challenges to becoming established by 500 ft, even during routine approaches not involving the traffic pattern. (Because of these and other challenges associated with operating at DUT, PenAir designated DUT as an airport that required PICs to have company-specific experience and a corresponding qualification before the PICs could operate there, as discussed in section 2.4.1.)

The airplane crossed the runway 13 threshold at an indicated airspeed of 127 knots and touched down at an indicated airspeed of about 125 knots and a groundspeed of about 142 knots. The runway was dry at the time of touchdown, as indicated by passenger videos of the touchdown and landing rollout as well as pavement images recorded by video from two off-airport security cameras.<sup>111</sup>

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was evaluating a performance application for future in-flight use. (The program was not included in company manuals and was not approved by the FAA. The accident captain had the concurrence of the chief pilot to evaluate the application.)

<sup>110</sup> As previously stated, the captain decided to land with 20° of flaps instead of 35° because he thought that the latter could lead to floating and difficulty pinpointing the landing spot.

<sup>111</sup> The NOTAM included in the weather packet that the flight crew received before departure indicated that the runway was damp with no standing water. (The NOTAM was issued more than 9 hours before the accident airplane touched down.) The AWOS 1-minute observation at 1741 (about

Less than 1 second after MLG touchdown, the captain reduced power to ground idle, and the flaps began to automatically retract from 20° to 15°. About 6 seconds later, the captain applied maximum reverse power. At that time, the airplane's groundspeed was about 100 knots. After the first officer called out "brakes," the captain replied, "I got em all the way." However, the airplane was not decelerating as expected. A flight deck master caution annunciated multiple times during the landing rollout; these annunciations were related to the antiskid brake system anomaly. Section 2.3 discusses this anomaly and the role that it played in the flight crew's inability to stop the airplane and avoid a runway overrun.

### **2.2.2.3 Captain Leadership and Decision-making**

The captain's decision to land with a significant tailwind instead of a headwind is concerning as are the captain's statements on the CVR that indicated uncertainty regarding the landing runway. Specifically, after the go-around decision, the captain stated that the airplane was going to make a 180° turn and come back for a landing. About 1 minute later, after hearing the first officer's radio transmission (to the pilot of another airplane in the area) about coming back for the visual approach to runway 13, the captain stated, "three one" twice and "back door?" The first officer stated that he thought that the airplane would be landing on runway 13, to which the captain replied, "oh okay...sure...we'll try again." (It is possible that the first officer did not realize that the captain's 180° turn remark indicated his intent to land on runway 31.)

A few seconds later, the first officer asked if the captain was "okay" with a landing on runway 13, and the captain replied that he was thinking about landing on the opposite runway because of wind shear. Less than 1 minute later, the flight crew learned that the wind was from 300° at 24 knots. The first officer then asked the captain whether they should conduct another go around. After receiving no response to his question, the first officer stated, "we'll try it again," to which the captain replied, "last try."

These exchanges showed that the captain understood that runway 31 was the preferred runway for landing based on the wind information. However, the captain demonstrated poor CRM by not explicitly sharing his position about runway 31 until after the first officer told the other pilot operating in the area that the airplane would be landing on runway 13. Afterward, when the first officer stated to the captain that

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1 minute after touchdown) indicated that a trace amount of precipitation had fallen since 1656, but the time period that the precipitation had accumulated since 1656 could not be determined.

he thought the airplane would be landing on runway 13, the captain immediately stated, "oh okay...sure...we'll try again."

The captain should have recognized that this situation called for a critical evaluation of the available data as part of the crew's discussion of the issue. Unlike the go-around decision, the decision about which runway to return to for landing did not need to be made within seconds.

Several PenAir pilots stated that, for a landing at DUT, they would choose the runway that favored the most recently reported wind. However, the captain did not conduct the landing on runway 31 and instead yielded twice to the first officer's understanding, based on cursory discussions, that runway 13 should be used. The NTSB concludes that the captain demonstrated inadequate aeronautical decision-making skills regarding which runway to use for landing and a lack of flight deck leadership by continuing the landing to a runway with a significant tailwind.

### **2.2.3 Evacuation and Emergency Response**

The accident was survivable for all the airplane occupants except for the passenger in seat 4A, who was struck and killed by a propeller blade from the left engine that separated and entered the cabin during the impact sequence. The serious injury to the passenger in seat 5D occurred when he was struck by debris of an unknown origin. Most of the eight passengers who sustained minor injuries received those injuries from slips and falls during the evacuation, primarily from the right wing, which was wet because of rain.

The evacuation resulting from the accident was unplanned. PenAir's flight attendant manual indicated that the flight attendant was "solely responsible for the organization and evacuation of the passengers." The manual also stated that evacuations should begin "as soon as the airplane stopped completely" and that no signal from the captain was necessary for an unplanned emergency situation.

The flight attendant assessed the conditions outside of passenger windows on the left side of the airplane and appropriately determined that her exit (the main cabin door on the left side of the airplane) was unusable. She immediately ordered an evacuation through the right-side overwing exit and the right service door in the aft cabin, which were the only exits used during the evacuation. Passengers evacuating from the right service door faced a significant drop to the ground due to the airplane's unusual, nose-down attitude and lack of an escape means. The passenger who opened the right service door stayed beneath the door after evacuating and assisted other passengers to the ground.

Passengers from row 5 and aft evacuated immediately, but the evacuation of airplane occupants from row 4 and forward (including the three crewmembers) was delayed because of the critical injuries to the passenger in seat 4A. This passenger was removed from his seat by other passengers and was placed in the aisle immediately after the airplane stopped (which effectively blocked the egress path for those occupants in row 4 and forward) so that other passengers could attend to his injuries until emergency responders arrived. After most of the passengers from and aft of row 5 had evacuated, a local doctor (who witnessed the accident) boarded the airplane and began providing medical assistance to the critically injured passenger, and emergency medical technicians boarded the airplane and removed this passenger. The remaining airplane occupants exited the airplane after the critically injured passenger was removed, and all were off the airplane about 19 minutes after the accident.

Although the evacuation delay for some occupants was not ideal, the flight attendant used her training and judgment to suspend the evacuation based on the need for the critically injured passenger to receive emergency medical attention. This decision was understandable and was supported by the flight crewmembers once they entered the cabin.<sup>112</sup> In addition, the lack of a usable exit at the front of the airplane and the cramped conditions of the small airplane cabin could not be overcome.

The emergency response to the accident included the on-airport ARFF vehicle as well as personnel from the Unalaska Fire Department and Unalaska Police Department, who responded to the accident site based on the mutual aid agreement in DUT's *Airport Certification Manual*. Review of the video files and computer-aided dispatch reports indicated that the airport's ARFF vehicle arrived on scene about 2 minutes 13 seconds after the airplane came to a stop. The first off-airport emergency vehicle arrived about 3 minutes later, and the critically injured passenger was removed from the airplane about 9 minutes afterward. The NTSB concludes that the evacuation delay for the crewmembers and some passengers was reasonable given the need to provide emergency medical attention to the critically injured passenger, and the emergency response was timely and effective.

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<sup>112</sup> During a postaccident interview, the captain stated that "there was no immediate danger to anyone in that aircraft at that point in time" and that the critically injured passenger "was the priority."

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## 2.3 Brake System

### 2.3.1 Left Main Landing Gear Outboard Tire

Because the outboard and inboard brakes transmit braking force to the wheel-mounted tires, the tires need to be kept in a serviceable condition to ensure proper stopping performance. During the preflight inspection of the airplane, the first officer noted a flat spot on the left MLG outboard tire. The first officer took a photograph of the flat spot area and showed the photograph to the captain, who indicated that the flat spot was not a concern because the tire “wasn’t showing cord” (that is, no reinforcing plies were observed). PenAir did not require the flight crew to take any further action regarding this matter.

The NTSB’s review of the first officer’s photograph found that no plies were showing on the tire, but the review also found the absence of grooves in the area of the flat spot. The Saab 2000 *Aircraft Maintenance Manual* stated that the tires were to be examined “for signs of damage, wear, and other...deterioration” and that a tire was to be removed “when tread has worn to the base of any groove.” According to this guidance, the tire should have been replaced before the accident flight. The airplane flew 16 flight legs after the tires were last examined (during a line check on October 13, 2019), and it is unknown when the flat spot first appeared on the tire, especially given that the first officer of the two flight legs immediately preceding the accident flight leg did not notice any tire anomalies during his walk-around checks of the airplane. Nevertheless, the absence of grooves in the area of the flat spot on the tire did not result in the airplane’s loss of braking ability, which is discussed in section 2.3.3.

After the accident, two major wear areas were noted on the left MLG outboard tire. One of these wear areas contained the oval-shaped flat spot that the first officer noted before the flight. This area of the tire was involved in the initial skid, and the tapered and oval shape of the plies indicated that the tire was inflated while skidding. As the tire skidding action wore into the plies, the reduction in plies (casing strength) was unable to maintain pressure, and the tire burst, resulting in a complete tire pressure loss. The other major wear area was a large oval-shaped ring about 180° from the flat spot area with intact tread, which was consistent with a subsequent skid while the tire was flat. Section 2.3.3 discusses the effect of the left MLG outboard tire skid on the airplane’s braking capability.

### 2.3.2 Antiskid Brake System

The antiskid system, one of the primary components of the airplane's brake system, includes a wheel speed transducer in each of the four wheels. A wire harness connects each wheel speed transducer to bulkhead fittings in the wheel well. If the wheel speed transducer wire harnesses are incorrectly connected, the performance of the antiskid system will be substantially compromised.

Postaccident examination of the wire harnesses for the wheel speed transducers showed that the left MLG outboard and inboard harnesses were incorrectly routed (see figure 9) at the top of the MLG shock strut. This incorrect routing caused the left outboard wheel speed transducer to be connected to the inboard channel of the antiskid control unit and the left inboard wheel speed transducer to be connected to the unit's outboard channel. As a result, the antiskid system was incapable of relieving a skid that was sensed by either of the left MLG wheels. This cross-wiring condition was not discovered until after the accident in part because the airplane was not in revenue service between the left MLG overhaul in January 2017 and PenAir's first revenue flight in June 2019.

In addition, the antiskid system does not generate a fault based on incorrect wiring. For the cross-wiring condition to potentially be detected, a significant skid event would have to occur for more than 2 seconds (based on the antiskid system's logic) and not be relieved, which would generate a fault (as discussed in the next section) that maintenance personnel might investigate. The fault that would be generated for this condition is ambiguous, and troubleshooting procedures for the fault message do not exist.

It is possible for the wheel speed transducer wire harnesses to be incorrectly routed at the lower portion of the MLG shock strut, but photographs of the left MLG taken on scene showed that the harness for the outboard wheel was routed on the left side of the strut and that the harness for the inboard wheel was routed on the right side of the strut, consistent with the installation instructions. The incorrect routing occurred at the top of the strut, with the wire harnesses with item Nos. 10 and 20 in figure 7 in the opposite positions.

APPH Limited (a subsidiary of Héroux-Devtek Inc.) manufactured the left and right MLG and the wheel speed transducer wire harnesses. A March 2021 Héroux-Devtek UK report acknowledged the possibility that the left MLG could have been assembled with the antiskid harnesses in the opposite positions, and the report noted that the crossed wiring could have occurred during the overhaul of the MLG at the

manufacturer's facility in 2017.<sup>113</sup> Héroux-Devtek UK further noted that "potential contributing factors" that resulted in the crossed wiring were "unclear harness part numbers and the [equipment] operator following the process incorrectly."

PenAir records showed no evidence of any maintenance that would have required altering the position of the wheel speed transducer wiring on the left MLG. Thus, the NTSB concludes that the incorrect routing of the wheel speed transducer wire harnesses most likely occurred during the landing gear manufacturer's overhaul of the left MLG and was undetected by PenAir because such incorrect routing cannot be discovered unless a significant unrelieved skid event happens.

As discussed in section 1.3.3.7, EASA issued an AD that required a one-time inspection of the Saab 2000 antiskid system harnesses within 5 months of the effective date of the AD (July 2, 2020). The FAA issued an AD that became effective on March 29, 2021, and required compliance with EASA's AD. The inspections that the ADs required should have identified any Saab 2000 airplanes with incorrect wheel speed transducer wiring, including those with MLG overhauled by APPH.

### **2.3.3 Effect of Left Main Landing Gear Outboard Tire Skid**

As part of this investigation, the NTSB determined the timing and duration of the skid of the left MLG outboard tire. The initial evidence of the skid on the runway was a dark skid mark, consistent with the position of the left outboard tire, which began at 1739:57 (about 3 seconds after touchdown) and ended at 1739:58. The skid mark was solid and had no tread pattern, and the flat spot on the tire also had no visible tread pattern, so the initial skid mark was from that pre-existing flat spot area of the tire. This skid mark was followed by light skid marks until 1739:59, when a short (5-ft) skid mark was made. That skid mark showed a tread pattern and thus resulted from the other area of damage to the tire (the large oval-shaped ring around an area with tread). This type of damage could only occur if the tire were deflated, indicating that the tire had burst before the second skid mark was made.

The first master caution recorded on the CVR occurred at 1740:01; the master caution had likely activated because the antiskid control unit had detected a skid and commanded a full brake release for more than 1.5 seconds (plus an additional 0.5-second delay that was part of the system logic). The MDC then recorded the first

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<sup>113</sup> Although the APPH component maintenance manual at the time of the landing gear overhaul contained discrepancies related to the nomenclature for the wheel speed transducer harnesses (which have since been resolved), the manual's illustration and item numbers, which should have guided the installation of the harnesses, were correct.



antiskid system fault messages (32# ANTI SKID CTL, INBD A-SKID), and the INBD A-SKID fault caution would have appeared on the EICAS.<sup>114</sup> The INBD A-SKID fault was recorded on the FDR (sampled every 4 seconds) at 1740:01 and remained active between 1740:01 and 1740:09. The CVR recording showed that the master caution continued at 5-second intervals from that point on (because the caution was not extinguished by the flight crew). In addition, the FDR showed that the longitudinal acceleration parameter increased momentarily at 1740:12, which was consistent with a brief release of the left outboard wheel skid. In response, the INBD A-SKID fault became inactive at 1740:13 but then became active again at 1740:17, and the MDC recorded the second set of fault messages (32# ANTI SKID CTL, INBD A-SKID). The MDC subsequently recorded the 32# L WHEEL SPD XDCR fault message, which was accompanied by the OUTBD A-SKID and the INBD A-SKID messages.<sup>115</sup>

The CVR, FDR, and MDC information showed that, during most of the landing rollout, the left outboard tire was in a skid (from 1739:57 to the time that the airplane departed the runway at 1740:19). Because of the crossed wiring, the antiskid system perceived that the left inboard wheel was skidding and reduced the pressure to the left and right inboard wheels. The system also perceived that the left outboard wheel was operating properly, even though the tire was skidding. As a result, the left outboard tire continued to skid and burst after skidding 170 ft down the runway.

If a crossed wire condition exists for the wheel speed transducers and the airplane enters a skid, the Saab 2000 would lose between one-half and three-quarters of its wheel braking capability. Because the accident airplane's antiskid system was incorrectly wired, the skid of the left outboard tire resulted in the complete release of brake pressure to the inboard wheels on both the left and right MLG (due to the

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<sup>114</sup> The MDC recorded the 32# ANTI SKID CTL (antiskid control) fault message because the antiskid control unit valve dump detector activated, which occurs if the unit commands a full brake release for more than 1.5 seconds. The accompanying INBD A-SKID (inboard antiskid) messages indicated that the faults occurred on the inboard antiskid channel, which was connected to the outboard tire. The INBD A-SKID message can occur when the antiskid control valve is not operating correctly. However, because the inboard antiskid control valve from the accident brake system was tested and found to have no significant issues, the message was likely recorded because of the persistent skid.

<sup>115</sup> The 32# L WHEEL SPD XDCR (left wheel speed transducer) fault message and the OUTBD A-SKID (outboard antiskid) and INBD A-SKID (inboard antiskid) messages indicated that there was a short or an open condition of the wiring to both the inboard and outboard wheel speed transducers on the left MLG. During the accident sequence, the left MLG received considerable damage when the airplane impacted a ditch and shoreline rocks beyond the airport property, and both left MLG wire harnesses were found fractured. Thus, the fault was likely recorded after the airplane departed the runway and impacted the ditch.

paired wheel design of the antiskid system). In addition, the braking from the left outboard wheel was ineffective during the skid, especially because there was very little load on the left outboard tire after it burst. Thus, only the right outboard tire would have been providing normal braking when the left outboard tire was skidding.

The NTSB concludes that, as a result of the crossed wiring of the left MLG wheel speed transducers, the antiskid system responded to the left outboard tire skid by completely releasing the brake pressure to the left and right MLG inboard wheels. The NTSB also concludes that, because the antiskid system could not alleviate the left MLG outboard tire skid, the tire subsequently burst and resulted in an additional loss of MLG wheel braking.

