Saab 2000 Runway Excursion in Dutch Harbor, Alaska

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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. 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 NTSB launched a Go Team from NTSB headquarters in Washington, D.C., while an investigator from the NTSB Anchorage regional office travelled to secure the wreckage and recover the flight recorders. Parties to the investigation were the Federal Aviation Administration (FAA), 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 (SHK) participated in the investigation as the accredited representative of the state of design and manufacture of the aircraft. The United Kingdom (UK) Air Accidents Investigation Branch (AAIB) 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 and European Union Aviation Safety Agency (EASA) participated in the investigation as technical advisors to the SHK, and Dowty Propellers, APPH, and Rolls-Royce participated in the investigation as technical advisors to the UK AAIB.

As a result of this investigation, the NTSB issued six new safety recommendations to the FAA, three new safety recommendations to EASA, and one new recommendation to the Saab Group. For more information about the PenAir 3296 accident investigation, see the NTSB’s website, www.ntsb.gov, and access the public docket for this investigation (DCA20MA002) and/or the final report (NTSB/AAR-21/05) [1].

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 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 pilot-in-command (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" [1].

From a causal perspective, the extent of the antiskid system issue laid latent for the 4 months the aircraft had been in service with PenAir until maximum braking performance was required. The crew's decision to land with an excessive tailwind on DUT's 3900 ft runway elicited the need for maximum braking and correspondingly exposed the latent failure in the antiskid system. Both elements contributed to this runway overrun, the severity of which was influenced by an insufficient runway safety area. This paper illustrates how these proximate factors were further evaluated to identify root factors and develop corresponding safety recommendations.

Proximate Factor 1: Crew decision to land with excessive tailwind.

During post-accident 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 [2]. 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.

Provided one "what went wrong?" answer had been determined here to be an inappropriate crew decision, Figure 1 details a subset of investigative questions leading to the root causes or "why" the captain made this decision despite being considered by many as a competent and experienced pilot.

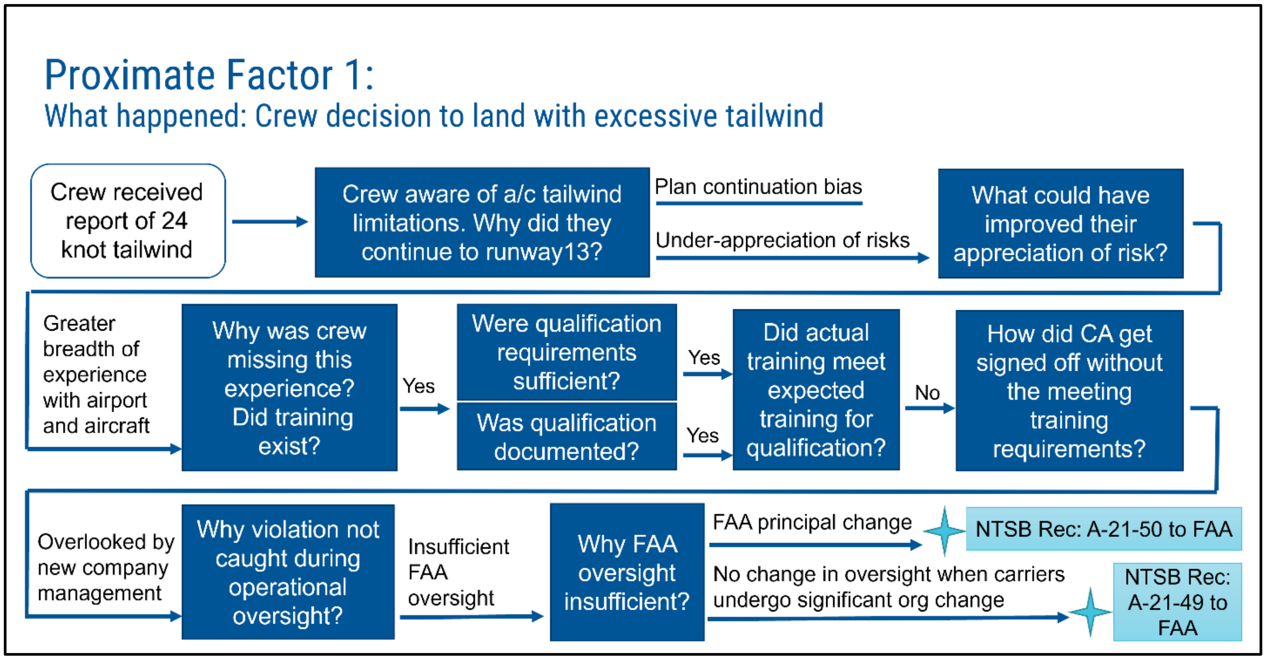

Figure 1. Flowchart illustrating investigative path to understand why the crew landed with an excessive tailwind and develop safety recommendations.

