National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: December 7, 2011

In reply refer to: A-11-92 through -95
A-07-61 (Reiteration)

Mr. Michael P. Huerta
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

On December 22, 2009, about 2222 eastern standard time, American Airlines flight 331, a Boeing 737-800, N977AN, ran off the departure end of runway 12 after landing at Norman Manley International Airport (KIN) Kingston, Jamaica. The aircraft landed approximately 4,000 feet down the 8,911-foot-long, wet runway with a 14-knot tailwind component and was unable to stop on the remaining runway length. After running off the runway end, it went through a fence, across a road, and came to a stop on the sand dunes and rocks above the waterline of the Caribbean Sea adjacent to the road.[1] No fatalities or postcrash fire occurred. Eighty-five of the 154 occupants (148 passengers, 4 flight attendants, and 2 pilots) received injuries ranging from minor to serious. The airplane was substantially damaged. Instrument meteorological conditions and heavy rains prevailed at the time of the accident flight, which originated at Miami, Florida, on an instrument flight rules flight plan.[2]

During flight 331's approach to KIN, air traffic control (ATC) advised the flight crew that it may be necessary to circle to land on runway 30 and indicated a wind from 320º at 10 knots. The flight crewmembers acknowledged the wind information and informed ATC of their intent to do a straight-in approach to runway 12. The KIN tower then indicated a wind direction of 320º at 14 knots and asked if the flight crew still wanted to land on runway 12. The flight crew confirmed runway 12, and the tower then advised that the runway was wet.[3] The flight crew

[1] After leaving the runway, the airplane travelled about 74 feet horizontally and dropped about 9.5 feet vertically before its initial impact with the sand berm. After impacting the berm, the airplane travelled about 100 feet along the upsloping berm before coming to rest.

[2] The Jamaican Civil Aviation Authority is conducting the investigation of this accident. In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, the National Transportation Safety Board is participating in the investigation, representing the State of the Operator, as well as Manufacture and Design.

[3] According to an interview with the KIN tower controller, the "wet" advisory was based on her knowledge that it was raining and observations outside rather than on any inspection information provided by airport operations personnel.

configured the airplane to land with a flap setting of 30º rather than the full flap setting of 40º.[4] Both flight crewmembers later reported that they felt the airplane float[5] prior to touchdown. Neither pilot called for a go-around at any point during the approach and landing.

Available information indicated that, at the time of departure from Miami, flight 331 was properly dispatched (according to the requirements of 14 CFR 121.195) to runway 12 at KIN based on "wet/good" runway conditions[6] at an estimated landing weight of 143,900 pounds and assuming no tailwind. However, weather conditions upon arrival at KIN had deteriorated since the flight's departure. Both crewmembers stated during postaccident interviews that they had landed at KIN many times and did not perform an arrival landing distance assessment to runway 12, even after ATC provided wind information that indicated tailwind conditions were present for that runway. The American Airlines 737 Operating Manual directs that an arrival landing distance assessment be performed if landing conditions change after departure, taking into consideration meteorological and runway surface conditions, among other factors.[7]

In the last 10 years, many aviation safety organizations have studied runway overruns involving transport-category airplanes to identify high risk factors that lead to overruns and strategies to mitigate risks. A common finding is that the risk of an overrun is greatly increased when landings are conducted on contaminated runways in tailwind conditions.[8] Any tailwind increases the approach and touchdown groundspeed of an aircraft, requiring more runway length to decelerate. This factor can be critical where poor runway conditions exist or where the required runway length for landing is close to the available runway length. Accordingly, the NTSB's investigations of several runway overrun accidents[9] and resultant recommendations[10]

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[4] American Airlines Boeing 737 Operating Manual, "Approach-Landing-Go Around," page 15.2 states, "flaps 15, 30, or 40 are the normal landing flap settings." It further states, in part, "use of flaps 40 is recommended when landing with…[t]ailwind." During his interview with investigators, the captain stated that flaps 30 "was normal for this situation," and further stated that "for these conditions and for the go-around, flaps 30 was the better choice."

[5] Floating occurs when an aircraft enters ground effect and the increased lift makes it more difficult for the pilot to place the aircraft on the runway within the touchdown zone. As a result, the aircraft will use up additional runway (float) prior to touchdown, reducing the length of runway available for stopping.