The NTSB notes that, according to the aircraft performance study for this accident, the airplane should have had adequate performance capability to stop (1) within the landing distance available on runway 13 with one antiskid circuit inoperative and both engines operating at maximum reverse power and (2) near the RSA/blast pad transition point with one antiskid circuit inoperative and both engines operating at ground idle power. The NTSB concludes that the Saab 2000 could tolerate all the conditions at the time of the accident except for a loss of MLG wheel braking in excess of 50%; thus, the combined loss of left and right inboard and left outboard MLG wheel braking prevented the flight crew from stopping the airplane on the runway.

#### **2.3.4 Design of Wheel Speed Transducer Wire Harnesses**

As the MLG manufacturer, APPH implemented several changes after the accident to prevent incorrect wiring of the wheel speed transducer harnesses, as discussed in section 1.3.3.7.<sup>116</sup> One of these changes involved the addition of fittings on test equipment used during overhaul. According to the company, these test fittings should allow maintenance personnel to immediately detect a crossed wire harness in the Saab 2000. In addition, Saab issued an SB to operators to inspect for incorrect wiring (an action that was subsequently mandated by EASA and the FAA, as discussed in section 2.3.2) and added the new inspection procedure to its aircraft maintenance manual.

Saab's new inspection procedure and APPH's postaccident changes should help decrease the possibility of crossed wheel speed transducer wire harnesses

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<sup>116</sup> Crane was responsible for the antiskid system, including the wheel speed transducers, and APPH was responsible for the wheel speed transducer wire harnesses. However, Saab has the ultimately responsibility for these components.

during overhaul and increase the possibility of detecting the condition before an airplane resumes service. However, it would be difficult to detect and troubleshoot wheel speed transducers with harnesses that are incorrectly wired after an overhaul is completed or during any subsequent maintenance.

The top ends of the wheel speed transducer wire harnesses have connectors that attach to fittings in the MLG wheel wells, and the bottom end of the harnesses have connectors that attach to the wheel speed transducers in the MLG axles. The top-end connectors are keyed differently, so each connector can be attached to only one of the fittings; this feature protects against human error when maintenance personnel attach the harnesses. However, the bottom-end connectors were not designed to anticipate and protect against human error in connecting the inboard wheel harness to the outboard wheel (and vice versa) because those connectors have no distinguishing feature to indicate which harness should be routed to the inboard wheel and which harness should be routed to the outboard wheel.

Further, unlike the top-end connectors, the bottom-end connectors have the same part number. In addition, the only label on each harness is placed at the top end of the harness where the label is difficult to access and potentially difficult to read. (The information on a wire harness for the right MLG on the accident airplane could not be read even after cleaning the heavy dark residue found on the label.)

The NTSB concludes that a more robust design for the Saab 2000 wheel speed transducer wire harnesses that protects against human error could mitigate the potential for the incorrect installation of the harnesses. Therefore, the NTSB recommends that Saab redesign the wheel speed transducer wire harnesses for the Saab 2000 airplane to prevent the harnesses from being installed incorrectly during maintenance and overhaul.

#### **2.3.4.1 Other Cross-Wiring Events in Transport-Category Airplanes**

Even though Saab's system safety assessment for the Saab 2000 was conducted in accordance with *Federal Aviation Regulation/Joint Aviation Requirement 25.1309, Equipment, Systems, and Installations* (see section 1.3.3.6), the NTSB's review of the system safety assessment found that it did not address the failure mode related to the cross-wiring of wheel speed transducer harnesses during maintenance or overhaul and the effect that this failure mode could have on the flight

crew and the airplane during landing.<sup>117</sup> As a result, Saab did not analyze the risk and hazard associated with a reduction in the airplane's antiskid system braking capability because of cross-wiring. Thus, the flight crew had no awareness of this potential hazard, including no system annunciation on the flight deck (such as a warning or caution) before takeoff and landing and no training or procedures regarding how to mitigate such a hazard.

The NTSB investigated three incidents that involved cross-wiring of antiskid system components in transport-category airplanes. The first incident occurred on January 19, 1995, when an Air South Boeing 737-200, N4515W, overran the runway at Hartsfield Atlanta International Airport, Atlanta, Georgia. None of the airplane occupants were injured, and the airplane sustained minor damage. The NTSB's investigation found that, during the landing rollout, the first officer felt the antiskid system releasing, so the captain took control of the airplane. The captain felt initial braking action, but all braking action was then lost. Postaccident examination of the airplane found that, among other brake system anomalies, the wiring to the left inboard and left outboard wheel speed transducers was crossed.<sup>118</sup> This and the other brake system anomalies were not detected during antiskid system testing that was performed about 2 weeks before the incident. The NTSB determined that the probable cause of this incident was maintenance personnel's "inadequate inspection of the aircraft...in that they did not properly diagnose discrepancies in the antiskid braking system."<sup>119</sup>

The second incident occurred on October 9, 2007, when a United Airlines Airbus A320, N431UA, departed the runway and impacted runway lighting during landing at O'Hare International Airport, Chicago, Illinois. All 127 airplane occupants were uninjured except for 1 flight attendant and 1 passenger, who sustained minor injuries. The airplane sustained minor damage. The NTSB's investigation found that, during the landing, the left MLG inboard wheel went to a high braking level and that the left MLG outboard wheel did not apply braking. The NTSB also found that the wiring for the airplane's left MLG inboard and outboard antiskid tachometer (Airbus' nomenclature for a wheel speed transducer) was reversed during scheduled

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<sup>117</sup> As previously stated, one of the multiple analyses conducted as part of system safety assessments is a functional hazard assessment, which is performed to determine potential system failures that could lead to hazards that could affect the airplane and its occupants.

<sup>118</sup> The NTSB's examination of the airplane also found that the left inboard antiskid valve brake and return lines were crossed and that the left inboard skid detect circuit was inoperative. In addition, the left MLG outboard tire was "blown."

<sup>119</sup> For more information about this incident, see case number [ATL951A043](#) at the NTSB's website.

maintenance. The NTSB determined that the probable cause of the incident was “the misrouted and reversed antiskid wiring by vendor maintenance personnel leading to the runway excursion.” Contributing factors to the incident included the operator’s maintenance procedures for the dual tachometer replacement, which were unclear to the vendor’s maintenance personnel.<sup>120</sup>

The third incident occurred on February 25, 2008, when a United Airlines Airbus A320, N442UA, departed the right side of the runway during landing at Jackson Hole Airport, Jackson, Wyoming. All 125 airplane occupants were uninjured except for 1 passenger, who received minor injuries during the evacuation. The airplane sustained minor damage. The NTSB’s investigation of this incident found that the inboard and outboard tachometer wires on the left MLG were cross-connected. As a result, when the inboard tire began to skid, there was a reduction in the hydraulic pressure to the outboard brake instead of the inboard brake, causing a loss of braking on the outboard wheel. Also, the hydraulic pressure to the inboard brake increased, causing it to fully skid and fail. As a result, when the captain applied full manual braking, the braking action on the left MLG was almost fully lost while the right MLG braking remained normal, resulting in the airplane veering to the right and exiting the runway. The NTSB determined that the probable cause of this incident was “the loss of braking action on the left main landing gear due to the cross connection of the wheel speed tachometer wires that was caused by inadequate maintenance performed on the airplane during the installation of the main landing gear.”<sup>121</sup>

The NTSB concludes that the potential for cross-wiring of wheel speed transducer harnesses during installation or maintenance exists for other airplane types. Therefore, the NTSB recommends that the FAA and EASA (1) identify all currently certificated transport-category airplanes for which system safety assessments for landing gear systems did not consider human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and (2) require manufacturers of transport-category airplanes without

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<sup>120</sup> For more information about this incident, see case number [CHI08IA026](#).

<sup>121</sup> For more information about this incident, see case number [DCA08IA044](#). According to an August 24, 2021, e-mail from the Bureau d’Enquêtes et d’Analyses pour la Sécurité de l’Aviation Civile (the NTSB’s counterpart agency in France), Airbus took several actions in response to this incident, including the following: (1) improving the aircraft maintenance manual figure of the tachometer wiring installation and adding a warning about the possibility of a cross-connection, (2) updating the component maintenance manual to show the routing of the harness (as viewed from the underside), (3) color-coding the brake harnesses to prevent tachometer cross-connection and issuing an SB about this modification, and (4) providing details about the correct installation of the tachometer wiring in “Operators Information Transmission” and “In-Service Information” documents.

such assessments to perform the assessments and then implement mitigations to prevent cross-wiring of antiskid brake system components.

The NTSB also recommends that the FAA and EASA require the submission and consideration of system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs. The certification should ensure that the system safety assessments are consistent with the intent of AC 25.1309, System Design and Analysis (and EASA Acceptable Means of Compliance 25.1309), and that the assessments evaluate and mitigate the potential for human error that can lead to a cross-wiring error.

#### **2.3.4.2 Safety Management Systems for Design, Manufacturing, and Maintenance Organizations**

Although Saab conducted system safety assessments for the landing gear system, the assessments did not consider and protect against human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers. An SMS could aid manufacturers in managing and mitigating such safety risks.

The NTSB notes that the FAA and EASA are developing requirements for an SMS for manufacturers of transport-category airplanes. According to the Office of Management and Budget's regulation information website, in December 2021, the FAA plans to issue a notice of proposed rulemaking that would require the implementation of an SMS for "persons engaged in the design and production of aircraft, engines, or propellers...[and] persons engaged in maintaining part 121 aircraft under part 145" (OMB 2020).<sup>122</sup>

EASA's website showed that the agency issued Notice of Proposed Amendment 2019-05, "Embodiment of the safety management system (SMS) requirements into Part-145 and Part 21," on April 17, 2019 (EASA 2019). EASA also issued Comment-Response Document 2019-05 on December 21, 2020, which summarized the comments that various organizations provided regarding the notice of proposed amendment (EASA 2020a). According to a September 15, 2021, e-mail from an EASA official, "SMS requirements should [enter] into force within the next two

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<sup>122</sup> (a) This notice for proposed rulemaking would also include "certificate holders that conduct common carriage operations under part 135...and persons conducting certain, specific types of air tour operations under part 91." (b) Title 14 *CFR* Part 145 addresses repair stations. According to the FAA, repair station "refers to a maintenance facility that has a certificate issued by the FAA...and is engaged in the maintenance, inspection, and alteration of aircraft and aircraft products."

years” and “some major European manufacturers have already started the SMS journey with various levels of implementation.”

If a requirement for SMS for manufacturers had been in place when the Saab 2000 was designed, it is possible that the risk of an antiskid system cross-wiring event could have been detected as part of the SMS safety risk management and safety assurance components.<sup>123</sup> In a September 29, 2021, e-mail to the NTSB, Saab stated that it started work to implement an SMS in accordance with EASA’s Notice of Proposed Amendment 2019-05. Saab also stated that it planned to complete this work during 2022 after EASA published a final rule on this subject.

The NTSB participated in the investigations of two recent fatal accidents that involved issues with the design of a flight control system introduced on the Boeing 737 MAX 8 airplane. The first accident occurred on October 29, 2018, in the Java Sea, Indonesia; the second accident occurred on March 10, 2019, near Ejere, Ethiopia.<sup>124</sup> On September 19, 2019, the NTSB issued a safety recommendation report, titled *Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance*, based on preliminary findings from the investigation authorities’ publicly released preliminary accident reports (NTSB 2019).

According to the NTSB’s safety recommendation report, the investigation of these accidents revealed that the system, known as the maneuvering characteristics augmentation system, did not function as designed. The NTSB’s report also stated that the accident pilots’ responses to the unintended system operation were not consistent with the underlying assumptions about pilot recognition and response that The Boeing Company used as part of the 737 MAX design (NTSB 2019).

According to the [FAA webpage on SMS for design and manufacturing organizations](#) (accessed October 18, 2021), the FAA “launched a Part 21/Safety Management System (SMS) Rulemaking Project in September 2014...to incorporate the ICAO [International Civil Aviation Organization] Annex 19 requirement, which requires that design and production approval holders, for a product, have an SMS.” Since that time, the FAA developed a voluntary SMS for design and manufacturing organizations. The FAA reported that, as of September 14, 2021, 13 manufacturers were participating in this voluntary program; 4 of those manufacturers (including The

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<sup>123</sup> These SMS components are defined in section 1.11.3. SMS is further discussed in section 2.4.2.

<sup>124</sup> For more information about these accidents, see the [final report](#) by the Komite Nasional Keselamatan Transportasi, Republic of India (accessed October 18, 2021), and the [interim report](#) by the Ministry of Transport, The Federal Democratic Republic of Ethiopia (accessed October 20, 2021).



Boeing Company) have letters from the FAA stating that their organization's SMS met the intent of Part 5.

The US Congress recognized the importance of SMS for manufacturers in legislation that was passed in December 2020. This legislation included a section focused on aircraft certification, safety, and accountability, and that section required the FAA to initiate a rulemaking to do the following:

Require that manufacturers that hold both a type certificate and a production certificate issued pursuant to section 44704 of title 49, United States Code, where the United States is the State of Design and State of Manufacture, have in place a safety management system that is consistent with the standards and recommended practices established by ICAO [International Civil Aviation Organization] and contained in annex 19 to the Convention on International Civil Aviation...for such systems.<sup>[125]</sup>

Further, organizations that maintain aircraft would also benefit from an SMS to manage safety, as demonstrated by the circumstances of this accident and the three incidents described in section 2.3.4.1. Thus, the NTSB concludes that SMS for aircraft designers, manufacturers, and repair stations would help identify and manage safety risks that current safety processes might not effectively mitigate. The NTSB is encouraged that the FAA and EASA have begun the process to require an SMS for designers, manufacturers, and repair stations. However, because those requirements are not yet in place, the NTSB recommends that the FAA and EASA require organizations that design, manufacture, and maintain aircraft to establish an SMS.

## **2.4 Operational Factors**

### **2.4.1 Pilot-in-Command Airport Qualification Policy**

PenAir designated DUT as an airport that required PIC qualification because of the airport's surrounding terrain and complex approach and departure procedures.<sup>126</sup> To be eligible for this qualification, a pilot needed to have either (1) 300 hours as PIC in PenAir airplanes or (2) 100 hours as PIC in PenAir airplanes along

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<sup>125</sup> Title 49 *United States Code* 44704 addresses type certificates, production certificates, airworthiness certificates, and design and production organization certificates.

<sup>126</sup> As discussed in section 1.11.1.1, the company-designated PIC airport qualification requirements were separate from the FAA's PIC airport qualification requirement for special airports.

with an e-mail or letter of recommendation from a company check airman who flew with the pilot and an e-mail or letter of approval from the company chief pilot.

At the time that the accident captain qualified as a PIC for DUT, he met neither qualification requirement. The captain's training records indicated that the Saab 2000 Company Designated PIC Airport Qualification form was signed by a company check airman less than 2 weeks after the captain's qualification flight to DUT. At the time of that flight, the captain had accumulated 20.6 hours in the Saab 2000, all of which he attained while with PenAir. The check airman stated that he signed the form based on the captain's performance during the qualification flight as well as his previous flight experience.

The PenAir chief pilot at the time of the accident stated that she waived the 300-hour PIC requirement for the accident captain because she had previously flown with him and "was confident he could go into Dutch safely." The chief pilot also stated that she was not aware that a pilot needed to accumulate 100 hours of PIC time in PenAir airplanes before the 300-hour requirement could be waived or that letters or e-mails from a check airman and the chief pilot were needed for PICs with only 100 hours of flight time in company airplanes.

The PenAir chief pilot considered the captain's previous flight experience in Alaska with turbopropeller airplanes, specifically, the Dash-8, as part of her waiver decision. However, the Dash-8 model that the captain had flown (the DHC-8-100) and the Saab 2000 are different in terms of performance. During a postaccident interview, the captain stated that the Dash-8 is a "highly maneuverable airplane" that "can fly a lot slower" during final approach than the Saab 2000, which he described as "a high-speed airplane" that is "more of your airliner type."

According to postaccident interviews with company personnel, the 300-hour requirement was intended to ensure that PICs had sufficient experience in the Saab 2000 and with PenAir operations before flying into company-designated airports because of the challenges associated with those airports. (Besides the surrounding mountainous terrain, the challenges associated with DUT included the wind.) Postaccident interviews with senior company pilots revealed that the 100-hour waiver was not intended for new-hire captains (or first officers upgrading to captain) with no previous Saab 2000 experience and little or no experience at the company-designated airports. Although the 100-hour waiver had an airplane experience requirement, the waiver did not have an airport experience requirement, which was critical for ensuring pilot proficiency at a company-designated airport given the reduced number of required hours for the PIC airport qualification waiver.