The unique challenges pilots face when operating at DUT are primarily due to surrounding terrain. This terrain constrains access to the airport, resulting in complex approach and departure procedures. It can also contribute to highly dynamic local weather such as strong and varying winds and low-level wind shear, which can greatly affect aircraft performance when landing on the short runway.

The crew's behavior was consistent with an underappreciation of the risks of landing on DUT's shorter runway with a reported tailwind 60% over the aircraft's limitations. Human decision-making in novel situations is highly dependent on prior experience and training [3]. Therefore, the investigation evaluated what training or experience could have helped the crew understand the unique risks of operating the Saab 2000 at Dutch Harbor. It was discovered that PenAir had specialized qualification requirements for captains flying into DUT as it was considered an FAA-designated special airport. Captains were required to amass a minimum of 300 hours flying as captain in the aircraft prior to being qualified to operate at a FAA-designated special airport. For captains especially experienced in the aircraft and operations at DUT, there was a waiver process to approve special airports qualification after 100 hours. According to the former chief pilot for PenAir, he would have considered using the waiver if that person had "10 years flying Saab 2000s or, […] 10 years of flying in and out of Dutch Harbor every day" [2].

Upon review of these qualifications, the intent there-of showed company procedures reflected the need for an extensive breadth of exposure to the different operating conditions at DUT. Further, review of the documentation of the captain's qualification showed he received a waiver and approval to fly into DUT after completing training. In theory, these should have been sufficient for the captain to have understood the risks; however, further investigation revealed that the captain did not meet required the 100 hours experience requirement as aircraft PIC or have the recommendation letter required for the waiver to be used. The company had mis-applied the DUT qualification waiver, resulting in the captain being approved to fly into DUT without the necessary breadth of experience to fully appreciate the unique challenges faced when operating at the airport.

This posed the next question of how he was approved to fly without the required training. At the time of the accident, the company had recently undergone significant change in management due to a merger with Ravn Air Group the year before. Interviews with company personnel familiar with the operations prior to and following this merger revealed a new management shift in attitude regarding operating into FAA-designated special airports. The VP of flight operations at Ravn stated during an interview with NTSB that their goal was to move PenAir towards operational efficiency present in the continental US. Pilots and management familiar with the operations prior to the merger voiced concern of new management initiatives to reduce the requirements to fly into special airports. Ultimately, at the time of the accident, no official change to the special airport qualifications was made; however, as mentioned, the accident captain had been approved to fly by the chief pilot without meeting necessary experience qualifications. The chief pilot had stated she was not aware that the 100-hour requirement had to be met, nor that a written recommendation letter was required to apply the waiver. The NTSB reviewed the verbiage in PenAir's guidance and found it to be consistent with the understanding described by personnel who had been with PenAir prior to the change in management.

While internal company operational oversight programs within Part 121 air carriers are intended to capture errors/violations in procedure application, such as the one that allowed the captain to fly into DUT without the required experience, FAA oversight is the remaining element to ensure company procedures are being followed. In this case, the investigation revealed that FAA surveillance was unable to capture this error in addition to shifts in safety culture that accompanied PenAir's acquisition by Ravn and resulting changes in management.

The investigation revealed that PenAir's FAA certificate management team (CMT) had been reassigned shortly prior to the accident and the new principals had limited information about specific challenges at PenAir. Further, it was found that FAA guidance did not account for changes needed in surveillance to reflect additional risks when operators are undergoing periods of significant organizational change.

Ultimately, the proximate factor of the crew decision-making error resulted in the NTSB issuing two recommendations addressing root factors to the FAA to (1) emphasize with CMTs importance of detecting and mitigating the safety risks that can result when certificate holders experience significant organizational change and (2) revise guidance to include a formalized transition procedure for CMT personnel responsible for overseeing a certificate holder that is undergoing significant organizational change to ensure that incoming CMT personnel are fully aware of potential safety risks [4].

Proximate Factor 2: Significant reduction in braking capability due to cross-wiring of antiskid wire harnesses.

Post-accident examination of the airplane's antiskid brake system found that the wire harnesses for the left (L) 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 L outboard wheel (and vice versa). As a result of the incorrect (crossed) wiring, the antiskid system performance was substantially compromised. The incorrect wheel speed transducer wiring most likely occurred during the overhaul of the L MLG at the landing gear manufacturer's facility in January 2017, more than 2.5 years before the accident.