[6] Required American Airlines 737-800 runway landing length charts use the following runway condition classifications: dry, wet/good, fair/med, and poor. According to American Airlines dispatch procedures, airplanes cannot be dispatched to runways with fair/med or poor conditions. The flight crew's dispatch paperwork for flight 331 also included a field condition report for KIN that described runways 12 and 30 as wet.

[7] American Airlines training personnel indicated during interviews that it was company policy, per American Airlines 737 Operating Manual Bulletin 737-07 (dated November 27, 2006), to not require flight crews to calculate landing distance assessments for individual runways if the conditions had not changed from those present at dispatch. While the American Airlines dispatcher for flight 331 dispatched the flight to a "wet" runway at KIN based on the forecast weather and the possibility of rain at the time of the flight's scheduled arrival, he did not (nor was he required to) factor in wind conditions (either a headwind or a tailwind) for dispatch landing purposes.

[8] For more information see (a) G.W.H. van Es and A.K. Karwal, *Safety Aspects of Tailwind Operations*, NLR-TP-2001-003 (The Netherlands: National Aerospace Laboratory NLR, 2001); (b) *Runway Excursions, Part 1: A Worldwide Review of Commercial Jet Aircraft Runway Excursions*, Aviation Research and Analysis Report – AR--2008-018(1) (Commonwealth of Australia: Australian Transport Safety Bureau, 2008); and (c) *Runway Safety Initiative: Reducing the Risk of Runway Excursions* (Alexandria, VA: Flight Safety Foundation, 2009).

[9] For more information see a) *Runway Overrun and Collision, Southwest Airlines Flight 1248, Boeing 737-7H4, N471WN, Chicago Midway International Airport, Chicago, Illinois, December 8, 2005*, Aircraft Accident Report NTSB/AAR-07/06 (Washington, DC: NTSB, 2007); b) *Runway Overrun During Landing Shuttle America, Inc.*

have focused on runway surface conditions and a lack of required arrival landing distance assessments; however, the accident involving American Airlines flight 331 highlights deficiencies in operational procedures and flight crew training and guidance concerning landing in tailwind conditions that should be addressed.

Training and Guidance in Mitigating the Risk of Runway Overruns

The 2009 Flight Safety Foundation publication *Reducing the Risk of Runway Excursions* provides prevention strategies for flight operations departments to implement as a means of addressing risk factors associated with runway overruns, including ensuring flight crews understand "that landing with a tailwind on a contaminated runway is not recommended." This publication also recommends that operators "define and train procedures for…[g]o-around, including during flare and after touchdown." At the time of the accident, American Airlines had a no-fault go-around policy in place that was documented in the American Airlines Flight Manual. The policy states, in part, that it exists in recognition that "a successful approach can end in a missed approach" and that "if in the pilot's judgment a safe landing cannot be accomplished within the touchdown zone, or the aircraft cannot be stopped within the confines of the runway, a go-around is…required."

Advisory Circular (AC) 91-79, "Runway Overrun Prevention," also provides a means for pilots and operators of turbine-powered airplanes to identify, understand, and mitigate risks associated with runway overruns during the landing phase of flight, including detailed information that may be used to develop company standard operating procedures to mitigate those risks. As a risk mitigation, the AC indicates that operators' standard operating procedures should address when to execute a go-around, but the AC does not discuss the increased risk of runway overrun during a landing in tailwind conditions or the associated mitigation strategies to prevent runway overruns while landing with a tailwind, such as fully extending flaps or being prepared to go around.

To ensure sufficient runway length is available to stop, pilots must land their aircraft within the touchdown zone,[11] which is a task made more challenging in tailwind conditions. Federal regulations concerning airline flight training requirements do not require that pilots receive training in conducting landings with a tailwind. The 737-800 fleet training manager for American Airlines indicated during an interview that the company does not provide training for

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Doing Business as Delta Connection Flight 6448 Embraer ERJ-170, N862RW, February 18, 2007, Aircraft Accident Report NTSB/AAR-08/01 (Washington, DC: NTSB, 2008; c) *Runway Overrun During Landing, Pinnacle Airlines Flight 4712, Bombardier/Canadair Regional Jet Cl600-2B19, N8905F, Traverse City, Michigan, April 12, 2007* Aircraft Accident Report NTSB/AAR-08/02 (Washington, DC: NTSB, 2008); and d) *Southwest Airlines Flight 1455, Boeing 737-300, N668SW, Burbank, California, March 5, 2000*, Aircraft Accident Brief NTSB/AAB-02/04 (Washington, DC: NTSB, 2002).