The accident captain had more than 14,000 flight hours and extensive experience operating in Alaska but had relatively little experience flying into DUT and no experience in the Saab 2000 before his employment with PenAir, which began 5 months before the accident. Regarding his DUT experience, the captain estimated that he had flown there about 20 times with his previous employer, and PenAir flight logs showed that the captain flew to DUT 9 times before the accident. Five of the nine flights were conducted with a check airman as part of the captain's operating experience.

The captain's first flight to DUT as a PIC occurred when he had about 96 hours in the Saab 2000, which was just under the minimum number of hours that the company required to operate at the airport as a PIC. However, the captain neither possessed an e-mail or letter of recommendation from a company check airman who flew with the pilot nor an e-mail or letter of approval from the company chief pilot, which were required for the waiver.

Additional flight hours in the Saab 2000 and experience with the various environmental and operational conditions at DUT were necessary to ensure that a PIC would be prepared to safely operate into the airport. However, PenAir's 2017 bankruptcy and the 2018 acquisition of the air carrier (through a company that owned Ravn Air Group) resulted in a shortage of qualified captains who could operate into DUT because some senior pilots were accepting positions with other air carriers.<sup>127</sup> As a result, the company aimed to get more pilots qualified to fly into DUT, even though some did not meet the required PIC airport qualification criteria, including the captain.

At the time of the accident, the captain had accumulated 131 flight hours in the Saab 2000. Although the captain's Saab 2000 flight hours exceeded the 100 hours required for the company-designated PIC airport qualification waiver, PenAir should not have qualified the captain under the 100-hour waiver given that he was a relatively new company captain with no Saab 2000 flight time before his employment with PenAir and limited DUT experience. The captain would have benefited from additional experience operating the Saab 2000, which he would have been afforded by the 300-hour PIC airport qualification requirement.

Further, although the captain had experience conducting go-arounds in the simulator, the accident flight was the first time that the captain had conducted a go-around in the Saab 2000 and at DUT. During postaccident interviews, company pilots

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<sup>127</sup> PenAir's bankruptcy and Ravn Air Group's acquisition of the company are discussed in section 1.11.

stated that they often conducted missed approaches under instrument flight rules but that the missed approaches were rarely followed by a VFR traffic pattern for a landing on the same runway. A former chief pilot for PenAir stated that it would be appropriate to discuss the VFR traffic pattern as part of the DUT airport qualification flight, but the available evidence for this accident did not indicate whether the captain had received this instruction.

The NTSB concludes that PenAir's decision to allow the captain to operate at DUT as a PIC without meeting the PIC airport qualification criteria was inconsistent with company policy to ensure the necessary skill and experience level to operate at the airport. The NTSB also concludes that the captain might not have fully understood the challenges associated with landing the Saab 2000 at DUT because he had not achieved the experience that the company-designated PIC airport qualification policy intended.

#### **2.4.2 PenAir Safety Management System**

PenAir had an SMS, which was required for all Part 121 air carriers. However, the SMS was not effective in certain areas. First, the SMS was insufficient to prevent management from circumventing the company's PIC airport qualification policy. Specifically, the SMS' inadequate controls to detect and prevent the company's noncompliance with this policy revealed a lack of safety risk management and safety assurance (two components of an SMS). Because the company did not comply with its PIC airport qualification policy, the captain was able to operate at DUT as a PIC without the company-required skill and experience level in the Saab 2000.

The SMS was also not effective in terms of safety assurance because the system did not detect company management actions that contributed to a punitive safety culture and had negative impacts on employee morale. For example, a pilot who had recently upgraded to captain decided not to conduct a scheduled flight due to safety concerns associated with the weather conditions at the destination airport, so the dispatcher subsequently canceled the flight. The PenAir chief pilot and the Ravn senior vice president of flight operations (who was involved with PenAir's operations during the acquisition and merger with Corvus Airlines) disagreed with this captain's decision not to conduct the flight and met with the captain to express their concerns. According to this captain, the Ravn senior vice president indicated that her decision

was “unprofessional and immature” and that she did not deserve to be on the flight schedule, which she perceived as a threat.<sup>128</sup>

The PenAir chief pilot told the captain that she could remain on the flight schedule but that she should consider the discussion to be a counseling session about the options that were available to her besides having the flight canceled. The actions of the Ravn senior vice president and the PenAir chief pilot in this situation contributed to the decline in pilot morale after Ravn’s acquisition of PenAir. Also, some company pilots were no longer comfortable communicating concerns and challenging management decisions because of the potential for reprisals.

Pilot morale also declined because of the efforts by the PenAir chief pilot and the Ravn Air Group senior vice president of flight operations to reduce the PIC airport qualification requirements so that more pilots could be qualified to fly into company-designated airports, including DUT. During postaccident interviews, several pilots stated that they expressed concerns to the PenAir chief pilot and the Ravn Air Group senior vice president about the proposed changes because those changes could have resulted in pilots not receiving the training that they needed for the airports and not experiencing the various environmental and operational conditions at the airports. However, the PenAir chief pilot and the Ravn senior vice president decided eventually to keep the existing PIC airport qualification requirements in place, possibly because of the concerns that pilots expressed.

In addition, the SMS was not effective because the manner in which PenAir implemented safety promotion (another SMS component) did not foster open communication. Specifically, although pilots could submit safety reports anonymously, some pilots were not comfortable reporting concerns because they thought that their concerns would not be addressed or that management would be able to determine who submitted the reports. For example, the chief pilot at the time of the accident had encouraged a pilot who had rejected a takeoff to submit a safety report, but the pilot did not want to submit a safety report because there had been “problems” with doing so. When the chief pilot told the pilot that safety reports are anonymous, the pilot stated, “no, they know. They always know.”

During a postaccident interview, the PenAir manager of safety stated that the company’s safety policy “describes management’s commitment to providing all the

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<sup>128</sup> Another company pilot reported comments that he perceived as a threat to his job. Specifically, this pilot resigned his position as a company check airman so that he could resume flying as a line pilot. The pilot stated that the chief pilot responded to his decision by indicating that his salary might decrease and that he would have to work more than he did at the time.

necessary resources so the employees can perform their jobs to the highest possible safety standard” and that “the way that the employees achieve those resources is through the safety report system.” However, the hesitancy of some pilots to submit safety reports showed that the company’s safety policy (the other SMS component) was also deficient. The PenAir manager of safety noted that, of the 30 to 40 safety reports that were received each month from December 2018 to December 2019, fewer than 10 were submitted by pilots.

The NTSB concludes that deficiencies associated with PenAir’s SMS decreased its effectiveness and resulted in reduced pilot feedback to management about safety concerns. The FAA’s safety assurance system (discussed in section 2.5.1) did not include any information about the deficiencies involving PenAir’s SMS. In addition, although PenAir is no longer a Part 121 air carrier and thus cannot address the issues discussed in this and the previous section (2.4.1), the NTSB notes that the lessons learned from this accident investigation could apply to any air carrier.

## **2.5 Federal Aviation Administration Oversight**

### **2.5.1 Certificate Management Team Oversight of PenAir**

The CMT for PenAir included a POI and an FLM, who was the POI’s immediate supervisor. The POI at the time of the accident had been in that position since July 2019. He was also the POI for Corvus Airlines (a Ravn Air Group air carrier that was in the process of merging with PenAir). The POI stated that he had not encountered any unusual challenges resulting from the merger process and that there had been no increased surveillance of PenAir because of the merger. The POI also stated that, during his transition to the position, he spoke with the outgoing POI, who mentioned no issues with PenAir and thought that the company was doing well.

The previous POI for PenAir had been in that position from January 2014 to July 2019. The previous POI stated that, because of PenAir’s bankruptcy and its merger with Corvus Airlines, he had used a matrix tool to determine the health of the company. The previous POI did not mention any revisions to the FAA’s surveillance plan for PenAir based on the results of the matrix tool, but he indicated that some increased surveillance, including ramp inspections, had been performed. The previous POI also stated that the high turnover among company pilots (resulting from senior pilots accepting positions with other air carriers after PenAir’s bankruptcy and its acquisition by Ravn Air Group) prompted him to provide additional surveillance of hiring, scheduling, and pairing of pilots. Further, the previous POI stated that, when he left the position, the transition to the incoming POI was “normal” and that he had no specific areas of concern to mention to the incoming POI.

The FLM for PenAir had been in that position since June 2019. The FLM noted that PenAir's bankruptcy and its merger with Corvus Airlines were both indicators in a tool used for documenting risk (the certificate holder's assessment tool) as well as the follow-up actions taken in response. The FLM stated that the risk indicators in the assessment tool were being adequately monitored through normal surveillance and that no enhanced surveillance had been conducted before the accident.

Volume 6, chapter 2, section 18 of FAA Order 8900.1, Safety Assurance System: Evaluation of a Certificate Holder's Management of Significant Changes Parts 121, 135, and 91 Subpart K, provided guidance to FAA inspectors for evaluating certificate holders undergoing change resulting from (among other things) financial distress and growth or downsizing. The order stated that, during such situations, certificate holders "may knowingly or unknowingly accept, or even generate, an undesirable level of safety risk" and that FAA inspectors "must anticipate potential hazards and evaluate the likelihood and severity of risks to ensure that the certificate holder is appropriately managing these risks consistently with the changing conditions."<sup>129</sup>

The FAA's safety assurance system showed no systemic or recurring safety issues or areas of concern regarding PenAir's operations, training, or safety from August 2017 (when the company filed for bankruptcy and began reducing its route structure) to October 2019 (when the accident occurred). However, during that time, senior pilots with experience operating into DUT were leaving PenAir for other air carriers, and the company was considering changing the PIC qualification requirements for company-designated airports to qualify pilots sooner than they would normally qualify.<sup>130</sup> In addition, the safety assurance system contained no

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<sup>129</sup> On February 23, 2010, the NTSB issued Safety Recommendation A-10-26, which asked the FAA (in part) to develop more stringent standards for surveillance of Part 121 operators that are experiencing "changes that warrant increased oversight." (This recommendation was issued as a result of the investigation of the February 2009 Bombardier DHC-8-400 accident involving Colgan Air flight 3407 in Clarence Center, New York.) On September 21, 2015, the FAA stated that it incorporated "improved policies and procedures" to address this recommendation. These policies and procedures were incorporated into revised air transportation oversight system and safety assurance system guidance. As a result, on November 2, 2015, the NTSB classified Safety Recommendation A-10-26 "Closed–Acceptable Action."

<sup>130</sup> For the accident captain, the company did not correctly apply the 100-hour waiver for the PIC airport qualification policy given that the waiver was intended only for pilots who had extensive flight experience in the Saab 2000 and/or at company-designated airports, including DUT. As stated in section 2.4.1, at the time that PenAir qualified the accident captain as a PIC for DUT, he had not accumulated 100 hours as PIC in the Saab 2000, and he did not possess the required e-mail or letter of recommendation from a company check airman who flew with the pilot as well as the required e-mail or letter of approval from the company chief pilot.



information about the deficiencies involving PenAir's SMS (see section 2.4.2) and the reduced pilot morale associated with the new management structure resulting from the company's acquisition.

The NTSB concludes that the FAA's oversight of PenAir during the 2 years before the accident was insufficient to identify safety risks resulting from the company's bankruptcy, reduced route structure, loss of experienced pilots, acquisition, and merger. Therefore, the NTSB recommends that the FAA notify POIs and FLMs about the circumstances of this accident and emphasize the importance of existing FAA guidance for detecting and mitigating the safety risks that can result when certificate holders experience significant organizational change, such as high personnel turnover, a reduction to route structures or flight schedules, bankruptcy, acquisition, and merger.

In addition, the POI and the FLM for PenAir had been in those positions for 3 and 4 months, respectively, at the time of the accident, and neither had previous experience overseeing an air carrier merger. The POI's transition to the position did not involve a formalized procedure that highlighted the former POI's knowledge about challenges resulting from PenAir's bankruptcy and subsequent acquisition and merger. Volume 6, chapter 2, section 18 of FAA Order 8900.1 did not address the need to ensure that any incoming FAA personnel would quickly become aware of potential safety issues that the certificate holder might be experiencing as a result of the significant organizational changes detailed in this section of the order.

Therefore, the NTSB recommends that the FAA revise Order 8900.1 to include a formalized transition procedure to be used during a changeover of CMT personnel responsible for overseeing a certificate holder that is undergoing significant organizational change (for a reason described in volume 6, chapter 2, section 18 of the order) to ensure that incoming personnel are fully aware of potential safety risks.

### **2.5.2 Authorization Process for Scheduled Air Carrier Operations at Airports**

The FAA categorized DUT runway 12/30—which later became runway 13/31—as runway design code B-II based on the AAC (aircraft approach category) and the ADG (airplane design group) of the type of airplane using or expected to use the airport (that is, the critical aircraft).<sup>131</sup> Because the airport did not meet the RSA standard required for this runway design code (300 ft long at each runway end and 150 ft

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<sup>131</sup> As stated in section 1.5.1, the critical aircraft is typically the most demanding aircraft that regularly uses, or is expected to regularly use, an airport. The AAC is based on the aircraft's approach speed, and the ADG is based on the aircraft's size (primarily its wingspan).

wide), ADOT undertook an airport improvement project in 2012 at DUT. After project completion in 2016, the airport included RSAs at the departure ends of runway 13/31 (marked as displaced thresholds) that were 300 ft long and 150 ft wide. This RSA configuration met the requirements in AC 150/5300-13A for airplanes with an AAC-ADG designation of B-II, including the Saab 340B, which PenAir operated at DUT while the airport improvement project was underway.

There were no changes to the RSA configuration at DUT between 2016 and the time of the accident. However, about the time of the airport improvement project's completion in 2016, PenAir started operating the Saab 2000 at DUT, which had an AAC-ADG designation of C-III based on the airplane's higher approach speed and increased size compared with the Saab 340B. According to AC 150/5300-13A, an RSA that extended 1,000 ft beyond the departure ends of the runway and was 500 ft wide was required for a runway design code designation of C-III.

The AAC-ADG for an airplane should correspond with the runway design code for a runway. However, during an April 2021 meeting with FAA Flight Standards Service staff members, the NTSB learned that they do not consider runway design codes or the corresponding RSA dimensions when authorizing a certificate holder to operate specific airplanes at an airport. As a result, the FAA approved PenAir's use of the Saab 2000 on DUT runway 13/31 (which had a B-II runway design code) without recognizing that the RSA would not meet the length and width criteria in the AC for an airplane with a C-III designation.

AC 150/5300-13A stated that operation of an airplane that exceeds the design criteria of an airport could result in either an unsafe operation or a lesser safety margin. The AC also stated, "aircraft operations cannot be prevented, regulated, or controlled simply because the airport or runway does not meet the design standards for a particular aircraft type," indicating that airport officials cannot decide whether a specific aircraft type can operate there. Similarly, AC 150/5000-17 stated that, for operations of scheduled revenue aircraft that exceed the design standards of an airport and do not operate there on a regular basis (less than 500 operations each year), airport officials "cannot restrict airport access based on design standards without an FAA determination."

The NTSB recognizes that the exceedance concept described in AC 150/5000-17 would not apply to Part 121 operations that regularly use, or were expected to regularly use, an airport (such as PenAir's operations at DUT). That concept relies on an airport notifying the FAA about aircraft that exceed airport design standards, which would not be the primary means of providing this oversight for Part 121 operations given the responsibilities of a POI.

For Part 121 operations, the FAA is involved in approving an air carrier's route structure. Specifically, FAA Order 8900.1 states that Operation Specification C070 (Airports Authorized for Scheduled Operations) is "where a POI authorizes the list of airports that a certificate holder uses in schedule[d] operations." However, the PenAir POI at the time that Saab 2000 operations were authorized at DUT had no recollection of the runway design code (for runway 13/31) or the AAC-ADG designation (for the Saab 2000) being considered as part of the authorization process. In addition, FAA Order 8900.1, volume 3, General Technical Administration, chapter 18, Operations Specifications, does not include guidance for inspectors to compare the runway design code for a runway with the AAC-ADG designation for the type of airplane that a certificate holder intends to operate at the airport to determine if airplane operations could be safely conducted at the airport.

Although the airport layout at DUT did not allow the length of the RSAs to be increased, no evidence indicated that either PenAir or the FAA was aware of the RSA standards accompanying the decision to operate the Saab 2000 at DUT or that either considered potential mitigations. An RSA at the end of runway 13 that had an additional 700 ft (to accommodate the Saab 2000 and meet the RSA length requirement for aircraft with a C-III designation) would have provided the accident airplane with a longer prepared area designed to reduce airplane damage during an overrun. The NTSB concludes that the accident airplane would have been able to stop within an RSA that was suitable for the approach speed and size of the Saab 2000.