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.

For this proximate factor, the "what went wrong?" answer was determined to be the cross-wiring of the L MLG antiskid wheel speed transducers. Figure 2 details a subset of investigative questions leading to the root causes of how this error occurred and could be prevented in the future.

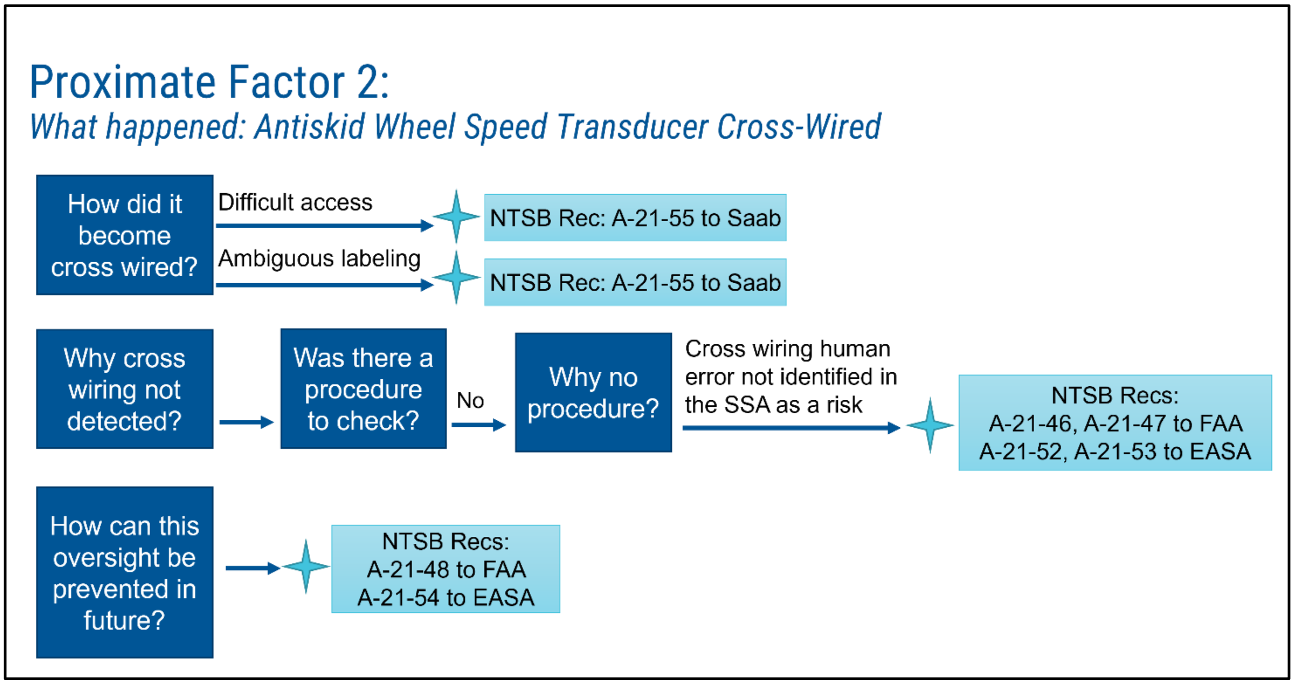

Figure 2. Investigative path illustrating how safety recommendations were developed to mitigate the risk of MLG cross-wiring in the future.

Upon discovering the wires were crossed, the investigation strove to understand how this error occurred. Figure 3 illustrates that the top end connectors of the wire harness had labels and individual mating keys for the left (yellow line in figure 3) and right (teal line in figure 3) wheels; however, the area is difficult to access in the wheel well and labels would not have been easily readable. The bottom end connecters were more easily accessed; however, both connectors were identical with the same part numbers and mating keys. Therefore, the human factors involved with connecting these harnesses were not optimal for ensuring the correct wiring between L and R wheels of a MLG. As a result, the NTSB issued a recommendation to Saab to redesign the antiskid wire harness to prevent human error that could result in cross-wiring [4].