[10] These recommendations include Safety Recommendations A-07-57 and A-07-61 through -63, which were issued as a result of the NTSB's investigation of the December 8, 2005, Southwest Airlines flight 1248 accident; Safety Recommendation A-08-17, which was issued following the investigation of the February 18, 2007, Shuttle America accident; and Safety Recommendation A-08-41, which was issued following the NTSB's investigation of the April 12, 2007, accident involving Pinnacle Airlines flight 4712.

[11] The touchdown zone is defined as the first third of the available landing distance but in no case more than 3,000 feet down the available landing distance. Volume 1, Section 10 of the American Airlines Flight Manual defines the desired touchdown point as within the first 800 to 1,500 feet beyond the landing threshold.

tailwind landings but does provide training for landings at higher elevations because “there was no difference between a high altitude landing versus a tailwind landing as there was a higher speed” associated with both. He also stated that he could not identify a benefit for training in tailwind landings.

The flight crew of flight 331 stated during postaccident interviews that they had landed with a tailwind before but had not received any training on conducting landings in tailwind conditions. American Airlines line pilots also reported that they do not receive training on tailwind landings during simulator or flight training nor do they receive guidance (including mitigation strategies) about the runway overrun risks associated with tailwind landings. The American Airlines Boeing 737 Operating Manual contains no restriction (beyond the airplane limitation) for a tailwind landing on a wet or contaminated runway, and landing with full flaps is only recommended. Several line pilots stated that the first time they had ever conducted a tailwind landing was during line operations. The NTSB believes pilots should be knowledgeable about the effects of a tailwind on the landing performance of their aircraft and should be trained on specific procedures and techniques associated with conducting tailwind landings, with the aim of reducing the risk of a runway overrun. While it may not be possible to train flight crews on tailwind landings in an actual airplane due to the variable dynamics of weather and ATC restrictions, an airline may train flight crews on tailwind landings in a full-motion flight simulator. With the availability of advanced simulation and technology, most flight training for airline pilots is accomplished in flight simulation training devices as allowed by 14 CFR Parts 121 and 135.

The NTSB concludes that providing pilots training in tailwind landings would improve pilots’ preparation in mitigating the risk of runway overruns while landing in tailwind conditions. Therefore, the NTSB recommends that the Federal Aviation Administration (FAA) require principal operations inspectors (POI) to review flight crew training programs and manuals to ensure training in tailwind landings is (1) provided during initial and recurrent simulator training; (2) to the extent possible, conducted at the maximum tailwind component certified for the aircraft on which pilots are being trained; and (3) conducted with an emphasis on the importance of landing within the touchdown zone, being prepared to execute a go-around, with either pilot calling for it if at any point landing within the touchdown zone becomes unfeasible, and the related benefits of using maximum flap extension in tailwind conditions.

The NTSB also concludes that because the dynamics of a tailwind approach and landing, particularly on wet or contaminated runways, expose flight crews to additional risks and challenges, they should be provided current and comprehensive guidance regarding the risks associated with tailwind landings and made aware of the reduced margins of safety during tailwind landing operations. Therefore, the NTSB recommends that the FAA revise AC 91-79 “Runway Overrun Prevention” to include a discussion of the risks associated with tailwind landings, including tailwind landings on wet or contaminated runways as related to runway overrun prevention. Once AC 91-79 has been revised, the NTSB recommends that the FAA require POIs to review airline training programs and manuals to ensure they incorporate the revised guidelines concerning tailwind landings.

Landing Distance Assessments

Although flight 331 was properly dispatched under the provisions of section 121.195(b)[12] at the time of departure, the weather conditions upon arrival at KIN (heavy rains and tailwind) had deteriorated, and the flight crew did not perform an arrival landing distance assessment for runway 12 as provided in the American Airlines 737 Operating Manual. As noted in Flight Safety Foundation Approach and Landing Accident Reduction (ALAR) Briefing Note 8.1,[13] a factor in runway overruns is worse-than-anticipated runway conditions. Had the flight crew performed an arrival landing distance assessment, the pilots would have determined, based on American Airlines landing distance charts, that the airplane was capable of landing within the available runway length with a 30º flap setting and 14-knot tailwind[14]; however, the arrival landing distance assessment also would have alerted the pilots that the stopping margin under these conditions was reduced, which may have prompted them to consider overrun risk mitigation strategies, such as using full flaps and maximum manual braking, selecting a different runway, considering a go-around, or choosing to divert.