With its oversight of air carrier operations, the FAA is in a position to ensure alignment between the capabilities and characteristics of an operator's airplanes and the RSAs available for the runways of intended use. If differences exist, the FAA is also in a position to work with the operator to determine acceptable operational mitigations. The NTSB concludes that, during the process of authorizing an air carrier to operate its aircraft at specific airports, the consideration of RSA dimensions for runways of intended use could help increase the aircraft's margin of safety if a runway excursion were to occur. Therefore, the NTSB recommends that the FAA include the runway design code for runways of intended use among the criteria assessed when authorizing a scheduled air carrier to operate its airplanes on a regular basis at an airport certificated under Part 139.

In addition, in May 2020, the FAA stated that the AAC for the Saab 2000 was C, yet ADOT stated that its engineering consultant (for DUT's airport master plan update) used data from the FAA's traffic flow management system counts that

indicated that the AAC for the Saab 2000 was B.<sup>132</sup> (Both the FAA and ADOT stated that the ADG for the Saab 2000 was III.) According to information that Saab provided as well as our understanding of the process for assigning an AAC to an aircraft, the AAC for the Saab 2000 is C.

As of October 28, 2021, the NTSB had not received an explanation from the FAA regarding why its traffic flow management system counts database (which was last updated in 2019) indicated that the Saab 2000 had an AAC of B. It is important that an airplane's AAC-ADG designation be correctly identified to ensure that the designation corresponds with a runway design code. As previously noted, the RSA length requirement for a C-III airplane (such as the Saab 2000) was 1,000 ft–700 ft longer than the current RSA for runway 13/31 at DUT, which has a runway design code of B-II.

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<sup>132</sup> The NTSB made numerous requests to the FAA to clarify this conflicting information. Also, as of October 18, 2021, the DUT master plan update had not been released.

## 3. Conclusions

### 3.1 Findings

1. None of the following were factors in this accident: (1) flight crew qualifications and airplane certification, which were in accordance with US regulations; (2) flight crew medical conditions; and (3) the airworthiness of the airplane's structures and engines.
2. The flight crew's decision to land on a runway with a reported tailwind that exceeded the airplane manufacturer's limit was intentional, inappropriate, and indicative of plan continuation bias.
3. The captain demonstrated inadequate aeronautical decision-making skills regarding which runway to use for landing and a lack of flight deck leadership by continuing the landing to a runway with a significant tailwind.
4. The evacuation delay for the crewmembers and some passengers was reasonable given the need to provide emergency medical attention to the critically injured passenger, and the emergency response was timely and effective.
5. The incorrect routing of the wheel speed transducer wire harnesses most likely occurred during the landing gear manufacturer's overhaul of the left main landing gear and was undetected by PenAir because such incorrect routing cannot be discovered unless a significant unrelieved skid event happens.
6. As a result of the crossed wiring of the left main landing gear (MLG) wheel speed transducers, the antiskid system responded to the left outboard tire skid by completely releasing the brake pressure to the left and right MLG inboard wheels.
7. Because the antiskid system could not alleviate the left main landing gear (MLG) outboard tire skid, the tire subsequently burst and resulted in an additional loss of MLG wheel braking.
8. The Saab 2000 could tolerate all the conditions at the time of the accident except for a loss of main landing gear (MLG) wheel braking in excess of 50%; thus, the combined loss of left and right inboard and left outboard MLG wheel braking prevented the flight crew from stopping the airplane on the runway.
9. A more robust design for the Saab 2000 wheel speed transducer wire harnesses that protects against human error could mitigate the potential for the incorrect installation of the harnesses.
10. The potential for cross-wiring of wheel speed transducer harnesses during installation or maintenance exists for other airplane types.

11. Safety management systems for aircraft designers, manufacturers, and repair stations would help identify and manage safety risks that current safety processes might not effectively mitigate.
12. PenAir's decision to allow the captain to operate at Unalaska Airport as a pilot-in-command (PIC) without meeting the PIC airport qualification criteria was inconsistent with company policy to ensure the necessary skill and experience level to operate at the airport.
13. The captain might not have fully understood the challenges associated with landing the Saab 2000 at Unalaska Airport because he had not achieved the experience that the company-designated pilot-in-command airport qualification policy intended.
14. Deficiencies associated with PenAir's safety management system decreased its effectiveness and resulted in reduced pilot feedback to management about safety concerns.
15. The Federal Aviation Administration's oversight of PenAir during the 2 years before the accident was insufficient to identify safety risks resulting from the company's bankruptcy, reduced route structure, loss of experienced pilots, acquisition, and merger.
16. The accident airplane would have been able to stop within a runway safety area that was suitable for the approach speed and size of the Saab 2000.
17. During the process of authorizing an air carrier to operate its aircraft at specific airports, the consideration of runway safety area dimensions for runways of intended use could help increase the aircraft's margin of safety if a runway excursion were to occur.

### **3.2 Probable Cause**

The National Transportation Safety Board determines that the probable cause of this accident was the landing gear manufacturer's incorrect wiring of the wheel speed transducer harnesses on the left main landing gear during overhaul. The incorrect wiring caused the antiskid system not to function as intended, resulting in the failure of the left outboard tire and a significant loss of the airplane's braking ability, which led to the runway overrun. Contributing to the accident were (1) Saab's design of the wheel speed transducer wire harnesses, which did not consider and protect against human error during maintenance; (2) the Federal Aviation Administration's lack of consideration of the runway safety area dimensions at Unalaska Airport during the authorization process that allowed the Saab 2000 to operate at the airport; and (3) the flight crewmembers' inappropriate decision, due to their plan continuation bias, to land on a runway with a reported tailwind that exceeded the airplane manufacturer's limit. The safety margin was further reduced

because of PenAir's failure to correctly apply its company-designated pilot-in-command airport qualification policy, which allowed the accident captain to operate at one of the most challenging airports in PenAir's route system with limited experience at the airport and in the Saab 2000 airplane.



## 4. Recommendations

### 4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

#### **To the Federal Aviation Administration:**

Identify all currently certificated transport-category airplanes for which system safety assessments for landing gear systems did not consider human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and require manufacturers of transport-category airplanes without such assessments to perform the assessments and then implement mitigations to prevent cross-wiring of antiskid brake system components. (A-21-46)

Require the submission and consideration of system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs. The certification should ensure that the system safety assessments are consistent with the intent of Advisory Circular 25.1309, System Design and Analysis, and that the assessments evaluate and mitigate the potential for human error that can lead to a cross-wiring error. (A-21-47)

Require organizations that design, manufacture, and maintain aircraft to establish a safety management system. (A-21-48)

Notify principal operations inspectors and frontline managers about the circumstances of this accident and emphasize the importance of existing Federal Aviation Administration guidance for detecting and mitigating the safety risks that can result when certificate holders experience significant organizational change, such as high personnel turnover, a reduction to route structures or flight schedules, bankruptcy, acquisition, and merger. (A-21-49)

Revise Order 8900.1, Flight Standards Information Management System, to include a formalized transition procedure to be used during a changeover of certificate management team personnel responsible for overseeing a certificate holder that is undergoing significant organizational change (for a reason described in volume 6, chapter 2, section 18 of the order) to ensure that incoming personnel are fully aware of potential safety risks. (A-21-50)

Include the runway design code for runways of intended use among the criteria assessed when authorizing a scheduled air carrier to operate its airplanes on a

regular basis at an airport certificated under Title 14 *Code of Federal Regulations* Part 139. (A-21-51)

**To the European Union Aviation Safety Agency:**

Identify all currently certificated transport-category airplanes for which system safety assessments for landing gear systems did not consider human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and require manufacturers of transport-category airplanes without such assessments to perform the assessments and then implement mitigations to prevent cross-wiring of antiskid brake system components. (A-21-52)

Require the submission and consideration of system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs. The certification should ensure that the system safety assessments are consistent with the intent of Acceptable Means of Compliance 25.1309, Systems Design and Analysis, and that the assessments evaluate and mitigate the potential for human error that can lead to a cross-wiring error. (A-21-53)

Require organizations that design, manufacture, and maintain aircraft to establish a safety management system. (A-21-54)

**To the Saab Group:**

Redesign the wheel speed transducer wire harnesses for the Saab 2000 airplane to prevent the harnesses from being installed incorrectly during maintenance and overhaul. (A-21-55)

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

**JENNIFER HOMENDY**

Chair

**MICHAEL GRAHAM**

Member

**BRUCE LANDSBERG**

Vice Chairman

**THOMAS CHAPMAN**

Member

**Report Date: November 2, 2021**

## Appendixes

### Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this accident about 2222 eastern daylight time on October 17, 2019. An investigator from the NTSB's Anchorage, Alaska, office responded to the accident scene the next day to secure the wreckage and recover the flight recorders. An investigative team from NTSB headquarters in Washington, DC, arrived on scene about 1130 Alaska daylight time on October 19, 2019. Investigative groups were formed in the areas of aircraft performance, human performance, operations, powerplants, and systems and structures. Specialists were assigned to perform the readout of the cockpit voice recorder and the flight data recorder at the NTSB's laboratory in Washington, DC. Specialists in the areas of maintenance records, meteorology, and survival factors also supported the investigation.

Parties to the investigation were the Federal Aviation Administration, PenAir, and Crane Aerospace and Electronics. In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, the Swedish Accident Investigation Authority (the NTSB's counterpart agency in Sweden) participated in the investigation as the accredited representative of the state of design and manufacture. Also, the Air Accidents Investigation Branch (the NTSB's counterpart agency in the United Kingdom) participated in the investigation as the accredited representative of the state of design and manufacture for the engines and the antiskid system harnesses. As provided in Annex 13, the Saab Group participated in the investigation as a technical advisor to the Swedish Accident Investigation Authority, and Dowty Propellers, APPH, and Rolls-Royce participated in the investigation as technical advisors to the Air Accidents Investigation Branch.

## Appendix B: Consolidated Recommendation Information

Title 49 *United States Code (USC)* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board’s collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board’s use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

### To the Federal Aviation Administration:

#### **A-21-46**

Identify all currently certificated transport-category airplanes for which system safety assessments for landing gear systems did not consider human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and require manufacturers of transport-category airplanes without such assessments to perform the assessments and then implement mitigations to prevent cross-wiring of antiskid brake system components.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.1, Other Cross-Wiring Events in Transport-Category Airplanes. Information supporting (b)(1) can be found on pages 86 through 89, (b)(2) is not applicable, and (b)(3) can be found on page 86.

#### **A-21-47**

Require the submission and consideration of system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs. The certification should ensure that the system safety assessments are consistent with the intent of Advisory Circular 25.1309, System Design and Analysis, and that the assessments evaluate and mitigate the potential for human error that can lead to a cross-wiring error.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.1, Other Cross-Wiring Events in Transport-Category Airplanes. Information supporting (b)(1) can be found on pages 86 and 89, (b)(2) is not applicable, and (b)(3) can be found on page 86.

**A-21-48**

Require organizations that design, manufacture, and maintain aircraft to establish a safety management system.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.2, Safety Management Systems for Design, Manufacturing, and Maintenance Organizations. Information supporting (b)(1) can be found on pages 89 through and 91, (b)(2) is not applicable, and (b)(3) can be found on pages 89 through and 91.

**A-21-49**

Notify principal operations inspectors and frontline managers about the circumstances of this accident and emphasize the importance of existing Federal Aviation Administration guidance for detecting and mitigating the safety risks that can result when certificate holders experience significant organizational change, such as high personnel turnover, a reduction to route structures or flight schedules, bankruptcy, acquisition, and merger.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1, Certificate Management Team Oversight of PenAir. Information supporting (b)(1) can be found on pages 96 through 98, (b)(2) is not applicable, and (b)(3) can be found on page 97.

**A-21-50**

Revise Order 8900.1, Flight Standards Information Management System, to include a formalized transition procedure to be used during a changeover of certificate management team personnel responsible for overseeing a certificate holder that is undergoing significant organizational change (for a reason described in volume 6, chapter 2, section 18 of the order) to ensure that incoming personnel are fully aware of potential safety risks.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1, Certificate Management Team Oversight of PenAir. Information supporting (b)(1) can be found on pages 96 through 98, and (b)(2) and (b)(3) are not applicable.

**A-21-51**

Include the runway design code for runways of intended use among the criteria assessed when authorizing a scheduled air carrier to operate its airplanes on a regular basis at an airport certificated under Title 14 *Code of Federal Regulations* Part 139.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.2, Authorization Process for Scheduled Air Carrier Operations at Airports. Information supporting (b)(1) can be found on pages 98 through 101, (b)(2) is not applicable, and (b)(3) can be found on pages 100 and 101.

**To the European Union Aviation Safety Agency:****A-21-52**

Identify all currently certificated transport-category airplanes for which system safety assessments for landing gear systems did not consider human error that could lead to cross-wiring of antiskid brake system components, including the wheel speed transducers, and require manufacturers of transport-category airplanes without such assessments to perform the assessments and then implement mitigations to prevent cross-wiring of antiskid brake system components.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.1, Other Cross-Wiring Events in Transport-Category Airplanes. Information supporting (b)(1) can be found on pages 86 through 89, (b)(2) is not applicable, and (b)(3) can be found on page 86.

**A-21-53**

Require the submission and consideration of system safety assessments addressing the landing gear antiskid system for the certification of future transport-category airplane designs. The certification should ensure that the system safety assessments are consistent with the intent of Acceptable Means of Compliance 25.1309, Systems Design and Analysis, and that the assessments evaluate and mitigate the potential for human error that can lead to a cross-wiring error.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.1, Other Cross-Wiring Events in Transport-Category Airplanes. Information supporting (b)(1) can be found on pages 86 through 89, (b)(2) is not applicable, and (b)(3) can be found on page 86.



**A-21-54**

Require organizations that design, manufacture, and maintain aircraft to establish a safety management system.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4.2, Safety Management Systems for Design, Manufacturing, and Maintenance Organizations. Information supporting (b)(1) can be found on pages 87 through 90, (b)(2) is not applicable, and (b)(3) can be found on pages 88 and 89.

**To the Saab Group:****A-21-55**

Redesign the wheel speed transducer wire harnesses for the Saab 2000 airplane to prevent the harnesses from being installed incorrectly during maintenance and overhaul.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.4, Design of Wheel Speed Transducer Wire Harnesses. Information supporting (b)(1) can be found on page 84, (b)(2) is not applicable, and (b)(3) can be found on pages 84 and 85.

## Appendix C: Cockpit Voice Recorder Transcript

The following is a transcript of the Honeywell 6022 solid-state cockpit voice recorder, serial number CVR120-03713, installed on PenAir flight 3296, a Saab 2000, N686PA, which departed the runway after landing at Unalaska Airport, Unalaska, Alaska, on October 17, 2019.

<b>LEGEND</b>	
<b>CAM</b>	Cockpit area microphone voice or sound source
<b>CTR</b>	Radio transmission from Anchorage center
<b>DOP</b>	Radio transmission from Unalaska airport ground operations
<b>DWX</b>	Radio transmission from Unalaska airport weather observer
<b>EGPWS</b>	Enhanced Ground Proximity Warning System annunciation
<b>HOT</b>	Flight crew audio panel voice or sound source
<b>INT</b>	Intercom transmission
<b>MOB1</b>	Radio transmission from the Unalaska gate controller, Mobile 1
<b>N546LM</b>	Radio transmission from nearby traffic, King Air N546LM
<b>PA</b>	Public address system voice or sound source
<b>RDO</b>	Radio transmission from N686PA
<b>-1</b>	Voice identified as the captain
<b>-2</b>	Voice identified as the first officer
<b>-3</b>	Voice identified as the flight attendant
<b>-A</b>	Voice identified as the first Anchorage center controller
<b>-B</b>	Voice identified as the second Anchorage center controller
<b>-C</b>	Voice identified as the third Anchorage center controller
<b>-?</b>	Voice unidentified
<b>?</b>	Unidentified source
<b>*</b>	Unintelligible word
<b>#</b>	Expletive
<b>@</b>	Non-pertinent word
<b>()</b>	Questionable insertion
<b>[ ]</b>	Editorial insertion

Note 1: Times are expressed in Alaska daylight time.

Note 2: Generally, only radio transmissions to and from the incident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control, or condition of the aircraft.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
1536:30.0			
	<b>START OF RECORDING</b>		
	<b>START OF TRANSCRIPT</b>		
15:44:13.4			
<b>HOT-1</b>	but it's supposed to be one...the way they (put/wrote) it here.		
15:44:14.9			
<b>HOT-2</b>	so one twenty seven's the approach speed.		
15:44:16.6			
<b>HOT-1</b>	yeah but...uh...we use ten plus one twenty six...so...		
15:44:19.7			
<b>HOT-2</b>	ok. so it's gonna be one twenty six...one thirty six...one forty eight.		
15:44:22.7			
<b>HOT-1</b>	yeah.		
15:44:23.3			
<b>HOT-2</b>	okay.		
15:44:24.6			
<b>HOT-2</b>	well I'll put that in.		
15:44:40.1			
<b>HOT-1</b>	mainly for like pilot purposes...		
15:44:42.7			
<b>HOT-1</b>	in what we're doing.		
15:44:45.9			
<b>HOT-1</b>	really *** until you can do this.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
15:44:48.8 <b>HOT-1</b>	I dunno...		
15:44:51.1 <b>HOT-1</b>	so I can go...like...runway analysis...just go right to runway analysis here.		
15:44:54.5 <b>HOT-2</b>	yeah.		
15:44:55.9 <b>HOT-1</b>	and then what I would do *** — [voice cut off by radio transmission]		
15:45:02.2 <b>HOT-1</b>	yeah...and then I'd just do arrival...Dutch...I don't have weather...but I can select my runway.		
15:45:10.2 <b>HOT-2</b>	we will have weather though as we get closer in...I'll have it...but...		
15:45:14.7 <b>HOT-1</b>	but if I...even if I didn't...I can *** nav *** here *** Dutch. [voice cut off by radio transmission]		
15:45:24.0 <b>HOT-1</b>	oh I have it on my phone...I got the latest one on my phone...before we left.		
15:45:37.7 <b>HOT-1</b>	Rommel.		
15:45:42.3 <b>HOT-1</b>	so temperature...let's see...so they want wind was one nine zero at eight so wind...one nine zero zero eight...		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
15:45:52.1 <b>HOT-2</b>	the...uh...temperature.		
15:45:56.4 <b>HOT-1</b>	seven...done...'timeter...two nine five zero...two nine...five zero...point five zero...done. then I just need my weight...so then I gotta go over here to get my weight...gotta get my calculator here is four five two one three...four five two one three done. here's the numbers. and now...what's really cool about it...is I can go...flaps thirty five... *** and when you land...thirty...thirty five would be one seventeen one twenty seven one forty eight...if you wanna go twenty... *** one nine er...say you wanna go one three — [voice cut off by radio transmission]		
15:46:55.7 <b>HOT-1</b>	if you wanna go back here to twenty ***...twenty six twenty seven and there's forty eight...so...		
15:47:05.0 <b>HOT-2</b>	cool.		
15:47:05.9 <b>HOT-1</b>	last minute changes...ya know.		
15:47:07.4 <b>HOT-2</b>	yeah.		
<b>BREAK IN TRANSCRIPT</b>			
15:53:48.9 <b>HOT-1</b>	I haven't seen (dude)...I-I-haven't heard of-but I have...well maybe I have heard...that some guys actually do full flap landings into Dutch even though it's not recommended.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
15:53:58.4 <b>HOT-2</b>	uhhh...first couple times I went in there with @ [company pilot] and um...uh-@ [company pilot] they both did thir-flaps thirty five.		
15:54:09.9 <b>HOT-2</b>	well @ [company pilot] did a flaps thirty five into Bethel.		
15:54:13.5 <b>HOT-1</b>	*.		
15:54:15.6 <b>HOT-2</b>	he asked me if I wanted to do it...and I was like...eh...I'll do twenty — I'm good.		
<b>BREAK IN TRANSCRIPT</b>			
16:01:16.4 <b>HOT-1</b>	bumps comin'.		
16:01:17.9 <b>HOT-2</b>	what's that?		
16:01:19.8 <b>HOT-1</b>	according to this thing we're gonna get a few bumps here.		
16:01:22.3 <b>HOT-2</b>	yeah *.		
16:01:29.9 <b>HOT-2</b>	we're outside what it was...the AIR-MET for it.		
16:01:34.6 <b>HOT-1</b>	*.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:01:35.2 <b>HOT-2</b>	but I mean...this obviously is not perfect so it could probably extend to us...and we're gonna hit more down through here...all AIR-METs for turbulence.		
16:01:43.7 <b>HOT-1</b>	but they're low aren't they?		
16:01:46.4 <b>HOT-2</b>	surface winds on that one yeah.		
16:01:50.6 <b>HOT-2</b>	sss-surface winds yeah...what about this one?		
16:01:57.4 <b>HOT-2</b>	surface winds okay...yeah they're all surface winds.		
16:02:04.9 <b>HOT-2</b>	the other day...when I was flying out there with uhh...		
16:02:11.4 <b>HOT-1</b>	@ [company pilot].		
16:02:12.2 <b>HOT-2</b>	@ [company pilot] yeah.		
16:02:14.0 <b>HOT-2</b>	we had em all along the route for flight level two seven to three six or somethin' like that.		
16:02:25.0 <b>HOT-1</b>	we were down...we were to MORDI we didn't get that many bumps.		
16:02:27.5 <b>HOT-2</b>	no?		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:02:29.5 <b>HOT-2</b>	yeah we got some it wasn't too bad.		
<b>BREAK IN TRANSCRIPT</b>			
16:23:04.4 <b>HOT-1</b>	oh plan this one for now I guess one three.		
16:23:07.2 <b>HOT-2</b>	okay.		
16:23:08.1 <b>HOT-1</b>	so...plan on...we're familiar with it...sounds good...twenty one April seventeen the date on my chart...um...		
16:23:17.8 <b>HOT-2</b>	same on mine.		
16:23:19.0 <b>HOT-1</b>	* G-P-S one three...field elevation is...twenty *...I keep going back and forth between these Jepps gonna get me pissed off...twenty four...touchdown zone twenty four feet...uh...go uh MORDI to ROFZU...technically we won't do it but it's...you're good to twenty three hundred feet...after ROFZU...twenty three hundred feet we're good to after EWSER good down to sixteen hundred feet and after IRUWU *** [enunciating IRUWU]...after IRUWU good down to five hundred...gonna put five hundred in there...no longer high mins.		
16:24:04.3 <b>HOT-2</b>	five hundred on my side.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:24:05.4 <b>HOT-1</b>	alright...(if we didn't) turn outside of OWGIM where we can make a visual approach from there...to the airport...right now it's only eight knots of wind so we can go straight in...from what I can see...*** [voice cut off by radio transmission] we'll get weather in just a second...so we can either go straight in if not we can make an early decision.		
		16:24:19.8 <b>CTR-A</b>	Peninsula thirty two ninety six in five minutes contact Anchorage Center one two five point four five g'day.
		16:24:26.0 <b>RDO-2</b>	twenty five forty five in five minutes Peninsula thirty two ninety six.
16:24:29.9 <b>HOT-1</b>	twenty five forty five.		
16:24:36.6 <b>HOT-1</b>	five minutes.		
16:24:36.9 <b>HOT-2</b>	I'mma start a minute timer so I don't forget.		
16:24:39.5 <b>HOT-1</b>	so...uh...		
16:24:42.0 <b>HOT-1</b>	...yeah we'll make that decision to go through the back door off of this approach if we have to...uh we did that the other day...right?		
16:24:49.5 <b>HOT-2</b>	yeah I think we did.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:24:50.3 <b>HOT-1</b>	and so...		
16:24:51.1 <b>HOT-2</b>	actually...I think we ended up going the back end...uhhh...we've done...yeah we've done both sides...yeah we did the front door and the back door together.		
16:25:05.6 <b>HOT-1</b>	yeah so this time we'll see...if we can't make in the front we can't we can't...[therefore] go around the back.		
16:25:10.3 <b>HOT-2</b>	all right.		
16:25:10.8 <b>HOT-1</b>	keep me honest with the mountains and don't forget the terrain thing we discu...		
16:25:15.2 <b>HOT-2</b>	okay		
16:25:16.1 <b>HOT-1</b>	uh...but...uh...other than that it's a missed approach so we'll do...if we can't do it or go around or whatever we have to do a climbing left turn to twenty three hundred to ROFZU and hold...caution do not exceed ground track of one point five nautical mile...and if we *...try it again or we're gonna...yeah then we're gonna go to Dillingham.		
		16:25:36.7 ?	(roger) [unclear source, possibly traffic, PIC or SIC]

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:25:39.4 <b>HOT-1</b>	bingo fuel...twenty-five...thirty...four thousand...one hundred and fifty...sixty two pounds...one hundred sixty two pounds is min...and we start.		
16:25:55.8 <b>HOT-2</b>	*** bugg-ed.		
16:25:57.4 <b>HOT-1</b>	bugg-ed fuel...we be bugg-ed.		
16:26:02.6 <b>HOT-1</b>	bugg-ed now.		
16:26:04.7 <b>HOT-2</b>	roger.		
16:26:12.0 <b>HOT-1</b>	[sound similar to (yawn/sigh)]		
16:26:27.8 <b>HOT-1</b>	oh...eh...airport...eh...wind was...what on your thing...what from your thingy was three one zero at six...six knot tailwind I don't really care about that too much...er...there's ten.		
16:27:06.8 <b>HOT-1</b>	here...three one zero.		
16:27:30.1 <b>HOT-1</b>	all right...unfactored landing distance would be five...three thousand fifty eight feet.		
16:28:30.8 <b>HOT-1</b>	***. [sound similar to unintelligible discussion]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:28:32.0 <b>HOT-2</b>	***. [sound similar to unintelligible discussion]		
16:28:50.0 <b>HOT-1</b>	yeah...saves about three hundred feet for unfactored landing distance if we did a flaps thirty five...unless you float...doesn't do you any good.		
16:29:01.5 <b>HOT-2</b>	haha.		
16:29:03.3 <b>HOT-1</b>	that's the thing I noticed like with full flaps landing with this plane and the Dashes...you...you don't just plant it...you float.		
16:29:11.6 <b>HOT-2</b>	yeah.		
16:29:18.4 <b>HOT-1</b>	if you try to grease it on...not a good...normally doesn't work out well for short landing (strips).		
16:29:25.0 <b>HOT-2</b>	hah...you just gotta drop and...chop and drop...get right down to it and you go ert...boom.		
16:29:31.6 <b>HOT-1</b>	yeah.		
16:29:38.2 <b>HOT-1</b>	huh huh. [sound similar to yawn]		
		16:29:43.5 <b>RDO-2</b>	Anchorage Center...Peninsula thirty two ninety six flight level three zero zero.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		16:29:47.8 <b>CTR-B</b>	Peninsula thirty two ninety six Anchorage Center roger.
<b>BREAK IN TRANSCRIPT</b>			
16:57:28.1 <b>HOT-2</b>	ah...we should be getting...uh...directions here to descend soon...I'm gonna see if I can't get weather...twenty five and uh...man...I'll be on two for a sec.		
16:57:41.2 <b>HOT-1</b>	yeah it's changed...the weather's updated...three zero...uh...three one zero at one one.		
16:57:46.4 <b>HOT-2</b>	m'kay.		
16:57:48.6 <b>HOT-1</b>	startin' to favor the back door a little more.		
16:57:57.2 <b>HOT-2</b>	welp...we've done that before.		
16:58:08.2 <b>HOT-2</b>	eh...tell em that we'll be there...thirty after? give em a couple extra minutes on that?		
16:58:16.7 <b>HOT-1</b>	yeah.		
		16:58:19.8 <b>RDO-2</b>	Dutch Ops thirty two ninety six.
16:58:24.0 <b>HOT-2</b>	no specials?		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
16:58:26.9 <b>HOT-1</b>	got an infant...that's it...or child.		
16:58:30.6 <b>HOT-2</b>	we might be too...too far out.		
16:58:32.6 <b>HOT-1</b>	yeah I think it's too early still.		
16:58:35.7 <b>HOT-2</b>	I'll stay on one for a bit...well once we're closer to twenty miles...or twenty minutes out I'll give em a call...try again.		
16:58:49.5 <b>HOT-2</b>	ah.		
16:59:27.7 <b>HOT-?</b>	[sound similar to yawn]		
17:00:16.4 <b>HOT-?</b>	do do do do do do. [sound similar to humming]		
17:00:23.0 <b>HOT-1</b>	that's gotta be a long trip out here in a nineteen hundred.		
17:00:26.5 <b>HOT-2</b>	oh yeah...yeah I should ask my buddy about it...he flies for Ace.		
17:00:32.9 <b>HOT-1</b>	oh.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:00:37.7 <b>HOT-1</b>	I know it's...it is in a Dash...but man it's just more comfortable plane.		
17:00:42.5 <b>HOT-2</b>	yeah.		
17:00:43.4 <b>HOT-1</b>	but yeah.		
		17:01:03.6 <b>CTR-B</b>	Peninsula thirty two ninety six descent pilot's discretion maintain flight level two niner zero.
		17:01:08.5 <b>RDO-2</b>	pilot's discretion two niner zero Peninsula thirty two ninety six.
17:01:11.4 <b>HOT-2</b>	pilot's discretion two niner zero.		
17:01:13.7 <b>HOT-1</b>	check.		
17:01:16.0 <b>HOT-1</b>	but uh...the only difference between the Dash is that we'd have to circumnavigate some of those tops over there.		
17:01:23.7 <b>HOT-2</b>	yeah.		
17:01:26.3 <b>HOT-1</b>	I see that little bit.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:01:39.3 <b>HOT-1</b>	yeah there's always a lot of dodging in the Dash cause it just...it...that ya know...that extra six thousand foot makes a difference.		
17:01:45.3 <b>HOT-2</b>	yeah.		
17:02:06.0 <b>HOT-1</b>	I wonder who keeps keying the mic.		
17:02:11.9 <b>HOT-2</b>	it's not me.		
17:02:12.7 <b>HOT-1</b>	yeah.		
17:02:29.5 <b>HOT-?</b>	do do do do do. [sound similar to humming]		
17:02:35.5 <b>HOT-2</b>	[sound similar to clearing throat]		
17:03:02.3 <b>HOT-2</b>	it won't update.		
17:03:04.4 <b>HOT-1</b>	*** what's your time?		
17:03:06.5 <b>HOT-2</b>	(fifty-five/sixty-five) minutes ago.		
17:03:08.7 <b>HOT-1</b>	mine's at four...fifty six on my side.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:03:14.2 <b>HOT-2</b>	yeah.		
17:03:20.1 <b>HOT-2</b>	[sound similar to clearing throat]		
17:03:38.7 <b>HOT-1</b>	yeah somebody on company keying the mic.		
17:03:41.9 <b>HOT-2</b>	is it?		
17:03:42.7 <b>HOT-1</b>	yep.		
17:03:51.6 <b>HOT-1</b>	I just turned the volume all the way down...and it stopped doing it.		
17:03:59.3 <b>HOT-2</b>	yeah.		
17:04:18.2 <b>HOT-1</b>	and see this...here...that dark cloud...see it?		
17:04:22.5 <b>HOT-2</b>	yeah.		
17:04:23.1 <b>HOT-1</b>	see all the white clouds behind and in front...below.		
17:04:25.9 <b>HOT-2</b>	yeah.		
17:04:26.6 <b>HOT-1</b>	we got that one dark one.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:04:29.4 <b>HOT-1</b>	that's...that's the remnants of...it kinda looks like an ash cloud...just sayin'.		
17:04:46.9 <b>HOT-1</b>	and it is comin' from the right direction.		
		17:04:49.0 <b>CTR-B</b>	Peninsula thirty two ninety six contact Anchorage Center one two one point four.
		17:04:52.6 <b>RDO-2</b>	one two one point four Peninsula thirty two ninety six thanks.
17:04:57.0 <b>HOT-2</b>	two two point.		
17:04:59.3 <b>HOT-1</b>	one two one point four...oh.		
17:05:00.5 <b>HOT-2</b>	two two six is the C-TAF.		
		17:05:08.5 <b>RDO-2</b>	Anchorage Center Peninsula thirty two ninety six flight level three zero zero pilot's discretion flight level two niner zero.
		17:05:14.9 <b>CTR-C</b>	Peninsula thirty two ninety six Anchorage Center amend altitude pilot's discretion maintain one zero thousand Dutch Harbor altimeter two niner five zero.
		17:05:22.7 <b>RDO-2</b>	two niner five zero pilot's discretion to one zero thousand Peninsula thirty two ninety six.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:05:27.2 <b>HOT-2</b>	all right.		
17:05:31.9 <b>HOT-1</b>	and we're good to...		
17:05:32.2 <b>HOT-2</b>	pilot's discretion to ten thousand.		
17:05:34.5 <b>HOT-1</b>	okay.		
17:05:42.1 <b>HOT-2</b>	eh...we are twenty four miles out or twenty four minutes...eh...I'm gonna give em a try again.		
17:05:47.9 <b>HOT-1</b>	okay...you'll probably get em this time.		
17:05:50.7 <b>HOT-2</b>	yeah.		
17:05:52.4 <b>HOT-1</b>	eh- I dunno...maybe...oh my butt.		
		17:05:56.9 <b>RDO-2</b>	Dutch Ops thirty two ninety f-six.
		17:06:04.1 <b>DWX</b>	hello thirty two ninety four...right now the winds um...two one zero at six gusting up to fourteen visibility's ten...um...except ops to the north says there's a shower in the vicinity...um...visibility in that direction is probably I would say seven right now...um your...your ceiling is four thousand three hundred broken temperature eight dewpoint one altimeter two niner five zero.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:06:33.6 <b>RDO-2</b>	alright copy the weather and we'll...uh...be there in about twenty-five minutes thirty two ninety six.
		17:06:40.8 <b>DWX</b>	copy that we'll see you in twenty five.
17:06:43.4 <b>HOT-1</b>	what she say the wind was?		
17:06:44.9 <b>HOT-2</b>	wind was two one zero let me conf-make sure of that.		
		17:06:49.1 <b>RDO-2</b>	and Dutch Weather Peninsula thirty two ninety six we wanted to confirm the we...winds are two one zero at six gusting fourteen?
		17:06:57.9 <b>DWX</b>	yes that's affirmative they are two one zero but they've come down quite a bit um if they pick up again and come out right out of the um...across the runway there at like two four zero I'll let you know.
		17:07:08.0 <b>RDO-2</b>	okay sounds good thank you.
17:07:09.1 <b>HOT-1</b>	direct crosswind...yeah it's pretty much a direct crosswind.		
17:07:12.9 <b>HOT-2</b>	rog...alright.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:07:14.8 <b>HOT-1</b>	we had that the other day too...I did that with @ [company pilot]...***...we're like a...half mile final when she says out of two four zero at two five...I went...the # do you want me to do about it now?		
17:07:26.6 <b>HOT-2</b>	yeah hah.		
17:07:28.8 <b>HOT-1</b>	ahem...landed it on the ground (per about)...		
17:07:32.6 <b>HOT-2</b>	all right I'll request a R-NAV three...uh one three .		
17:07:35.8 <b>HOT-1</b>	alright.		
		17:07:38.2 <b>RDO-2</b>	Anchorage Center Peninsula thirty two ninety six request the R-NAV one three eh Dutch Harbor we have the current weather.
		17:07:43.5 <b>CTR-C</b>	Peninsula thirty two ninety six you can expect that.
		17:07:55.9 <b>DOP</b>	Peninsula thirty two ninety six copy that twenty five minutes out.
17:08:23.4 <b>HOT-1</b>	yep...pretty much a direct crosswind there.		
17:08:46.6 <b>HOT-?</b>	[sound similar to sh]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:08:58.1 <b>HOT-1</b>	yep...I guess we can go ahead and start heading down.		
17:09:00.3 <b>HOT-2</b>	alright.		
17:09:01.2 <b>HOT-1</b>	in range when you get a chance.		
17:09:02.0 <b>HOT-2</b>	roger.		
17:09:03.1 <b>CAM</b>	[sound similar to double single chime]		
		17:09:05.5 <b>RDO-2</b>	Anchorage Center Peninsula thirty two ninety six in the descent.
		17:09:09.3 <b>CTR-C</b>	Peninsula thirty two ninety six roger.
17:09:11.9 <b>HOT-2</b>	A-TIS.		
17:09:14.0 <b>HOT-1</b>	uh...		
17:09:18.1 <b>HOT-2</b>	check.		
17:09:18.6 <b>HOT-1</b>	check yeah.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:09:19.1 <b>HOT-2</b>	hahaha...the E-F-Bs.		
17:09:20.7 <b>HOT-1</b>	wasn't really an A-TIS but okay just how my brain was going...** bravo configured...*** bugs are twenty six one thirty six and I have one forty eight — [continuing to read checklist] [overlapping HOT mic, PA, and ATC]		
17:09:23.8 <b>PA-3</b>	ladies and gentlemen we have begun our gradual descent into...Dutch Harbor please remain seated with your seatbelts securely fastened for the duration of the flight in just a few minutes I'll be coming through the cabin to * any remaining service items...thank you.		
17:09:45.9 <b>HOT-2</b>	checked.		
17:09:46.5 <b>HOT-1</b>	checked.		
17:09:47.7 <b>HOT-2</b>	F-M-S.		
17:09:49.6 <b>HOT-1</b>	checked.		
17:09:49.8 <b>HOT-2</b>	checked.		
17:09:50.5 <b>HOT-2</b>	flight attendant's been notified A-P-R is off...in range checklist complete.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:09:55.0 <b>HOT-1</b>	thank you.		
17:09:58.8 <b>HOT-1</b>	there we are...ah...butt check.		
17:10:04.7 <b>HOT-2</b>	checked...right?		
17:10:06.9 <b>HOT-1</b>	yeah.		
17:10:14.2 <b>HOT-?</b>	[sound similar to pilot whistling]		
17:10:28.5 <b>HOT-1</b>	so if it's...oh that was the other thing...if we touchdown...if it's squirrely...weird...creepy in any way...you...uh...give it ** even if it's before eighty knots ***...go into reverse...** gonna be on tiller and brakes. [voice cut off by radio transmission]		
17:10:42.2 <b>HOT-2</b>	all right yeah I'll—I'll get on the uh tops early.		
17:10:45.7 <b>HOT-1</b>	yeah.		
17:10:48.1 <b>HOT-2</b>	I had to do that yesterday.		
17:10:50.1 <b>HOT-1</b>	yeah cause it just...you you gotta use everything in it.		
17:10:52.7 <b>HOT-2</b>	yeah.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:10:52.9 <b>HOT-1</b>	just give it a push on the nose so I have traction.		
17:10:53.9 <b>HOT-2</b>	yeah.		
17:11:00.1 <b>HOT-2</b>	oh my butt.		
17:11:01.4 <b>HOT-1</b>	yeah.		
17:11:12.7 <b>HOT-2</b>	I'm gonna get the rudders pushed out a little bit further.		
17:11:15.9 <b>HOT-1</b>	yeah I'm gonna get an adjustment here in a minute. ** a little lower...* a little further along.		
17:11:59.2 <b>HOT-1</b>	oh it's the Alaska Airlines frequency...oh no that's it...yeah.		
17:12:03.5 <b>HOT-2</b>	twenty nine five?		
17:12:05.0 <b>HOT-1</b>	yeah.		
17:12:55.0 <b>HOT-2</b>	ahem.		
17:13:01.3 <b>HOT-1</b>	[sound similar to pilot humming]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:13:20.1 <b>HOT-1</b>	[sound similar to pilot humming]		
17:13:25.6 <b>HOT-1</b>	you alright?		
17:13:26.3 <b>HOT-2</b>	yeah I just need to stretch my legs out more.		
17:13:28.5 <b>HOT-1</b>	yeah.		
17:13:32.0 <b>HOT-2</b>	I'm good now...I got all...got the rudder pedals all the way out.		
17:13:36.3 <b>HOT-1</b>	haha.		
17:13:37.9 <b>HOT-2</b>	and seat's all the way back as well...as far back as I can get it with as much recline as I can get.		
17:13:42.6 <b>HOT-1</b>	uh huh.		
17:13:46.6 <b>HOT-2</b>	ya know for a six foot guy this plane doesn't...I mean it...you can give yourself plenty of legroom which is pretty nice.		
17:13:53.2 <b>HOT-1</b>	yeah.		
17:14:21.3 <b>HOT-1</b>	[sound similar to pilot humming]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:14:35.7 <b>HOT-1</b>	huh.		
17:14:40.2 <b>HOT-1</b>	[sound similar to pilot whistling]		
17:14:48.5 <b>HOT-2</b>	all right...on to ROFZU.		
17:14:52.0 <b>HOT-1</b>	MORDI to ROFZU.		
		17:14:56.8 <b>CTR-A</b>	Peninsula thirty two ninety six advise (if/for) Dutch Harbor zero zero five six METAR or more current I have it if you need it...the runway one three and three one field condition code five five five one hundred percent wet observed at one six two six.
17:15:08.7 <b>HOT-2</b>	um...okay...(should we—)what do you want me to just say understood?		
17:15:11.1 <b>HOT-1</b>	all right we have current weather thank you.		
17:15:12.6 <b>HOT-2</b>	all right.		
		17:15:13.1 <b>RDO-2</b>	all right we have the current weather at Dutch Harbor Peninsula thirty two ninety six.
		17:15:16.9 <b>CTR-A</b>	Peninsula thirty two ninety six are you planning on R-NAV runway three one?

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:15:20.4 <b>RDO-2</b>	affirmative...uh negative...we want the R-NAV one three Peninsula thirty two ninety six.
		17:15:26.0 <b>CTR-A</b>	Peninsula thirty two ninety six roger cleared R-NAV runway one three approach Dutch Harbor airport at ROFZU change of advisory frequency approved report cancellation of I-F-R on this frequency.
		17:15:34.1 <b>RDO-2</b>	cleared for the R-NAV one three and change of frequency at ROFZU we'll report back with you to cancel Peninsula thirty two ninety six thanks.
17:15:40.9 <b>HOT-2</b>	okay.		
17:15:42.3 <b>HOT-1</b>	shift over at ROFZU.		
17:15:44.6 <b>HOT-2</b>	clear for the R-NAV.		
17:15:45.3 <b>HOT-1</b>	and just like the other day if there's any major changes in wind then we'll just—		
17:15:48.3 <b>HOT-2</b>	we'll switch.		
17:15:49.4 <b>HOT-1</b>	call her back...if we have it in sight we're gonna take the visual.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:15:52.6 <b>HOT-2</b>	rog'.		
17:15:56.8 <b>HOT-1</b>	that way we're on the up and up legal.		
17:15:58.4 <b>HOT-2</b>	yeah.		
17:16:06.3 <b>HOT-2</b>	[sound similar to clearing throat]		
17:16:51.1 <b>HOT-2</b>	so...		
17:16:52.4 <b>HOT-1</b>	I was hoping that the daily schedule thing would have stayed on my phone without the internet.		
17:16:57.1 <b>HOT-2</b>	oh.		
17:17:07.5 <b>HOT-1</b>	[sound similar to yawn]		
17:17:42.3 <b>HOT-1</b>	and coming up on transition...let's do the descent checklist.		
17:17:48.7 <b>HOT-2</b>	roger.		
17:17:51.9 <b>HOT-2</b>	cabin pressure's checked. altimeter two niner five zero.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:17:55.9 <b>HOT-1</b>	two niner five zero left center and crosscheck through.		
17:17:58.8 <b>HOT-2</b>	and right cross check eighteen eight.		
17:18:01.2 <b>HOT-1</b>	eighteen eight.		
17:18:02.4 <b>HOT-2</b>	cross check complete. descent checklist complete.		
17:18:09.6 <b>HOT-1</b>	[sound similar to pilot whistling]		
17:18:13.2 <b>HOT-1</b>	I didn't realize I was that much older than @ [company pilot]...huh.		
17:18:16.3 <b>HOT-2</b>	how old is @ [company pilot]?		
17:18:17.2 <b>HOT-1</b>	@ [company pilot]'s like fifty three.		
17:18:18.6 <b>HOT-2</b>	how old are you?		
17:18:19.5 <b>HOT-1</b>	fifty seven.		
17:18:20.4 <b>HOT-2</b>	oh.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:18:22.8 <b>HOT-2</b>	you still got plenty of time to keep flying with us...you don't need to retire again.		
17:18:29.9 <b>HOT-1</b>	ehhh don't wanna do it and don't wanna do that...unless it's fun — if it's still fun then I'll keep doin' it but...at a point where it's just like...yeah...not fun anymore...done...then I'm done done...I can give instruction and stuff would be fun just to (go down/get out) and do somethin'.		
17:18:50.0 <b>HOT-2</b>	yeah.		
17:18:50.5 <b>HOT-1</b>	but.		
17:18:51.6 <b>HOT-2</b>	I—I mean...as a former flight instructor...I enjoy it...um...ya know I like seeing people learn and...		
17:19:00.6 <b>HOT-1</b>	yep.		
17:19:01.1 <b>HOT-2</b>	succeed.		
17:19:02.5 <b>HOT-1</b>	yep.		
17:19:03.6 <b>HOT-2</b>	but uh...I enjoy the fact that no one's trying to kill me right now.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:19:11.8 <b>HOT-1</b>	heh...yeah ***. [voice cut off by radio transmission]		
17:19:15.8 <b>HOT-2</b>	what's that?		
17:19:17.3 <b>HOT-2</b>	yeah...don't have people bombing me in the practice area you know just...		
17:19:22.8 <b>HOT-1</b>	oh yeah.		
17:19:27.9 <b>HOT-1</b>	aright that's just it then...that's what makes it un...sometimes unpleasant especially when there's guys who are like real #.		
17:19:35.9 <b>HOT-2</b>	yeah.		
17:19:36.9 <b>HOT-1</b>	yeah...but uh...		
17:19:43.6 <b>HOT-2</b>	and I enjoy...I mean...I've enjoyed flying with everybody so far.		
17:19:47.7 <b>HOT-1</b>	yeah me too.		
17:19:49.7 <b>HOT-2</b>	so it makes this job easy for me.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:19:55.2 <b>HOT-1</b>	what was the temperature that she gave us? do you remember?		
17:19:57.9 <b>HOT-2</b>	it is...eight.		
17:20:05.9 <b>HOT-1</b>	yeah...all right.		
17:20:30.8 <b>HOT-1</b>	[sounds similar to pilot whistling and humming]		
		17:20:40.1 <b>N546LM</b>	and Dutch Weather King Air five four six lima mike.
17:20:45.6 <b>HOT-2</b>	what'd I tell ya...five four six lima mike.		
17:20:47.3 <b>HOT-1</b>	oh yeah that's life med.		
		17:20:47.6 <b>DWX</b>	hello lima...lima mike...um right now your winds are one eight zero at seven visibility ten showers in vicinity by Eider um restricting visibility over there to I would say eight miles right now their ceiling is three thousand nine hundred broken temperature eight dewpoint one altimeter two niner five zero.
		17:21:07.8 <b>N546LM</b>	hey my kind of weather @ [DWX] we'll uh...we'll se ya in about I dunno thirty five minutes...um...do you know is @ [airport services] still uh available?

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:21:21.8 <b>DWX</b>	yeah I'm sure he's still here but their flight is right before you so you'll have to wait 'till he's done with them.
		17:21:28.2 <b>N546LM</b>	oh yeah I just kinda wondered if we could leave the airplane parked over on the other side and he could get to us.
		17:21:37.3 <b>DWX</b>	I'll ask her...um what time are you due in exactly?
		17:21:42.0 <b>N546LM</b>	I'm thinking about thirty five minutes.
		17:21:45.3 <b>DWX</b>	copy that I'll let her know.
17:22:01.3 <b>HOT-1</b>	[sound similar to pilot whistling]		
17:22:22.3 <b>HOT-1</b>	(q ops)...guess I'm ready to turn this # on...um left engine...on...check. right engine...on...check. make sure we turn it off...and I'll probably go into high rpm.		
17:22:40.6 <b>HOT-2</b>	okay.		
17:22:41.1 <b>HOT-1</b>	that's a @ [company pilot] thing...I like it...haha...I think @ [company pilot] does that...I'm not sure...pretty sure he does...he's the one who showed it to me so...we'll go with that.		
17:22:55.6 <b>CAM</b>	[sound similar to altitude alert]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:22:58.1 <b>HOT-2</b>	uh we can set lower...can we?		
17:22:59.9 <b>HOT-1</b>	did she...she—		
17:23:01.7 <b>HOT-2</b>	she cleared us for the R-NAV.		
17:23:02.3 <b>HOT-1</b>	oh yeah if we're cleared we're good.		
17:23:03.4 <b>HOT-2</b>	to twenty three.		
17:23:04.1 <b>HOT-1</b>	to twenty three yeah.		
17:23:07.9 <b>HOT-1</b>	and she said cancel on the ground with her.		
17:23:09.9 <b>HOT-2</b>	yeah.		
17:23:11.4 <b>HOT-1</b>	ten thousand.		
17:23:16.2 <b>HOT-2</b>	all right.		
17:23:18.4 <b>CAM</b>	[sound similar to double single chime]		
17:23:19.8 <b>HOT-2</b>	ten thousands are complete.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:23:21.5 <b>HOT-1</b>	thanks.		
17:23:29.7 <b>PA-3</b>	ladies and gentlemen in order to prepare the cabin for landing please ensure that all hand carried items are stowed completely beneath the seat in front of you...your seatbacks and tray tables must be in their upright and locked position...armrests in the down position and your seatbelts securely fastened...thank you.		
17:24:11.2 <b>HOT-1</b>	[sound similar to pilot whistling]		
17:24:19.3 <b>HOT-1</b>	does anybody ever *...does this...this turbulence mode do anything?		
17:24:22.6 <b>HOT-2</b>	it eases the...it dampens the...uh autopilot's response a little bit so it smooths things out.		
17:24:29.0 <b>HOT-1</b>	have you ever seen it work?		
17:24:30.8 <b>HOT-2</b>	yeah I've seen um...who's put it on...um...who have I flown with lately.		
17:24:36.4 <b>HOT-1</b>	I think it turns on ***.		
17:24:38.7 <b>HOT-2</b>	do what?		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:24:39.4 <b>HOT-1</b>	I think it turns on a light and a button.		
17:24:40.8 <b>HOT-2</b>	I've seen @ [company pilot] turn it on...I've seen uh...uh...@ [company pilot] turned it on.		
17:24:47.4 <b>HOT-1</b>	'kay.		
17:24:48.3 <b>HOT-2</b>	somebody else.		
17:24:51.1 <b>HOT-1</b>	well...okay I'm gonna test it...is that all right?		
17:24:52.6 <b>HOT-2</b>	yeah.		
17:24:53.9 <b>HOT-1</b>	just curious...I'm sure we'll get a bump somewhere.		
17:24:59.9 <b>HOT-2</b>	goin' through that for sure.		
17:25:01.5 <b>HOT-1</b>	[sound similar to yawn]		
17:25:03.7 <b>HOT-2</b>	a little vertical development right there.		
17:25:06.0 <b>HOT-1</b>	yeah.		
17:25:45.9 <b>HOT-1</b>	'kay my engine anti ice is on.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:25:53.4 <b>HOT-1</b>	** now... * deal with it later.		
		17:26:02.3 <b>RDO-2</b>	Dutch Harbor traffic Peninsula thirty two ninety six thirty miles north of the airport and uh descending out of six thousand one hundred R-NAV one three Dutch Harbor.
17:26:43.1 <b>HOT-2</b>	ROFZU.		
17:26:44.6 <b>HOT-1</b>	there's ROFZU still good to twenty three check.		
17:26:47.3 <b>HOT-2</b>	roger.		
17:26:49.9 <b>HOT-1</b>	[sound of breathing]		
17:26:59.4 <b>CAM</b>	[sound similar to PA chime]		
17:27:03.4 <b>INT-2</b>	yes ma'am...hello...yes.		
17:27:15.2 <b>INT-3</b>	cabin secure.		
17:27:16.2 <b>INT-2</b>	copy thanks how's the temperature?		
17:27:18.1 <b>HOT-1</b>	eh...doesn't matter.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:27:19.2 <b>HOT-2</b>	whatever.		
17:27:21.8 <b>HOT-2</b>	cabin secure.		
17:27:22.8 <b>HOT-1</b>	roger thanks...so before landing checks all we got to go on that right? already did everything else?		
17:27:30.1 <b>HOT-2</b>	uh...yeah...flight attendant...we just need the flaps and the gear.		
17:27:30.6 <b>HOT-1</b>	*		
17:27:33.2 <b>HOT-1</b>	all right.		
17:27:37.7 <b>HOT-2</b>	cabin's already been notified.		
17:27:39.2 <b>HOT-1</b>	check.		
17:28:08.7 <b>HOT-1</b>	[sound similar to pilot humming]		
17:28:46.0 <b>HOT-1</b>	there's a shower over EWSER just to the left of it so...two bumps here.		
17:28:53.5 <b>HOT-2</b>	rog'.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:28:56.2 <b>HOT-1</b>	unless they're bouncing off the water which I don't think is...		
17:29:00.0 <b>HOT-2</b>	not at that tilt.		
17:29:01.9 <b>HOT-1</b>	I hope not...eh I could be...no maybe not uh...		
17:29:14.2 <b>CAM</b>	[sound similar to altitude alert]		
17:29:15.8 <b>HOT-2</b>	thirty three for twenty three.		
17:29:17.8 <b>HOT-1</b>	thirty three for twenty three. thousand to go checks.		
17:29:19.6 <b>HOT-2</b>	rog'.		
17:29:23.3 <b>HOT-2</b>	we'll be...setting sixteen here in a minute.		
17:29:26.5 <b>HOT-1</b>	okay.		
17:29:44.8 <b>HOT-2</b>	all right...sixteen.		
17:29:46.8 <b>HOT-1</b>	and...sixteen sure...checks.		
17:29:51.1 <b>HOT-2</b>	sixteen set.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:30:00.6 <b>HOT-1</b>	there's that shower I was tellin' you about.		
17:30:02.1 <b>HOT-2</b>	yep.		
17:30:05.7 <b>HOT-1</b>	how's that look?		
17:30:06.7 <b>HOT-2</b>	clean.		
17:30:07.6 <b>HOT-1</b>	good.		
17:30:12.3 <b>HOT-2</b>	it's above freezing.		
17:30:14.0 <b>HOT-1</b>	yeah...it's good...eh.		
17:30:21.3 <b>HOT-2</b>	here we go.		
17:30:22.0 <b>HOT-1</b>	**		
17:30:26.2 <b>HOT-1</b>	the island over here off to the left.		
17:30:27.9 <b>HOT-2</b>	yep...I can see...can almost see through that.		
17:30:32.6 <b>HOT-1</b>	got Split Top...so if we have to go the other way...		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:30:38.7 <b>HOT-2</b>	I can...just barely make out...what is that...Point Eider?		
17:30:44.3 <b>HOT-1</b>	Eider Point.		
17:30:45.1 <b>HOT-2</b>	yeah...I don't think...I don't think I can see it yet.		
17:30:47.0 <b>HOT-1</b>	right...twelve o'clock.		
17:30:47.8 <b>HOT-2</b>	actually it's right there.		
17:30:48.0 <b>HOT-1</b>	you'd better be lookin' at it...haha that's it...you are lookin' at it.		
17:30:55.2 <b>HOT-2</b>	uh...sixteen hundred.		
17:30:56.9 <b>HOT-1</b>	sixteen hundred. leveling.		
17:31:01.1 <b>HOT-2</b>	what are we about...not quite ten to the north?		
17:31:06.2 <b>HOT-1</b>	and flaps...just about...hold on...and flaps fifteen.		
17:31:13.0 <b>HOT-2</b>	all right speed check. flaps fifteen.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:31:27.9 <b>HOT-1</b>	Eider Point...got the end of Hog Island there.		
17:31:31.9 <b>HOT-2</b>	I got em I wouldn't...I'm not calling it yet haha.		
		17:31:36.5 <b>RDO-2</b>	Dutch Harbor traffic Peninsula thirty two ninety six one thousand six hundred ten miles to the north R-NAV one three Dutch Harbor.
17:31:43.7 <b>HOT-1</b>	just (dim).		
17:31:44.4 <b>HOT-2</b>	what?		
17:31:44.8 <b>HOT-1</b>	a little fuzzy right there.		
17:31:45.9 <b>HOT-2</b>	yep.		
17:31:47.8 <b>HOT-1</b>	well who's on this side.		
17:31:50.8 <b>HOT-1</b>	'kay uh gear down.		
17:31:53.2 <b>HOT-2</b>	gear down.		
17:31:58.1 <b>HOT-1</b>	and our next altitude is...		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:31:59.9 <b>HOT-2</b>	five hundred.		
17:32:03.8 <b>HOT-2</b>	* come on...five hundred set.		
17:32:06.4 <b>HOT-1</b>	thanks.		
17:32:08.7 <b>HOT-1</b>	flaps twenty final checks...before landing checklist...sorry.		
17:32:14.2 <b>HOT-2</b>	all right flaps twenty...before landing checklist.		
17:32:17.9 <b>HOT-2</b>	flight attendant is secure.		
17:32:19.0 <b>CAM</b>	[sound similar to double single chime]		
17:32:20.5 <b>HOT-2</b>	flaps set twenty. indicating twenty. gear.		
17:32:23.9 <b>HOT-1</b>	down three green.		
17:32:24.8 <b>HOT-2</b>	down three green. before landing checklist complete.		
17:32:27.3 <b>HOT-1</b>	then we got...oh there's Hog.		
17:32:28.6 <b>CAM</b>	[sound similar to altitude alert]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:32:29.8 <b>HOT-1</b>	***.		
17:32:30.8 <b>HOT-2</b>	all right...fifteen for five.		
17:32:32.4 <b>HOT-1</b>	all right...wind check from her real quick if you don't mind.		
17:32:35.3 <b>HOT-2</b>	all right.		
		17:32:37.7 <b>RDO-2</b>	Dutch Weather thirty two ninety six wind check.
		17:32:43.5 <b>DWX</b>	actually right now um...two seven zero at ten.
		17:32:49.6 <b>RDO-2</b>	copy thanks.
17:32:50.5 <b>HOT-2</b>	two seven zero at ten.		
17:32:51.7 <b>HOT-1</b>	whad'ya think? straight? left?		
17:32:54.1 <b>HOT-2</b>	mmm.		
17:32:55.0 <b>HOT-1</b>	how bout we give it a shot?		
17:32:57.1 <b>HOT-2</b>	two seven's gonna be...		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:32:59.6 <b>HOT-1</b>	autopilot's off.		
17:33:00.6 <b>CAM</b>	[sound similar to cavalry charge, autopilot off]		
17:33:01.4 <b>HOT-2</b>	rog'.		
17:33:01.5 <b>EGPWS</b>	one thousand. [electronic voice]		
17:33:02.2 <b>HOT-2</b>	uhh...whatever you feel comfortable with.		
17:33:05.0 <b>HOT-1</b>	eh...we'll go straight.		
17:33:05.7 <b>HOT-2</b>	all right.		
17:33:06.2 <b>HOT-1</b>	screw it.		
17:33:08.2 <b>HOT-1</b>	ah...bump...get a little bit of a bump here too.		
17:33:08.5 <b>CAM</b>	[sound of button click]		
17:33:12.1 <b>HOT-2</b>	yeah.		
17:33:20.4 <b>HOT-1</b>	yeah there ya go...mhm.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:33:27.9 <b>HOT-2</b>	yeah...it's gonna be ugly in here isn't it?		
17:33:30.2 <b>HOT-1</b>	little bit.		
17:33:35.1 <b>HOT-2</b>	all right...we are at OWGIM.		
17:33:37.4 <b>HOT-1</b>	eh...OWGIM...Hog Island...		
17:33:39.8 <b>HOT-2</b>	five hundred above.		
17:33:40.9 <b>HOT-1</b>	runway end in sight.		
17:33:42.1 <b>HOT-2</b>	roger.		
17:33:56.1 <b>HOT-1</b>	[sound similar to pilot humming]		
17:34:02.3 <b>HOT-2</b>	I'll call mo...call mobile one here in a minute.		
17:34:04.5 <b>HOT-1</b>	m'kay.		
17:34:06.4 <b>HOT-1</b>	there's seven hundred.		
17:34:20.1 <b>HOT-1</b>	all right...there's six...holdin' there.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:34:24.1 <b>HOT-2</b>	plus twenty.		
17:34:25.6 <b>HOT-1</b>	roger plus twenty.		
17:34:26.9 <b>HOT-2</b>	do you want your wipers?		
17:34:28.0 <b>HOT-1</b>	nah...we're good.		
17:34:28.7 <b>HOT-2</b>	rog'.		
		17:34:30.6 <b>RDO-2</b>	Mobile one clear the deck close the gate.
		17:34:34.7 <b>MOB1</b>	copy.
		17:34:43.0 <b>DWX</b>	and em...visibility over by Eider has dropped quite a bit um I would say we're at four miles over there right now...ten miles everywhere else.
		17:34:47.8 <b>?</b>	[nine sounds similar to clicking mic key]
17:34:50.4 <b>HOT-1</b>	that'd be about right.		
17:34:52.1 <b>HOT-?</b>	[sound similar to sneeze]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:34:52.9 <b>RDO-2</b>	sounds about right we have the er...runway in sight.
17:34:55.9 <b>HOT-1</b>	all right...if it gets too sheer-y just say go around we'll go out the back door.		
17:34:58.4 <b>HOT-2</b>	rog'.		
17:34:59.2 <b>EGPWS</b>	five hundred. [electronic voice]		
17:35:01.0 <b>HOT-1</b>	all right.		
17:35:02.9 <b>HOT-1</b>	give me speed and altitude callouts.		
		17:35:03.0 <b>MOB1</b>	all right thirty two ninety six lights on gate closed deck is cleared.
17:35:04.3 <b>HOT-2</b>	I will.		
17:35:06.3 <b>HOT-2</b>	ready to copy ***.		
17:35:07.6 <b>EGPWS</b>	four hundred. [electronic voice]		
17:35:08.4 <b>HOT-1</b>	everything you can think of ***.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:35:09.3 <b>HOT-2</b>	roger you are plus fifteen.		
17:35:11.9 <b>HOT-1</b>	high R-P-M.		
17:35:12.2 <b>HOT-2</b>	down eight.		
17:35:13.5 <b>HOT-1</b>	bleeds comin' off.		
17:35:18.9 <b>EGPWS</b>	three hundred. [electronic voice]		
17:35:19.9 <b>HOT-2</b>	plus fifteen down three.		
17:35:21.5 <b>HOT-1</b>	all right.		
17:35:23.5 <b>CAM</b>	[sound similar to altitude alert]		
17:35:24.8 <b>HOT-1</b>	#.		
17:35:26.8 <b>HOT-1</b>	whad'ya think?		
17:35:27.2 <b>HOT-2</b>	go around.		
17:35:27.9 <b>EGPWS</b>	two hundred. [electronic voice]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:35:27.9 <b>HOT-1</b>	goin' around.	17:35:28.8 <b>DWX</b>	now three zero zero at eight.
17:35:28.9 <b>HOT-1</b>	max power.		
17:35:30.4 <b>HOT-1</b>	go around power.	17:35:32.2 <b>RDO-2</b>	Dutch Harbor traffic Peninsula —
17:35:33.0 <b>HOT-1</b>	positive rate...flaps...positive rate...gear up...flaps seven.		
17:35:35.7 <b>HOT-2</b>	flaps seven. positive rate. gear up.		
17:35:39.5 <b>HOT-2</b>	we can set back up for it.		
17:35:40.6 <b>HOT-1</b>	yeah...and just tell her we're comin' around for a visual.	17:35:44.1 <b>RDO-2</b>	Dutch Harbor traffic Peninsula thirty two ninety six goin' around we're gonna come back around for a visual.
17:35:46.8 <b>HOT-1</b>	climb power.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:35:48.7 <b>HOT-2</b>	climb power set...ah.		
17:35:52.6 <b>HOT-2</b>	all right flaps up.		
17:35:54.0 <b>HOT-1</b>	and flaps up.		
17:36:04.9 <b>HOT-1</b>	and reduce the power for me.		
17:36:05.5 <b>CAM</b>	[sound similar to altitude alert]		
17:36:07.4 <b>HOT-2</b>	whad'ya want it at?		
17:36:08.8 <b>HOT-1</b>	uh...just bring it back to about fifty.		
17:36:12.6 <b>HOT-1</b>	and get me on a thousand...I think we'll be —		
17:36:16.1 <b>HOT-2</b>	on the altitude?		
17:36:16.9 <b>HOT-1</b>	yeah.		
17:36:17.8 <b>HOT-2</b>	thousand set.		
17:36:18.6 <b>HOT-1</b>	yeah...we're gonna go out here and do a one eighty and come back in.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:36:20.4 <b>HOT-2</b>	rog'...all right you're at a thousand feet.		
17:36:23.7 <b>HOT-1</b>	'kay.		
17:36:23.9 <b>HOT-2</b>	fifty.		
		17:36:24.8 ?	[three sounds similar to clicking mic key]
17:36:24.9 <b>HOT-1</b>	altitude.		
17:36:27.0 <b>HOT-2</b>	alts.		
17:36:30.1 <b>HOT-1</b>	heading.		
17:36:30.7 <b>HOT-2</b>	heading.		
17:36:31.1 <b>HOT-1</b>	keep punching my bug.		
17:36:32.4 <b>HOT-2</b>	yep.		
17:36:32.9 <b>HOT-?</b>	[sound of sigh]		
17:36:38.5 <b>HOT-2</b>	set you up...we'll fly a heading of three four zero for now.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:36:41.3 <b>HOT-1</b>	yeah.		
17:36:41.4 <b>CAM</b>	[sound similar to altitude alert]		
17:36:43.3 <b>HOT-2</b>	twelve hundred...you're two hundred above.		
17:36:44.9 <b>HOT-1</b>	'kay.		
17:36:48.4 <b>HOT-1</b>	oh *.		
17:36:49.4 <b>HOT-1</b>	slow me up...back off on power.		
		17:36:51.2 <b>N546LM</b>	Peninsula thirty two ninety six this is King Air five four six lima mike are you on the ground yet?
17:36:56.1 <b>HOT-1</b>	nope.		
		17:36:56.9 <b>RDO-2</b>	negative we're circling around to come back in for a visual.
17:37:00.7 <b>HOT-1</b>	yep.		
		17:37:01.4 <b>N546LM</b>	uh...okay...he's gonna land on three one? we're uh we're we're held up at eleven we're wondering what altitude you're at.



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:37:04.2 <b>DWX</b>	we have thirty now two nine zero at um sixteen gusting to thirty.
		17:37:08.6 <b>RDO-2</b>	we're at twelve hundred comin' back around for uh one...the visual one three.
		17:37:13.3 <b>N546LM</b>	okay you're at twelve hundred thanks.
17:37:14.9 <b>HOT-1</b>	three one. three one.		
17:37:16.4 <b>HOT-2</b>	three one?		
17:37:16.9 <b>HOT-1</b>	back door?		
17:37:17.8 <b>HOT-2</b>	I thought we were doin' one three.		
17:37:18.8 <b>HOT-1</b>	oh okay...sure...we'll try again.		
17:37:22.1 <b>HOT-1</b>	okay.		
17:37:22.5 <b>HOT-2</b>	alright.		
17:37:23.2 <b>HOT-1</b>	gear down.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:37:24.7 <b>HOT-2</b>	gear down.		
17:37:25.0 <b>EGPWS</b>	one thousand. [electronic voice]		
17:37:26.5 <b>HOT-1</b>	flaps fifteen.		
17:37:27.8 <b>HOT-2</b>	speed checks...flaps fifteen.		
17:37:34.7 <b>HOT-1</b>	and put five hundred in again.		
17:37:36.0 <b>HOT-2</b>	roger.		
17:37:38.9 <b>HOT-2</b>	five hundred's in.		
17:37:40.9 <b>HOT-2</b>	you okay with this?		
17:37:42.1 <b>HOT-1</b>	eh...I was thinking about going the other way (might be better) * shear.		
		17:37:43.1 <b>N546LM</b>	and Dutch Weather King Air six lima mike.
17:37:46.9 <b>HOT-2</b>	we just got (twenty).		
		17:37:47.5 <b>DWX</b>	go ahead lima mike.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:37:49.0 <b>N546LM</b>	uh yeah given what I'm hearing you say does it look okay for three one?
17:37:49.9 <b>HOT-2</b>	twenty.		
17:37:53.7 <b>HOT-2</b>	do you want the before again?		
17:37:54.7 <b>HOT-1</b>	yeah.		
		17:37:55.0 <b>DWX</b>	there's showers just moving through um right at the moment it is perfect for three one but I'm I'm thinking it might switch back to where it was before this...once this shower moves through...I'll let you know as soon as PenAir gets in here...if it's changed.
17:37:55.3 <b>HOT-2</b>	all right flight attendant secure. flaps set twenty. indicated twenty. gear.		
17:38:03.0 <b>HOT-2</b>	gear.		
17:38:07.6 <b>HOT-2</b>	@ [captain]...gear.		
17:38:07.7 <b>HOT-1</b>	(down/yeah) three green.		
		17:38:08.8 <b>N546LM</b>	okay thanks.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:38:08.8 <b>HOT-2</b>	down three green.		
17:38:09.8 <b>HOT-2</b>	before landing checklist complete.		
17:38:10.7 <b>HOT-1</b>	aight.		
17:38:11.5 <b>HOT-2</b>	all right.		
17:38:12.2 <b>HOT-1</b>	all right.		
17:38:14.6 <b>HOT-1</b>	that's good.		
17:38:15.6 <b>HOT-2</b>	hahahaha.		
17:38:21.3 <b>HOT-1</b>	(set turn/trim)...# son of a #.		
17:38:25.1 <b>HOT-1</b>	okay...get a wind check from her again.		
17:38:26.9 <b>HOT-2</b>	rog'.		
		17:38:32.6 <b>RDO-2</b>	Dutch Weather thirty two ninety six another wind check.
		17:38:36.4 <b>DWX</b>	right now...midfield winds at three zero zero at twenty four.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:38:40.1 <b>HOT-2</b>	oh God.		
17:38:40.8 <b>HOT-1</b>	ah #.		
		17:38:43.3 <b>RDO-2</b>	copy that.
17:38:44.8 <b>HOT-2</b>	#...do you wanna...back out...do it again?		
17:38:47.8 <b>HOT-1</b>	uh...		
		17:38:48.6 <b>DWX</b>	yeah it picked up and moved pretty quickly.
17:38:50.0 <b>HOT-2</b>	I think —		
17:38:51.0 <b>HOT-1</b>	keep talking to weather.		
17:38:55.1 <b>HOT-2</b>	aright...we'll try it again.		
17:38:56.7 <b>HOT-1</b>	aright...last try.		
17:38:57.8 <b>HOT-2</b>	rog'.		
		17:38:59.8 <b>RDO-2</b>	Mobile one...clear the deck close the gate.

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
		17:39:03.3 <b>MOB1</b>	copy.
17:39:05.6 <b>HOT-2</b>	you got it.		
17:39:06.0 <b>EGPWS</b>	five hundred. [electronic voice]		
		17:39:08.2 ?	[seven sounds similar to clicking mic key]
17:39:08.6 <b>HOT-1</b>	give me speed —		
17:39:09.1 <b>HOT-2</b>	aright you are...yes rog'...you are uh plus fifteen.		
17:39:13.6 <b>HOT-2</b>	down seven.		
17:39:14.7 <b>HOT-2</b>	plus ten...plus fifteen down seven.		
17:39:16.9 <b>EGPWS</b>	four hundred. [electronic voice]		
		17:39:19.5 <b>MOB1</b>	all right thirty two ninety six lights on gate is closed deck is cleared.
17:39:21.1 <b>HOT-1</b>	light shear. it might be easier (if you) apply the power just up and down for me to maintain speed.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:39:22.8 <b>HOT-2</b>	okay.		
17:39:23.9 <b>HOT-2</b>	rog'.		
17:39:25.5 <b>HOT-1</b>	I need both (hands) ** so...		
17:39:25.9 <b>HOT-2</b>	I got this.		
17:39:27.5 <b>HOT-2</b>	all right...I'm gonna keep you about plus ten plus fifteen here plus fifteen.		
17:39:28.4 <b>HOT-1</b>	*		
17:39:28.9 <b>EGPWS</b>	three hundred. [electronic voice]		
17:39:31.3 <b>HOT-1</b>	rog'.		
17:39:31.6 <b>HOT-2</b>	down six.		
17:39:32.6 <b>HOT-1</b>	okay.		
17:39:33.1 <b>CAM</b>	[sound similar to altitude alert]		
17:39:34.7 <b>HOT-2</b>	we're plus ten down six.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:39:39.0 <b>EGPWS</b>	two hundred. [electronic voice]		
17:39:41.3 <b>HOT-2</b>	plus ten.		
17:39:43.1 <b>HOT-2</b>	you got it.		
17:39:43.2 <b>HOT-1</b>	* down.		
17:39:43.6 <b>HOT-1</b>	got it.		
17:39:44.6 <b>EGPWS</b>	sink rate. [electronic voice]		
17:39:45.4 <b>HOT-1</b>	yeah I know.		
17:39:46.0 <b>EGPWS</b>	sink rate. [electronic voice]		
17:39:47.5 <b>EGPWS</b>	fifty. [electronic voice]		
17:39:48.0 <b>HOT-2</b>	you're plus five.		
17:39:48.8 <b>EGPWS</b>	forty. [electronic voice]		
17:39:49.0 <b>HOT-1</b>	altitude.		



Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:39:49.5 <b>EGPWS</b>	twenty. [electronic voice]		
17:39:49.8 <b>HOT-2</b>	ref.		
17:39:50.7 <b>EGPWS</b>	ten. [electronic voice]		
17:39:54.0 <b>CAM</b>	[sound similar to touchdown]		
17:39:54.0 <b>HOT-2</b>	down.		
17:39:54.9 <b>HOT-1</b>	okay you got the yoke.		
17:39:54.9 <b>CAM</b>	[sound similar to engine reverse]		
17:39:55.3 <b>HOT-2</b>	I got it.		
17:39:56.8 <b>HOT-2</b>	[sound of (respiration)]		
		17:39:58.2 ?	[three sounds similar to clicking mic key]
17:39:59.3 <b>HOT-2</b>	(yeah we're) down there.		
17:40:00.6 <b>HOT-2</b>	eighty knots.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:40:01.5 <b>CAM</b>	[sound similar to Master Caution]		
17:40:02.6 <b>HOT-1</b>	*		
17:40:04.2 <b>HOT-2</b>	brakes.		
17:40:04.7 <b>HOT-1</b>	I got em all the way.		
17:40:06.3 <b>CAM</b>	[sound similar to Master Caution]		
17:40:07.5 <b>PA-3</b>	on behalf of PenAir and Alaska Airlines we'd like to welcome you to...Dutch Harbor.		
17:40:08.4 <b>HOT-1</b>	hang on.		
17:40:08.5 <b>CAM</b>	[sound of two thumps]		
17:40:11.4 <b>HOT-1</b>	I'm sliding.		
17:40:11.5 <b>CAM</b>	[sound similar to Master Caution]		
17:40:13.4 <b>HOT-1</b>	#.		
17:40:13.9 <b>HOT-2</b>	#####.		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:40:15.3 <b>CAM</b>	[sound similar to exhale]		
17:40:16.1 <b>HOT-2</b>	# # #.		
17:40:16.5 <b>CAM</b>	[sound similar to Master Caution]		
17:40:17.8 <b>HOT-2</b>	# # #.		
17:40:19.1 <b>CAM</b>	[sound of multiple low frequency thumps and thuds]		
17:40:19.8 <b>HOT</b>	[sounds of rattling]		
17:40:20.0 <b>HOT</b>	[sound similar to PA chime]		
17:40:20.6 <b>CAPTAIN SIDE MIC AND CAM STOP RECORDING</b>			
17:40:21.8 <b>HOT</b>	[sound similar to Master Caution]		
17:40:21.9 <b>HOT</b>	[sound similar to rapid ticking/brushing]		
17:40:23.4 <b>HOT-2</b>	# # #.		
17:40:24.4 <b>HOT</b>	[sound similar to Config Warning]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:40:24.7 <b>HOT-?</b>	[sound of groan/exhale/unintelligible speech]		
17:40:25.5 <b>HOT</b>	[sound similar to three FA call chimes]		
17:40:26.7 <b>HOT</b>	[sound similar to Master Warning]		
17:40:27.8 <b>HOT-2</b>	# # #.		
17:40:31.5 <b>HOT-1</b>	(evacuate.)		
17:40:31.8 <b>HOT</b>	[sound similar to Master Warning]		
17:40:36.8 <b>HOT-2</b>	#.		
17:40:36.9 <b>HOT</b>	[sound similar to Master Warning]		
17:40:37.7 <b>HOT</b>	[sound similar to Engine Fire Bell]		
17:40:39.9 <b>PA-1</b>	evacuate right hand side evacuate right hand side...(all people) evacuate right hand side get out get away.		
17:40:41.9 <b>HOT</b>	[sound similar to Master Warning]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:40:46.9 <b>HOT</b>	[sound similar to Master Warning]		
17:40:51.9 <b>HOT</b>	[sound similar to Master Warning]		
		17:40:52.3 <b>RDO-1</b>	Dutch Harbor PenAir thirty two ninety six we're off the runway uh...(just * get out) ** (emergency) equipment.
17:40:56.9 <b>HOT</b>	[sound similar to Master Warning]		
17:41:00.4 <b>HOT</b>	[sound similar to Config Warning]		
17:41:25.2 <b>HOT</b>	[sound of three switches actuating]		
17:41:27.0 <b>HOT</b>	[sound similar to DCU Startup/Restart]		
17:41:27.9 <b>HOT</b>	[sound similar to mic key]		
		17:41:28.6 <b>RDO-1</b>	and Dutch Harbor Radio we need uh - crash fire rescue...uh...crash fire rescue.
17:41:29.4 <b>HOT</b>	[sound similar to Master Warning]		
17:41:30.9 <b>HOT</b>	[sound similar to Config Warning]		

Time and Source	Intra-Aircraft Communication	Time and Source	Over-the-Air Communication
17:41:34.4 <b>HOT</b>	[sound similar to Master Warning]		
17:41:36.9 <b>HOT</b>	[sound of switch actuating]		
1741:37.2 <b>END OF TRANSCRIPT</b> <b>END OF RECORDING</b>			

## Appendix D: Comments from the Swedish Accident Investigation Authority and the United Kingdom Air Accidents Investigation Branch



Type of document	Page
LETTER	1 (3)
Date	Doc. number
28 October 2021	SHK L-149/19
Your reference	File number
N686PA Unalaska, Alaska, October 17, 2019	

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Senior Aviation Accident Investigator  
Investigator-in-Charge  
National Transportation Safety Board  
Office of Aviation Safety  
Major Investigations Division

### SHK and AAIB UK Submission of dissenting opinion to the draft report dated October 22, 2021:

*Aircraft Accident Report - Runway Overrun During Landing, N686PA, Unalaska, Alaska, October 17, 2019*

As accredited representatives from the Swedish Accident Investigation Authority (SHK) jointly with the Accredited Representative of the UK Air Accidents Investigation Branch (UK AAIB) we are hereby respectfully sending a submission of dissenting opinion to the NTSB.

Following separate and joint discussions between the investigating authorities, the NTSB, UK AAIB and SHK, we have now reviewed the NTSB amended report dated October 22, 2021 and request that our comments of dissenting opinion be appended to the final report (ref. chapter 6.3 including note 2 of Annex 13 to the Chicago Convention).

The statements below are the common and mutually agreed statements from the UK AAIB and SHK accredited representatives to this accident investigation.

Yours sincerely,

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**Dissenting opinions:****3.2: Probable cause:**

Based on the factual reports, we consider that the operational factors of landing the aircraft, from an unstable approach, in a reported wind well beyond the aircraft limitations, on a challenging runway without full consideration to the aircraft performance at time of arrival were the primary cause of this accident.

The aircraft had made many successful flights with the antiskid anomaly, including several to the accident airport; all were without incident. We consider it is the intentional exceedance of the aircraft limits, on a limiting runway, that revealed the previously hidden latent antiskid anomaly, and both were required to cause the accident.

We believe the *Probable Cause* section of the report does not reflect the causes of the accident in proportion to their actual contribution as described in the Analysis and the Findings sections of the report, neither does it highlight the wind conditions reported and recorded in the Meteorology factual report which indicated a tailwind of at least 20 knots\*.

Our analysis of the crew's disregard to changes in the dispatch planning conditions, the aircraft configuration, the repetitively reported wind speed which exceeded the aircraft tailwind limitations and the option of a fully available into wind reciprocal runway to be the dominating causal factors in this accident.

Furthermore, to try and prevent such accidents from happening in the future, we believe that addressing the operational aspects of landing in conditions clearly beyond the aircraft limitations will have better and broader effect.

**Other comments:**

We were surprised that a transport category aircraft is permitted to proceed with a landing in conditions and configuration different from those used in the pre-dispatch calculations, without an analysis of landing performance using time of arrival conditions and the inclusion of safety factors.

There have been several similar landing overrun accidents and we therefore suggest that a safety recommendation, to make it an operational requirement for the operator to evaluate the Time of Arrival conditions and re-evaluate the aircraft landing performance based on the FAA SAFO\*\* guidelines, would be an important step in trying to prevent similar accidents in the future.

**4.0 Recommendations:**

Regarding the recommendation to Saab.

Mitigating safety actions have been taken by both the landing gear manufacturer and Saab which should be sufficient to prevent re-occurrence of similar events.

The following safety actions were taken:



- Updated instructions and procedures and manuals for repair and overhaul
- Saab's mandatory one-time inspection of the Saab 2000 aircraft fleet
- Incorporation of a functional test of the anti-skid harness in the Aircraft Maintenance Manual (AMM) following maintenance, overhaul and installation of landing gear on aircraft.

We consider that these safety actions in addition to the existing instructions and illustrations provide an adequate multi-layered mitigation for such a system and therefore suggest these safety actions are included as safety actions taken, rather than a recommendation for a redesign.

Consideration should also be taken to proportionality in that Saab 2000 production ended 1999 and less than 45 aircraft remain in operational service worldwide.

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\* The wind reported from the AWOS just before landing (touchdown at time 1739:54) was 300/22 G25 kt (at time 1738), 310/23 (at time 1739), 310/20 G25 (at time 1740) and 310/19 G25 (at time 1741).

\*\* 19001 (Landing Performance Assessments at Time of Arrival dated March 11, 2019). To find the Landing Distance Required (LDR), multiply the certificated (i.e., AFM dry, unfactored) Landing Distance by the applicable LDF in Table 1 (1.67) for the runway conditions existing at the time of arrival.

## References

- EASA (European Union Aviation Safety Agency). 2020a. "Comment-Response Document 2019-05; Embodiment of Safety Management System (SMS) Requirements into Part 145 and Part 21," December 21. [https://www.easa.europa.eu/sites/default/files/dfu/crd\\_2019-05.pdf](https://www.easa.europa.eu/sites/default/files/dfu/crd_2019-05.pdf).
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- FAA (Federal Aviation Administration). 2021. "Airworthiness Directives; Saab AB, Support and Services (Formerly Known as Saab AB, Saab Aeronautics) Airplanes," *Federal Register*, February 22: 10447. <https://www.govinfo.gov/content/pkg/FR-2021-02-22/pdf/2021-01824.pdf>
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