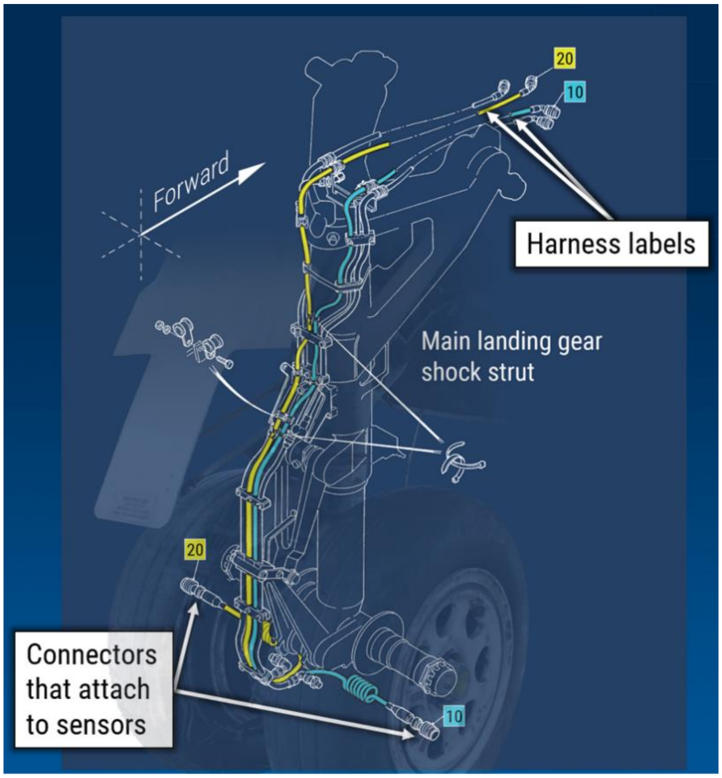

Figure 3 Main landing gear depiction with anitskid wheel speed tranducer wiring harness (yellow indicates the wiring for the left wheel and teal indicates the wiring for the right wheel). Source: APPH. Adapted from [1].

Where maintenance hazards could result in serious consequences, a common mitigation is to conduct a verification test to ensure the hazard does not exist. In this case, a procedure to verify the functionality of the antiskid system following maintenance may have been beneficial to identify the error before the aircraft re-entered service. The NTSB investigated why such a procedure did not exist and found that the manufacturer's system safety assessment 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. 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 [4].

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. Further, a review of similar cases revealed the potential for cross-wiring of wheel speed transducer harnesses during installation or maintenance exists for other airplane types as well [5, 6, 7].

A recommendation was issued to the FAA and EASA to identify system safety assessments for landing gear systems on currently certificated (and future 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 [4].

After evaluating how these oversights could be prevented in the future, the NTSB made an additional recommendation to the FAA and EASA to require organizations that design, manufacture, and maintain aircraft to establish a safety management system (SMS) [4]. 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.

Proximate Factor 3: Runway safety area not sufficient for regular operation of Saab 2000 into DUT.

The fatal injury in this accident was caused when a propeller projectile entered the cabin once it separated from the engine after impacting a boulder at the end of the runway. RSAs were developed to protect an aircraft from terrestrial hazards in the case of runway excursions. Post-accident analysis revealed that the airplane would have been able to stop within a runway safety area that was suitable for the operation; however, the actual RSA at DUT for each runway was 700 feet shorter than what would have been suitable for an aircraft with the approach speed and size of the Saab 2000.

Figure 4. Graphic depicting the runway safety areas at DUT at the time of the accident.

For this proximate factor, the "what went wrong" answer was determined to be that the RSA at DUT was of insufficient length to protect for a runway overrun of the Saab 2000. Figure 5 details a subset of investigative questions leading to the root causes of how PenAir received approval to fly this aircraft into DUT on a consistent schedule despite this discrepancy.

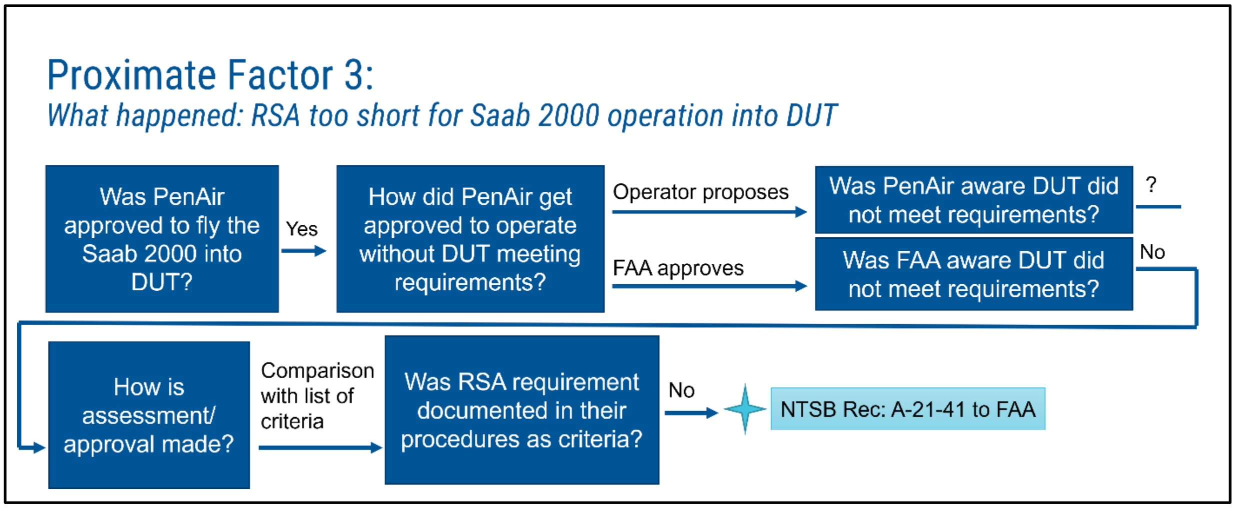

Figure 5. Flowchart illustrating investigative path to understand how the Saab 2000 was approved to operate into DUT despite the insufficient runway safety area for the aircraft size/speed and develop safety recommendations.

The investigation found that the approval process for an air carrier to operate on a regular basis at a specific airport involves the operator providing a proposal and the FAA evaluating the proposal and approving the operation. The investigation could not determine if PenAir had been aware of and accounted for the insufficient RSA in its proposal to the FAA to operate the Saab 2000 into DUT as a ransomware attack on PenAir computer systems in December 2019 compromised documentation related to this proposal. Upon interviewing FAA personnel that approved PenAir's operation of the Saab 2000 into DUT, it was discovered that FAA personnel were not aware of the discrepancy at the time of the accident or when approval was provided earlier that year [8]. This lack of awareness resulted in neither PenAir nor the FAA considering potential mitigations to ensure that the Saab 2000 could safely operate at the airport.

Upon evaluation of the FAA's process for approval, it was discovered that the guidance used in this assessment did not include evaluating the RSA dimensions appropriateness for the size/speed of the aircraft operating into the airport. Therefore, the NTSB recommended to the FAA to 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 [4].

Investigative Challenges:

One major challenge to this investigation involved the remote accident location. This resulted in over 24 hours of travel time for the team from NTSB headquarters to arrive on-scene. The airplane wreckage was blocking a major thoroughfare through the local town and the NTSB team's delayed arrival increased pressure to move the aircraft limiting the time available for investigators to document the wreckage prior to recovery.

There was no access initially to a suitable land-based crane to move the airplane wreckage from the accident location, and a barge-based crane was used to recover the aircraft resulting in further complexity to transport to its storage location and delays to investigator access to the aircraft. This recovery option also introduced the additional risk of losing aircraft parts in the water.

This delay in arrival and limited infrastructure availability extended the time the airport runway was out of service following the accident. In DUT, the airport is a critical element in the supply chain for basic societal needs; therefore, the closed runway brought about shortages that influenced citizens of the town meeting their grocery, mail, and medical needs.

Additionally, the NTSB headquarters cell phones did not function on the available network in DUT, and Wi-Fi at the hotel was limited resulting in delays to communications and limitations in access to airplane data. The local police department was able to acquire several cell phones for NTSB use which allowed each investigative group to have access to the command center and investigator-in-charge.

Further, the remote accident location combined with immigration challenges in San Francisco delayed the arrival of the SHK and Saab team providing technical support for the investigation.

Finally, the rapidly changing weather at DUT with rain, snow, and strong winds posed challenges to airplane recovery, aircraft access, and investigator safety on scene.

During the investigation, there were 2 instances of evidence being lost during the shipping process. This involved the L MLG antiskid outboard control valve and the crew toxicological samples for assessment by FAA. The tox box was subsequently located 3 months later at the airport. Samples were sent and evaluated, and results were qualified to account for errors that could have resulted from this delay in processing. The L MLG box arrived at NTSB headquarters; however, the box was water damaged and the outboard antiskid control valve was missing. This evidence was not subsequently recovered.

The COVID-19 pandemic began a few months after the accident occurred. The resulting limits to societal interaction caused a 7-month delay in returning to the wreckage to retrieve the remains of the antiskid system wheel speed transducer wire harnesses for the left and right main gear for testing. Because the testing of the antiskid components did not reveal any significant faults, these wires were critical in determining the cause of the significant loss of braking capacity.

In December 2019, a ransomware attack on the PenAir computer system compromised many company documents; therefore, documentation requested following this attack took extended time to recover or was not recoverable at all and could not be used in the investigation. Further, Ravn declared bankruptcy 7 months into the investigation. The party coordinator for the airline remained engaged to support the investigation; however, safety recommendations to the company were not issued because they were no longer operating.

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