Because the performance effects of a tailwind on landing distance are not taken into account for dispatch purposes,[15] flight crews would be better prepared to employ runway overrun risk mitigation strategies if they had a full understanding of the performance issues associated with a tailwind landing on a particular runway. A reliable way for flight crews to assess aircraft performance in actual wind conditions before landing is the required performance of a landing distance assessment before every arrival.

Following its investigation of the runway overrun accident involving Southwest Airlines flight 1248, the NTSB issued Safety Recommendation A-07-61 on October 2, 2007, which asked the FAA to do the following:

> Require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to accomplish arrival landing distance assessments before every landing

[12] Dispatch, or factored, landing distance calculations are used during flight planning to ensure that dispatched airplanes will be able to land safely at the intended destination airport or a planned alternate and are based on estimated landing weights and forecast conditions. Factored landing distances, including preflight landing safety margins, are required and standardized by U.S. and international aviation authorities. Specifically, in accordance with 14 CFR 121.195, "Airplanes: Turbine Engine Powered: Landing Limitations: Destination Airport," "no person operating a turbine engine powered large transport-category airplane may take off unless the weight of the airplane on arrival…would allow a full stop landing at the intended destination airport within 60 percent of the effective length of each runway." The effective runway length (factored) is further extended by 15 percent if "the runways at the destination airport may be wet or slippery at the estimated time of arrival."

[13] ALAR Briefing Note 8.1 is part of the Flight Safety Foundation ALAR toolkit, which is a collection of awareness materials designed to help reduce the frequency and severity of approach and landing accidents and incidents.

[14] Assuming a 1,000 foot air distance from 50 feet to touchdown and a landing within the touchdown zone, the pilots would have calculated an arrival landing distance of about 7,500 feet on a wet/good runway with a 9-knot tailwind and a 30º flap setting; considering a wet/good runway with a 14-knot tailwind and a 30º flap setting, they would have calculated a required landing distance of about 8,100 feet.

[15] Sections 121.195(b), 135.385(b), and 91.1037(b) and (c) require operators to comply with certain landing distance requirements at the time of takeoff that limit the allowable takeoff weight to that which would allow the airplane to land within a specified percentage of the landing distance available on the most favorable runway at the destination airport under still air conditions and the most suitable runway in the expected wind conditions.

> based on a standardized methodology involving approved performance data, actual arrival conditions, a means of correlating the airplane's braking ability with runway surface conditions using the most conservative interpretation available, and including a minimum safety margin of 15 percent.

In its most recent response (dated August 23, 2010) concerning this recommendation, the FAA stated that it was evaluating recommendations provided by the Take Off and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC) and intended to initiate rulemaking in 2011. The FAA also stated that, in the interim, it was validating the accuracy and usability of the ARC-developed runway surface condition reporting matrix, which forms the foundation for many of the TALPA recommendations, and continuing to encourage operators to incorporate the safety elements contained in Safety Alert for Operators 06012[16] pending the completion of the rulemaking process. The FAA stated that it would provide an updated response by January 2011. Safety Recommendation A-07-61 is classified "Open—Acceptable Response."

Although the FAA published SAFO 06012 with the intent of pursuing rulemaking that addresses landing distance assessments, in the interim, operators are still not required to comply with its recommendations and currently many operators do not.[17] During postaccident interviews, the American Airlines 737-800 aircrew program manager stated that he was not familiar with the operational aspects of SAFO 06012, and an American Airlines ground instructor stated that the airline did not provide instructors and check airmen with SAFO information that would benefit pilots' decision-making when considering overrun prevention.

The NTSB is concerned that, because of operational and conditional variations that may include a tailwind landing upon arrival at the destination, it is possible for an airplane to use more of the landing runway than predicted during preflight (dispatch) calculations and for pilots to continue to overrun runways while landing. As the FAA concluded in SAFO 06012, operator compliance with preflight landing distance planning requirements alone "does not ensure that the airplane can safely land within the distance available on the runway in the conditions that exist at the time of arrival, particularly if the runway, runway surface condition, meteorological conditions, airplane configuration, airplane weight, or use of airplane ground deceleration devices is different than that used in the preflight calculation." The FAA continues to rely on

[16] Issued in August 2006, SAFO 06012 states, in part, that its purpose is to urgently recommend that operators of turbojet airplanes "develop procedures for flightcrews to assess landing performance based on conditions actually existing at time of arrival, as distinct from conditions presumed at time of dispatch. … Once the actual landing distance is determined, an additional safety margin of at least 15% should be added to that distance. Except under emergency conditions flightcrews should not attempt to land on runways that do not meet the assessment criteria and safety margins as specified in this SAFO."

[17] According to SAFO 06012, "A survey of operators' manuals indicated that approximately fifty percent of the operators surveyed do not have policies in place for assessing whether sufficient landing distance exists at the time of arrival, even when conditions (including runway, meteorological, surface, airplane weight, airplane configuration, and planned usage of decelerating devices) are different and worse than those planned at the time the flight was released." In its December 17, 2007, response to Safety Recommendation A-07-57, the FAA reported that, on the basis of its survey of Part 121 operators, 92 percent of U.S. air carrier passengers were being transported by carriers that had adopted SAFO 06012 in full or in part. However, the FAA did not indicate the percentage of Part 121 carriers that had fully adopted the SAFO or those parts of the SAFO that had not been adopted by other Part 121 carriers.

operators' voluntary compliance with SAFO 06012 but, as demonstrated by statements provided by American Airlines personnel, the SAFO is not being consistently disseminated or implemented. The NTSB concludes that, until rulemaking requiring the performance of arrival landing distance assessments is complete, the FAA needs to ensure that operators distribute the information in SAFO 06012 to the necessary personnel. Therefore, the NTSB recommends that the FAA require POIs to ensure that the information contained in SAFO 06012 is disseminated to Part 121, 135, and 91 subpart K instructors, check airmen, and aircrew program designees and they make pilots aware of this guidance during recurrent training.

The NTSB did not receive an update in January 2011 on the status of the rulemaking as stated in the FAA's August 2010 response concerning Safety Recommendation A-07-61. If implemented as recommended, this rulemaking would require Part 121, 135, and 91 subpart K flight crews to perform arrival landing distance assessments for the specific runway of intended landing, including operations conducted in tailwind conditions. More than 4 years after this recommendation was issued, the continued lack of this requirement greatly reduces the likelihood that flight crews will make fully informed decisions about the performance capabilities of their aircraft prior to landing, particularly on wet or contaminated runways, and, under such circumstances, increases the risk of a runway overrun. Therefore, the NTSB reiterates Safety Recommendation A-07-61 and reclassifies it "Open—Unacceptable Response."

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Require principal operations inspectors to review flight crew training programs and manuals to ensure training in tailwind landings is (1) provided during initial and recurrent simulator training; (2) to the extent possible, conducted at the maximum tailwind component certified for the aircraft on which pilots are being trained; and (3) conducted with an emphasis on the importance of landing within the touchdown zone, being prepared to execute a go-around, with either pilot calling for it if at any point landing within the touchdown zone becomes unfeasible, and the related benefits of using maximum flap extension in tailwind conditions. (A-11-92)
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> Revise Advisory Circular 91-79, "Runway Overrun Prevention," to include a discussion of the risks associated with tailwind landings, including tailwind landings on wet or contaminated runways as related to runway overrun prevention. (A-11-93)
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> Once Advisory Circular 91-79, "Runway Overrun Prevention," has been revised, require principal operations inspectors to review airline training programs and manuals to ensure they incorporate the revised guidelines concerning tailwind landings. (A-11-94)
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> Require principal operations inspectors to ensure that the information contained in Safety Alert for Operators 06012 is disseminated to 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K instructors, check airmen, and

aircrew program designees and they make pilots aware of this guidance during recurrent training. (A-11-95)

The National Transportation Safety Board also reiterates the following recommendation to the Federal Aviation Administration and reclassifies it "Open—Unacceptable Response":

Require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to accomplish arrival landing distance assessments before every landing based on a standardized methodology involving approved performance data, actual arrival conditions, a means of correlating the airplane's braking ability with runway surface conditions using the most conservative interpretation available, and including a minimum safety margin of 15 percent. (A-07-61)

In response to the recommendations in this letter, please refer to Safety Recommendations A-11-92 through -95 and A-07-61. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman