National Transportation Safety Board
Washington, D.C. 20594

Safety Recommendation

Date: December 10, 2001

In reply refer to: A-01-49 through -70

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On June 1, 1999, at 2350:44 central daylight time,[1] American Airlines flight 1420, a McDonnell Douglas DC-9-82 (MD-82), N215AA, crashed after it overran the end of runway 4R during landing at Little Rock National Airport in Little Rock, Arkansas. Flight 1420 departed from Dallas/Fort Worth International Airport, Texas, about 2240 with 2 flight crewmembers, 4 flight attendants, and 139 passengers aboard and touched down in Little Rock at 2350:20. After departing the end of the runway, the airplane struck several tubes extending outward from the left edge of the instrument landing system localizer array, located 411 feet beyond the end of the runway; passed through a chain link security fence and over a rock embankment to a flood plain, located approximately 15 feet below the runway elevation; and collided with the structure supporting the runway 22L approach lighting system. The captain and 10 passengers were killed; the first officer, the flight attendants, and 105 passengers received serious or minor injuries; and 24 passengers were not injured. The airplane was destroyed by impact forces and a postcrash fire. Flight 1420 was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 on an instrument flight rules (IFR) flight plan.[2]

The National Transportation Safety Board determined that the probable causes of this accident were the flight crew's failure to discontinue the approach when severe thunderstorms and their associated hazards to flight operations had moved into the airport area and the crew's failure to ensure that the spoilers had extended after touchdown. Contributing to the accident were the flight crew's (1) impaired performance resulting from fatigue and the situational stress associated with the intent to land under the circumstances, (2) continuation of the approach to a landing when the company's maximum crosswind component was exceeded, and (3) use of reverse thrust greater than 1.3 engine pressure ratio (EPR) after landing.

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[1] Unless otherwise indicated, all times in this report are central daylight time, based on a 24-hour clock.

[2] For more information, see National Transportation Safety Board. 2001. *Runway Overrun During Landing, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999.* Aircraft Accident Report NTSB/AAR-01/02. Washington, DC.

Summary of the Flight Crew's Performance During the Approach

As the flight crew was maneuvering the airplane for landing, there were events that, individually, might not necessitate aborting an approach: a runway change because of a shifting wind, a failed visual approach to the newly assigned runway, the temporary inability of the airborne weather radar to show the weather conditions at the airport because of the airplane's direction of travel, the controller's report of the second part of the thunderstorm moving through the airport area, and the acceptance of a short approach near the outer marker because of the airplane's location in relation to the storm. However, these events, collectively, should have heightened the crewmembers' awareness that they might not be able to safely continue the approach. Thus, it would have been appropriate for the flight crew to have discussed specific options (holding, diverting to one of the two alternate airports, or performing a missed approach after the airplane was established on the final approach segment) in the event that the weather would necessitate aborting the approach later.[3]

As the airplane intercepted the instrument landing system (ILS) final approach course for runway 4R, the flight crew entered an event-dependent, high workload phase of flight. Under normal conditions, tasks during this phase of flight include controlling and maneuvering the airplane, configuring the airplane to land, performing final landing checks, and evaluating the airplane's performance relative to the landing criteria. In this case, the flight crew's earlier decision to accept a short approach increased the crew's already high workload by compressing the amount of time that was available to accomplish required tasks. In fact, the first officer highlighted this issue at the public hearing on this accident[4] when he stated, "I remember around the time of making that base-to-final turn, how fast and compressed everything seemed to happen."

During the final approach, the flight crew had a significant amount of weather information that had to be simultaneously evaluated. This information included the controller's previous report of heavy rain at the airport with visibility less than 1 mile, the second windshear alert,[5] a rapidly decreasing runway visual range (RVR), and several wind reports. Under these circumstances, some flight crews would have decided to abandon the approach.

The flight 1420 crew then poorly performed, and did not complete, the second half of the Before Landing checklist. Although the sound of the landing gear being operated was recorded by the cockpit voice recorder (CVR), there is no CVR evidence to indicate that the first officer verbalized this checklist item as "down, three green" as required, which would have indicated

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[3] The Safety Board notes that the airplane would have had an adequate fuel supply for each of these options.

[4] The Safety Board held a public hearing on this accident from January 26 to 28, 2000, in Little Rock (see appendix A of the subject accident report). The Board may hold a public hearing as part of its investigation into an accident to supplement the factual record of the investigation. The Board calls technical experts and material witnesses to testify, and Board investigative staff and designated representatives from the parties to the investigation ask questions to obtain additional factual information. The hearing is not intended to analyze factual information for cause.

[5] Even though American's flight manual indicated that windshear alerts were advisory, its DC-9 Operating Manual instructed pilots to avoid areas of known severe windshear and search for clues to indicate the presence of severe windshear. The operating manual indicated that such clues included thunderstorm and convective clouds, rain showers, and strong or gusty surface winds. All of these conditions were present at some point and to some degree during flight 1420's approach to the airport.

that all three landing gear systems were in the down and locked position. Also, the captain commanded the 40° final landing flap configuration only after being queried by the first officer. As previously stated, the captain did not realize that he had not yet called for the flaps; as a result, this checklist item was performed late. In addition, there is no CVR evidence to indicate that the first officer called out that the spoiler lever was armed, checked the annunciator lights, and completed the Before Landing checklist or that either pilot had armed the spoiler lever and considered the use of automatic rather than manual braking in light of the deteriorating weather conditions.[6]

As previously discussed, the flight crew should have initiated a go-around during the final approach segment when a specific operational criterion was not met, that is, when the company's maximum crosswind component for conducting the landing was exceeded. The flight crewmembers' failure to establish the final landing flap configuration before reaching 1,000 feet above field level (afl) and their failure to maintain a normal rate of descent, under different circumstances, might not necessitate a go-around. However, the Safety Board concludes that, because of the flight crew's failure to adequately prepare for the approach and the rapidly deteriorating weather conditions, the likelihood of safely completing the approach was decreasing, and the need to take a different course of action was progressively increasing; as a result, the flight crew should have abandoned the approach. Factors that contributed to the flight crew's performance during the accident flight are discussed later in this letter.

Finally, it is important to note that a microburst, with a peak wind gust of 76 knots and rainfall rates of 9 inches per hour, impacted the airport shortly after the flight 1420 accident and thus was not a factor. National Weather Service (NWS) radar data, however, detected that the microburst was over runway 4R at 2353:00. Thus, if flight 1420's takeoff, en route flight, or approach to landing had been delayed by less than 2 minutes, the flight could have encountered the microburst on final approach. Microbursts can result in vertical and horizontal windshear that can be extremely hazardous to aircraft, especially at low altitudes, as demonstrated by the 1994 USAir flight 1016 accident in Charlotte, North Carolina, and the 1985 Delta Air Lines flight 191 accident in Dallas, Texas.[7] As a result, the Safety Board is concerned that the flight crew was operating in an environment that was conducive to microburst conditions.[8] An industry-wide recommendation to develop operational strategies and guidance to promote better flight crew decision-making regarding the penetration of severe convective activity is presented later in this letter.

The Landing

Flight 1420 touched down on runway 4R at 2350:20 at a speed of 160 knots. The airplane touched down about 2,000 feet down the 7,200-foot runway, slightly to the right of the centerline

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[6] The Safety Board notes that several events were competing for the first officer's attention at the time that he was performing the Before Landing checklist, as detailed in section 2.2.1.3 of the subject accident report. The Board further notes that, even though the first officer did not verbalize that the Before Landing checklist had been completed, as required, the CVR indicated that he did verbalize (early in the approach) that the Descent checklist had been completed.

[7] See section 1.18.5 in the subject accident report for a detailed discussion of these accidents.

[8] The Safety Board notes that, during flight 1420's final approach segment, the microburst was located northwest of the airport and that the missed approach procedure would have taken the airplane east of the airport.

and sliding to the right. According to calculations based on flight data recorder (FDR) data, the airplane was subjected to a 5-knot tailwind component upon touchdown and a 20- to 25-knot left-to-right crosswind component during the landing.

The NWS' Automated Surface Observing System (ASOS) weather data indicated that surface winds from 290° at 16 knots gusting to 22 knots were present about the time that flight 1420 touched down, but this information was not available to the flight crew or the controller because the system's 2-minute wind data are not directly reported to the control tower. The controller's final wind report to the flight crew (320º at 23 knots, which was transmitted 27 seconds before touchdown) would not have indicated the possibility of a tailwind component at touchdown. Although the 5-knot tailwind component was within the 10-knot limitation required by American's flight manual and advised by Boeing in its MD-80 Flight Crew Operating Manual (FCOM), the Safety Board notes that the flight crew's purpose in changing runways from 22L to 4R was to avoid a tailwind component. The 20- to 25-knot crosswind component, however, exceeded the 10-knot limitation required by American's flight manual for a runway with an RVR of less than 1,800 feet.

Flight 1420 departed the end of runway 4R sliding to the left, with its nose gear on the left edge of the runway and the main gear off the left edge of the runway, at a calculated speed of 97 knots. The airplane sustained no damage before its departure from the runway. The airplane likely collided with the runway 22L approach lighting system support structure at a calculated speed of about 83 knots.

With the use of Boeing's MD-80 Operational Landing Program, the Safety Board predicted that the accident airplane experienced a wet runway braking coefficient of at least 0.23 at 140 knots and 0.25 at 160 knots. Typical braking coefficients to indicate dynamic hydroplaning range from 0.02 to 0.04. Thus, flight 1420 experienced a maximum braking coefficient that was over six times greater than the maximum typical hydroplaning braking coefficient.

Examination of the accident airplane's hydraulic brake system and the lack of hydraulic fluid contamination on the runway indicated that the hydraulic brake system was most likely capable of functioning within operational parameters. Examination and testing of the airplane's antiskid system and the lack of flat spots or reverted rubber on any main landing gear tire indicated that the antiskid system was most likely capable of functioning within operational parameters.

The Safety Board's examination of runway 4R determined that it was in good condition with normal or better-than-normal surface conditions for friction levels and counter-hydroplaning effectiveness. A senior research engineer from the National Aeronautics and Space Administration's (NASA) Langley Research Center stated at the public hearing that runway 4R's grooving was satisfactory but that its microtexture was above average and macrotexture was excellent. More importantly, the engineer stated that the runway's ability to prevent hydroplaning and other braking problems was excellent. The Safety Board concludes that dynamic or reverted rubber hydroplaning did not occur during the accident airplane's landing rollout.

Flight 1420's substantial drift angle while on the runway (as much as 16º both to the right and the left of the direction of travel) was evidence of a directional control problem. The Safety Board examined the lack of spoiler deployment upon touchdown, the use of reverse thrust greater than 1.3 engine pressure ratio (EPR),[9] and the use of manual rather than automatic brakes and evaluated the role that each played in the flight crew's inability to maintain directional control of the airplane on the runway and stop the airplane within the remaining available runway length (5,200 feet).

Lack of Spoiler Deployment

The spoiler system aboard the accident airplane was reported to be operating properly by the previous flight crew. FDR data from the airplane's previous landing showed that the left outboard and right inboard flight spoilers (the only two spoiler parameters recorded) deployed upon touchdown and remained fully deflected for about 33 seconds. Also, FDR data from the accident flight indicated that the flight spoilers extended symmetrically (in response to a pilot input using the spoiler handle) for about 55 seconds during the descent into Little Rock.

After the accident, the ground and flight spoilers were found in the retracted position. FDR data showed that, other than a momentary deflection by the left outboard flight spoiler concurrent with a left aileron deflection, the spoilers did not deploy upon touchdown. FDR data also showed a momentary full deflection of the right inboard flight spoiler concurrent with a full right aileron roll input during the landing rollout. The spoiler movement recorded on the FDR indicated that the spoiler position sensors and the spoiler control and hydraulic systems were working properly before and during the landing rollout.

Autospoiler Arming

American Airlines' Before Landing checklist is accomplished using a mechanical checklist in the cockpit. American Airlines DC-9 Operating Manual (dated December 21, 1998) indicates that autospoiler arming is one of the 10 items on the Before Landing mechanical checklist. According to American's DC-9 Operating Manual procedures that were in effect at the time of the accident, the nonflying pilot was responsible for ensuring that each checklist item had been accomplished. For autospoiler arming, the nonflying pilot was to state "spoiler lever," announce that the spoilers had been armed, and move the spoiler lever switch on the mechanical checklist. American's DC-9 Operating Manual procedures, however, did not specify which pilot was responsible for physically arming the spoilers. The company's June 25, 2001, party submission indicated that, for flight 1420, the first officer (the nonflying pilot) was responsible for arming the spoilers.

According to postaccident interviews with company line pilots, instructors, and check airmen, American's MD-80 pilots were instructed during simulator training that the nonflying pilot was to arm the spoilers. In contrast, the line pilots indicated that it was accepted practice for captains to arm the spoilers, regardless of whether they were the flying or nonflying pilot, because the spoiler handle is located on the forward left, or captain's, side of the center

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[9] Thrust reversers redirect engine exhaust to help slow an airplane. EPR is a measurement of engine power as a ratio of gases in the exhaust pipe compared with air entering the inlet.

pedestal.[10] The Safety Board notes that, on February 23, 2000, American revised its procedures to state that the captain is always responsible for arming the spoilers.

As the chief pilot at American's Chicago base of operations, the captain was required to fly less frequently than line pilots. However, the captain had become a chief pilot only months before the accident and had flown 54 hours in the 90 days before the accident flight. Thus, it is likely that he was aware of the common practice during line operations for the captain, rather than the nonflying pilot, to arm the spoilers. However, as a check airman, the captain would have likely been ensuring during check rides that the nonflying pilot was arming the spoilers.

The first officer for flight 1420 stated, in a postaccident interview, that he did not arm the spoilers because he thought that the captain had armed them. The first officer indicated that he had moved the switch on the mechanical checklist to indicate that the spoilers had been armed. However, the CVR did not indicate any mention of the first officer's required "spoiler lever" callout or any verbal verification that the spoilers were armed.[11] In addition, there were no sounds or other indications on the CVR that were consistent with the spoiler handle being armed.

During postaccident examination, the spoiler handle appeared to be in the full aft position with the red ARM indicator stripe partially visible; however, the cockpit center pedestal showed deformation and displacement in the left downward direction as a result of the damage to the cockpit floor structure during the impact sequence. Teardown of the center pedestal revealed no significant marks on the spoiler handle or handle slot to indicate the handle's position at impact. In addition, the teardown revealed that the autospoiler crank arm was found in its fully extended position and was positioned above the spoiler handle's roller—the contact point against which the crank arm pushes to extend the handle during normal autospoiler extension.

Teardown of the autospoiler actuator revealed that the actuator was in the fully extended (deployed) position, which was consistent with proper autospoiler operation with the autospoiler handle in the unarmed position. Thus, the spoiler handle was actually in the stowed position at impact but appeared to be in the fully extended position only because of impact damage. Further, testing of the primary components of the autospoiler system—the autospoiler actuator, the autospoiler switching unit, the ground spoiler control box, and the two ground nose oleo switches—revealed that all were capable of functioning properly.

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[10] To arm the spoilers on the MD-80 series airplane, the handle must be grasped and squeezed while it is lifted up toward its full travel limit. The pilot in the left seat of the airplane can reach the handle without obstruction, but the pilot in the right seat of the airplane must reach in front of, or behind, the throttle levers (and possibly around the captain's arm if his or her hand were on the throttle at the time) to manipulate the spoiler handle. A search of NASA's Aviation Safety and Reporting System database using the terms "spoiler handle" and "spoiler arming" did not reveal any reports consistent with flight crews having difficulty arming the spoiler handle.

[11] There are straightforward visual cues to indicate the position of the spoiler handle to the flight crew, and a visual assessment of the handle's status can be made from either seat in the MD-80 cockpit. The pilot in the left seat has an unobstructed view of the entire length of the spoiler handle. As a result, no change in head or body position is required to visually assess the status of the handle. However, the pilot in the right seat of the airplane normally has a partially obstructed view of the spoiler handle. Obstructions in the normal field of view include the throttle handles, the thrust reverser levers, and the right hand of the pilot in the left seat. If the pilot in the right seat were to adjust his or her head position, an unobstructed view of the handle could be achieved to assess the status of the spoiler handle. A search of the Aviation Safety and Reporting System database using the terms "spoiler handle" and "spoiler arming" did not reveal any reports consistent with flight crew difficulty confirming the spoiler handle's status on MD-80 series airplanes.

The CVR transcript identified the sound of two “thuds” similar to the sound of an airplane touching down on a runway along with a “squeak” sound at 2350:20.2, 2 seconds before the first officer stated, “we’re down.” Analysis of the CVR sound spectrum for the accident airplane indicated that the first “thud” was main landing gear touchdown and that the second “thud” was nose gear touchdown. Safety Board investigators determined that the squeak sound, which occurred in between the two “thud” sounds, was the autospoiler actuator operating. Because of the placement of the squeak sound, Board investigators further determined that the actuator was triggered at main landing gear touchdown by the wheel spin-up transducers.

The Safety Board compared the CVR sound spectrum for the accident airplane with those for other CVR recordings obtained during an incident at Palm Springs, California, involving an American Airlines MD-80 series airplane that did not experience autospoiler extension at touchdown.[12] Flight 1420’s CVR sound spectrum was also compared with the flight and ground tests that were conducted as part of the investigations of this accident and the Palm Springs incident. According to the CVR sound spectrum study, the sound durations associated with the autospoiler actuator extension for the Little Rock and Palm Springs flights (0.08 and 0.06 second, respectively) were consistent with the ground test in which the spoiler handle was unarmed (0.06 second). The study also indicated that, for the two flight tests and two ground tests involving normal autospoiler operation (that is, when the spoiler handle was armed before touchdown and the spoilers fully deployed after touchdown), the sounds associated with the activation of the autospoiler actuator lasted at least two times longer for the flight and ground test airplane recordings (between 0.16 and 0.19 second) than the sounds for the Little Rock airplane recording.

The ground tests conducted on the Palm Springs airplane also indicated that, when the left throttle was at least 1 3/8 inches above idle and the autospoiler actuator operated, the spoiler handle would fully extend (by means of the autospoiler actuator), be knocked down, and retract about 0.5 second later to the stowed position. Because the two spoiler positions—the left outboard and right inboard—are recorded alternately every 0.5 second with about 0.25 second in between recordings, it is likely that an autoretract event would be captured by an FDR. In fact, the ground test FDR captured all of the autoretract events, and the two spoiler autoretract events reported by American[13] were captured on FDR data. However, no indication of an autoretract event was found on the flight 1420 FDR data.

The CVR sound spectrum study, physical evidence, and testing and teardown results indicate that the autospoiler actuator on the flight 1420 airplane operated properly at touchdown

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[12] The description for this incident, DCA00IA027, can be found on the Safety Board’s Web site at <http://www.ntsb.gov>. Also, for a detailed discussion of this accident, see section 1.16.1.1 in the subject accident report.

[13] American Airlines reported two instances in which the spoiler handle aboard an MD-80 series airplane extended and then retracted after main landing gear touchdown. The events occurred at Dallas/Fort Worth on June 5, 2000, aboard flight 497 and on September 17, 2000, aboard flight 787. The FDR from the flight 497 airplane only recorded the right outboard spoiler position at a sampling rate of once per second, and the FDR indicated that the spoiler deployed at touchdown and then retracted about 1 second later. The FDR from the flight 787 airplane showed that both the left outboard and right inboard flight spoilers deployed at touchdown and then retracted about 1 second later. According to American, both flight crews could feel the spoilers retract, after which the crews manually deployed the spoilers and safely decelerated the airplanes. American also indicated that the flight crews believed the throttles were idle at touchdown.

and that the spoiler handle was in the unarmed position when the autospoiler actuator extended. Accordingly, the Safety Board concludes that the autospoiler system operated properly and that the spoilers did not automatically deploy because the spoiler handle was not armed by either pilot before landing.

Checklist Design Regarding Spoiler Arming

At the time of the accident, American did not require spoiler arming to be a dual crewmember challenge and response checklist item. Dual callouts protect against the failure that one pilot would identify an item as complete before it has been accomplished or omitting an item entirely during a high workload phase of flight.[14]

The human factors principles of checklist design established by the Federal Aviation Administration (FAA) and incorporated in its publications are available to airlines and FAA inspectors. These principles prescribe that checklist items affecting safety of flight should ensure that the proper levels of operational redundancy have been achieved. For example, many checklists require both flight crewmembers to positively confirm the status of flap settings before takeoff and gear position before touchdown. The Safety Board recognizes that MD-80 series airplanes can be dispatched with the autospoiler system inoperative; thus, the system is not considered to be an item that is critical to safety of flight. However, spoiler deployment after touchdown is crucial to optimal landing performance, and the autospoiler system, if installed and operative, is the most reliable and efficient way to engage the flight and ground spoilers during landing.

The Safety Board notes that, on June 22, 2000, American revised its Before Landing checklist procedures, requiring both the flying and nonflying pilots to verify and respond that the spoilers have been armed. The Board acknowledges that American's procedures now require dual crewmember confirmation of the spoiler arming checklist item but is concerned that other airplane operators may not include this requirement in their operating procedures. The Safety Board concludes that a high level of operational redundancy should exist to ensure that spoiler arming has been completed before landing. Therefore, the Safety Board believes that the FAA should require, for all 14 CFR Part 121 and 135 operators of airplanes equipped with automatic spoiler systems, dual crewmember confirmation before landing that the spoilers have been armed and that the FAA should verify that these operators include this procedure in their flight manuals, checklists, and training programs.

Manual Spoiler Deployment

At the time of the accident, American's DC-9 Operating Manual required both pilots to monitor the automatic deployment of the spoilers after touchdown. Pilots can verify that the spoilers have automatically deployed by the extensive movement of the handle to the extend position and the distinct "clanking" sound associated with the handle's travel. No written procedure in any of American's manuals required either pilot to announce the failure of the

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[14] See U.S. Department of Transportation, Federal Aviation Administration. 1995. *Human Performance Considerations in the Use and Design of Aircraft Checklists*. Also see Degani, A., and Wiener, E.L. 1990. *Human Factors of Flight-Deck Checklists: The Normal Checklist*. National Aeronautics and Space Administration Contractor Report 177549.

spoilers to automatically deploy. However, American’s DC-9 Operating Manual indicated that, if the spoilers failed to deploy automatically, the captain was responsible for manually extending them regardless of which pilot was making the landing.

Even though American’s manuals did not require pilots to announce if the spoilers failed to automatically extend, the MD-80 Fleet Manager and several MD-80 check airmen stated, during postaccident interviews, that pilots were trained to make this announcement. However, the CVR did not record any announcement by either pilot that the spoilers had failed to deploy automatically or any sounds that could be associated with an attempt to manually extend the spoilers.

The Safety Board concludes that the flight crew failed to verify that the spoilers had automatically deployed after landing and that the captain failed to manually extend the spoilers when they did not deploy. As a result, the wings continued to support most of the airplane’s weight, and very little weight was transferred to the landing gear, preventing the main landing gear tires from developing the braking and cornering forces required to achieve expected deceleration and directional control performance.

In the Little Rock accident, the pilots’ workload associated with attempting to maintain directional control of the airplane on the runway may have prevented them from detecting that the spoilers had not automatically deployed. The flight crew’s failure to detect that the spoilers had not deployed might have been avoided if a procedural requirement similar to the one in Boeing’s MD-80 FCOM had been in place at the time. According to the Boeing manual, the nonflying pilot should call out “no spoilers” if the spoiler lever does not move aft after touchdown, and the flying pilot should then move the lever aft to the full extend position and up to the latched position. American’s February 23, 2000, revision to its DC-9 Operating Manual incorporated a similar requirement. The Safety Board acknowledges American’s revision but is disappointed that this change and those related to spoiler arming (that is, the captain will always arm the spoilers and both crewmembers will confirm that the spoilers have been armed) were not put into effect until after the Palm Springs incident, which occurred more than 8 months after the Little Rock accident.

The Safety Board is concerned that other air carriers may not require callouts regarding the status of the spoilers after touchdown. The Safety Board concludes that, because spoiler deployment is critical for optimal landing performance, procedures to ensure that the spoilers have deployed after touchdown should be a required part of all air carriers’ landing operations. Therefore, the Safety Board believes that the FAA should require, for all 14 CFR Part 121 and 135 operators, a callout if the spoilers do not automatically or manually deploy during landing and a callout when the spoilers have deployed and that the FAA should verify that these operators include these procedures in their flight manuals, checklists, and training programs. The procedures should clearly identify which pilot is responsible for making these callouts and which pilot is responsible for deploying the spoilers if they do not automatically or manually deploy.

The Safety Board's Airplane Performance Study[15] demonstrated that spoiler deployment is critical to an airplane's braking force. For example, when the spoilers on an MD-80 series airplane weighing 127,000 pounds and traveling at 140 knots are extended, about 65 percent of the airplane's weight is supported by the main landing gear; when the spoilers are not extended, only about 15 percent of the airplane's weight is supported by the main landing gear.[16] In this accident, the light loading of the landing gear substantially reduced the effectiveness of the brakes and the ability of the gear to develop cornering loads to counter the aerodynamic side loads produced by the crosswind.[17] The Safety Board concludes that the lack of spoiler deployment led directly to the flight crew's problems in stopping the airplane within the remaining available runway length and maintaining directional control of the airplane on the runway. Regarding the inability to stop an airplane within an available runway length, the lack of spoiler deployment is far more critical than the use of reverse thrust.

Use of Reverse Thrust Above 1.3 Engine Pressure Ratio

Procedures in American's DC-9 Operating Manual that were in effect at the time of the accident indicated that, for landings on slippery runways, pilots were not to exceed 1.3 EPR on the "slippery portions of the runway" except in an emergency situation. Likewise, Boeing's MD-80 FCOM indicated that reverse thrust of no more than 1.3 EPR should be used on wet or contaminated runways, except in an emergency. However, FDR evidence indicated that reverse thrust exceeded 1.3 EPR several times during flight 1420's landing sequence.[18] Further, American's and Boeing's maximum reverse thrust setting for landings on dry runways was 1.6 EPR, and FDR data showed that even this setting was exceeded many times during the landing.

The CVR recorded the first officer's statement "we're sliding " about 4 seconds after the airplane touched down on the runway. FDR data indicated that, about 1 1/2 seconds after this statement, 1.89 and 1.67 reverse EPR were being applied to the left and right engines, respectively. FDR data indicated that the thrust reversers were returned to the unlocked status as the airplane was continuing to slide.[19] However, the thrust reversers were deployed again; the left engine reached a maximum setting of 1.98 reverse EPR, and the right engine reached a setting of

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[15] For more information, see section 1.16.4 in National Transportation Safety Board. 2001. *Runway Overrun During Landing, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999*. Aircraft Accident Report NTSB/AAR-01/02. Washington, DC.

[16] These findings were consistent with information presented by the Boeing aerodynamics engineer at the public hearing for this accident regarding the spoilers' effect on the weight applied to the wheels immediately after touchdown for an MD-80 series airplane with a similar landing weight as the accident airplane.

[17] The effects of the light loading on the main landing gear may have been exacerbated by the position of the elevator surfaces during the landing roll. McDonnell Douglas' 1996 all operators letter indicated that, when operating on wet or slippery runways, pilots should not apply an excessive amount of down elevator because it will unload the main gear and reduce braking efficiency. However, the left and right elevator surfaces were deflected full nose down between 2,800 and 5,000 feet beyond the runway 4R threshold.

[18] The thrust reverser deployment recorded on the FDR when the airplane powered back from the gate during its departure from Dallas/Fort Worth to Little Rock indicated that the thrust reverser position sensors were working properly.

[19] American's DC-9 Operating Manual stated that, if an airplane begins to drift across the runway while reversing, pilots should immediately come out of reverse thrust to help regain directional control and restore rudder effectiveness.

1.64 reverse EPR. The reversers were returned again to the unlocked status; as the right thrust reverser was moving to the unlocked status, the right engine reached a maximum setting of 1.74 reverse EPR. By this point, the captain was likely applying excessive reverse thrust because he perceived that the landing had become an emergency situation.

On the MD-80 series airplane, excessive reverse thrust can reduce or eliminate rudder and vertical stabilizer effectiveness.[20] In fact, FDR data for the flight 1420 airplane were consistent with deteriorated rudder and vertical stabilizer performance because of the use of excessive reverse thrust.[21] Specifically, at the time that the heading of the airplane was moving nose left from 1° to 3° per second despite substantial nose right rudder inputs, the thrust reversers were deployed. The left engine EPR reached values of 1.3 or greater almost continuously; the right engine EPR reached values of 1.3 or greater several times. The heading stopped moving left, and rudder effectiveness was restored, when the thrust reversers were briefly stowed.

When reverse thrust was applied again, the airplane started to yaw left once more (the heading was moving left about 1.5° per second) despite full right rudder inputs. The airplane then reacted dramatically to the rudder inputs when the thrust reversers were stowed for the second time; the yaw rate reversed, and the heading started to move right up to 7° per second. The airplane was continuing to yaw to the right (the heading was increasing 4° per second) when it departed the left side of the runway; at that time, the left engine thrust reverser was deployed, but the engine's EPR was at an idle power level. The Safety Board concludes that the use of reverse thrust at levels greater than 1.3 EPR significantly reduced the effectiveness of the airplane's rudder and vertical stabilizer and resulted in further directional control problems on the runway.

Postaccident observations of American's MD-80 simulator training sessions revealed that the training focused on applying 1.6 EPR reverse thrust when landing. There was no discussion of the company's procedures to limit reverse thrust to 1.3 EPR when landing on slippery runways, and pilots were observed exceeding 1.3 EPR when slippery runway conditions were presented. In fact, one of the simulator instructors initially taught that 1.6 EPR was acceptable for landing on a slippery runway unless a crosswind was present. On February 23, 2000, American revised its DC-9 Operating Manual, indicating that, for all MD-80 landings, reverse thrust should not exceed 1.3 EPR unless stopping distance is in doubt.

The Safety Board concludes that the maximum reverse thrust for MD-80 landings on wet or slippery runways should be 1.3 EPR, except when directional control can be sacrificed for a marginal increase in deceleration. Therefore, the Safety Board believes that the FAA should issue a flight standards information bulletin that requires the use of 1.3 EPR as the maximum reverse thrust power for MD-80 series airplanes under wet or slippery runway conditions, except in an

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[20] American's DC-9 Operating Manual stated that the rudder is almost "completely ineffective" at 1.6 EPR and a speed of 90 knots. McDonnell Douglas, in its 1996 all operators letter, warned that, as reverse thrust increases above approximately 1.3 EPR, rudder effectiveness continues to decrease and that, at a reverse thrust greater than approximately 1.6 EPR, the rudder provides little or no directional control. During the time that the accident airplane's reverse thrust settings were 1.6 EPR and greater, the airplane was traveling down the runway at speeds greater than 90 to 100 knots.

[21] Loss of directional control associated with high reverse thrust EPRs has been observed in other accidents involving DC-9 airplanes landing on wet or contaminated runways, including the March 5, 1997, American Airlines flight 320 accident in Cleveland, Ohio. The description for this accident, IAD97FA052, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

emergency in which directional control can be sacrificed for decreased stopping distance. The Safety Board also believes that the FAA should require principal operations inspectors (POIs) of all operators of MD-80 series airplanes to review and determine that these operators' flight manuals and training programs contain information on the decrease in rudder effectiveness when reverse thrust power in excess of 1.3 EPR is applied. The Safety Board further believes that the FAA should require all operators of MD-80 series airplanes to require a callout if reverse thrust power exceeds the operators' specific EPR settings.

Use of Manual Braking

The preflight weather package (which contained weather information issued about 2205) indicated that the runways at Little Rock airport were wet with no measurable rain and no braking action reports. According to the CVR, the captain had decided, at 2331:24 (before establishing contact with the Little Rock tower), to use manual brakes. At that point in the approach, the flightpath was still free of convective activity. However, the CVR did not record any discussion between the pilots regarding whether the use of manual brakes for the landing was still prudent in light of the changing weather conditions on approach to the airport.

The flight crewmembers received a report from the controller that heavy rain was falling at the airport, so they should have been concerned that the runway would be slippery. The crewmembers also received a report from the controller about a strong crosswind, so they should have been aware that significant rudder inputs could be required to maintain directional control of the airplane on the runway and that these inputs could take away from their ability to maximize manual braking. In addition, the flight crew recognized that runway 4R was considered a short runway for a DC-9 landing,[22] so maximum efficiency of the brakes was critical. These conditions justified the use of autobrakes for the landing on runway 4R. In fact, Boeing's procedures indicated that maximum autobrakes should be used for landing on a wet or slippery runway.[23]

According to FDR data, the initial application of manual brakes began about 5 seconds after touchdown, and full application of the manual brakes was not recorded until about 11 seconds after touchdown.[24] These time intervals are not indicative of aggressive manual braking.

The use of autobrakes requires either automatic or manual spoiler deployment at touchdown, which did not occur in this situation; therefore, autobrakes would not have helped decelerate the accident airplane. However, if the spoilers had deployed and the flight crew had selected maximum autobrakes for the landing, initial brake application could have occurred about 4 seconds sooner.

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[22] In a postaccident interview, the first officer stated that the captain briefed 40° flaps for the landing because of the short runway.

[23] American's DC-9 Operating Manual stated that maximum autobrakes could be used on short or slippery runways but did not specify the type of braking that should be used on wet runways or during crosswind conditions.

[24] American's DC-9 Operating Manual stated that aggressive manual braking could be used on short or slippery runways. The manual further stated that, for manual brake stopping on short or slippery runways, the full brake pedal should be used immediately after nose gear touchdown.

On June 27, 2000, American issued a revision to its DC-9 Operating Manual, requiring the use of autobrakes for four specific circumstances: when a runway is less than 7,000 feet long; an RVR is less than 4,000 feet or visibility is less than 3/4 mile; a runway is contaminated with standing water, snow, slush, or ice; or braking conditions are reported to be "less than good." Also, the revision recommended, but did not require, the use of autobrakes when landing with gusty winds or crosswinds. The Safety Board acknowledges that American has implemented specific criteria requiring the use of autobrakes but is concerned that the company still does not require autobrakes during landings with crosswinds.

In the aviation industry, it is generally understood that landing during high crosswinds (that is, in excess of 10 knots) requires the pilot to make significant rudder pedal inputs to maintain directional control of the airplane. Because manual braking is accomplished by applying pressure to the upper portion of the rudder pedals, the Safety Board is concerned that a pilot who uses manual brakes during high crosswind conditions might not be able to immediately apply and maintain aggressive manual braking. In this accident, the captain likely did not apply full manual braking for 11 seconds because he was making significant rudder pedal inputs to keep the airplane on the runway. In fact, the first officer stated that he had to help the captain with his braking efforts as the airplane was nearing the end of the runway.

FDR data showed that the left brake pedal was relaxed momentarily after full braking was achieved. However, this brake relaxation occurred while the airplane was drifting to the right (that is, its nose was pointed to the left of the direction of travel) and coincided with the application of full right rudder. Thus, the brake pedal relaxation may have been the result of the captain's attempt to apply differential brakes to correct the airplane's heading or his inability to maintain full braking while applying full right rudder.

The use of automatic brakes is also important for airplanes landing on wet or slippery runways. Brakes decrease stopping distance most effectively when they are applied at a high speed. Any delay in brake application after touchdown results in a considerable increase in the required stopping distance because the highest speed during the ground roll (the most distance traveled per unit of time) occurs immediately after touchdown. An interruption in brake application at lower speeds is less critical because the airplane does not travel as far (that is, it does not consume as much runway) in the same time at low speed as it does at high speed. Because wet or slippery runway conditions degrade an airplane's landing performance, fast brake application in these circumstances is critical.

The Safety Board recognizes that airplane operators may not choose to require automatic braking because that type of braking, compared with manual braking, will wear out brakes faster and thus require brake replacement more often. The Board also recognizes that, during optimal landing situations, pilots can apply manual brakes more quickly than automatic brakes.[25] However, during high workload landing situations that may require active or aggressive use of the rudder pedals, the use of automatic brakes provides pilots with a faster, more consistent

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[25] Boeing's MD-80 FAA-approved Airplane Flight Manual, Appendix 5, "Automatic Brake System," states that, because of the delay in automatic brake application and the conservative testing conditions that were used to construct the automatic brake landing distance data, stopping performance in the MAX setting does not achieve the same level of performance compared with manual braking. In addition, the manual states, "stopping distances are provided for guidance information only to assist in the selection of the most desirable setting."

means for stopping an airplane within the available runway length. The Safety Board concludes that automatic brake systems reduce pilot workload during landings in wet, slippery, or high crosswind conditions. Therefore, the Safety Board believes that the FAA should require, for all 14 CFR Part 121 and 135 operators, the use of automatic brakes, if available and operative, for landings during wet, slippery, or high crosswind conditions and that the FAA should verify that these operators include this procedure in their flight manuals, checklists, and training programs.

Summary of the Landing

The airplane's performance during the landing roll indicates that flight 1420 experienced many of the difficulties discussed in a McDonnell Douglas February 1996 MD-80 all operators letter regarding landing operations on wet or slippery runways: greatly reduced reaction forces on the gear (because of the spoiler position), unloading of the main gear because of large nose-down elevator inputs, strong crosswinds, loss of vertical stabilizer and rudder effectiveness because of reverse thrust greater than 1.3 EPR, and a slight tailwind. In addition, the airplane touched down about 2,000 feet down the 7,200-foot runway going 29 knots faster than the zero-wind touchdown ground speed that would result from an approach at the reference airspeed. The resulting ground trajectory of the airplane is consistent with the expected airplane performance, as determined from Boeing's Operational Landing Program, and the operational experience outlined in the all operators letter.

The Safety Board's Airplane Performance Study indicated that the accident airplane could have stopped about 700 feet before the end of the runway if the spoilers had deployed, a constant symmetrical reverse thrust at 1.3 EPR had been maintained, and the flight 1420 manual braking profile had been applied. In contrast, with the spoilers not extended, the airplane could not have stopped within the remaining runway length even if maximum manual braking had been applied immediately after touchdown and symmetrical reverse thrust at 1.3 EPR had been maintained throughout the landing roll. Thus, the Safety Board concludes that the lack of spoiler deployment was the single most important factor in the flight crew's inability to stop the accident airplane within the available runway length.

Human Factors

During the accident flight, both crewmembers made basic errors in flight management and the completion of routine tasks, including required callouts. In addition, the flight crew did not appear to be effectively evaluating the weather cues that were available or considering their cumulative effect, specifically, that the thunderstorm had likely already arrived at the airport. The Safety Board recognizes that the flight crew was provided with only general, advisory information on severe weather avoidance rather than specific operational decision-making criteria regarding the penetration of convective activity. However, the Safety Board concludes that the flight crewmembers' performance during the accident flight was degraded, as evidenced by their operational errors and impaired decision-making.

The flight crew's degraded performance was inconsistent with the level of performance that would have been expected from both pilots, considering that the captain was a chief pilot and check airman and that the first officer, as a new hire, had been recently trained in American's standards and procedures. Also, the flight crew's performance deviated significantly from the positive statements that other pilots made about both pilots' skills, abilities, and cockpit style. The captain was described in postaccident interviews as a conservative pilot who used common sense, demonstrated wisdom and experience, and was professional. The first officer was described in postaccident interviews as an above-average new hire who was very competent and knowledgeable and an experienced pilot with good cockpit discipline, and his probationary file contained favorable comments about his performance. In addition, the captain was appointed to the chief pilot position because he possessed good technical skills and leadership abilities.

The Role of Situational Stress

The presence of weather as a potential threat to the safety of flight and efforts to expedite the landing were stresses to the flight crew. Research has demonstrated that decision-making can be degraded when individuals are under stress because they selectively focus on only a subset of cues in the environment. As a result, any situation assessment may be incomplete, and the resulting decision, even when made by an expert, may be degraded. Stress can also impede an individual's ability to evaluate an alternative course of action, resulting in a tendency to proceed with an original plan even though it may no longer be optimal. Research on decision-making has demonstrated a natural tendency for individuals to maintain their originally selected course of action until there is clear and overwhelming evidence that the course of action should be changed.

The CVR contained no evidence to indicate that the flight crew had reevaluated its original plan to expedite the landing because of the approaching weather. The actions taken by the flight crewmembers throughout the approach were consistent with their original plan. Despite several cues that indicated that the weather at the airport had deteriorated, neither crewmember discussed a need to initiate a go-around, enter a holding pattern, or divert to an alternate airport. The Safety Board also notes that any delay in landing would have further extended the pilots' duty day, but there is no evidence to indicate that this factor affected the flight crew's decision to continue the approach.

The flight crewmembers' intention to expedite the landing despite the weather diverted their attention away from other activities during the final minutes of the flight and, as a result, affected the crew's ability to properly assess the situation and make effective decisions. Therefore, the Safety Board concludes that the flight crewmembers' focus on expediting the landing because of the impending weather contributed to their degraded performance.

Industry Standards and Practices

The Safety Board evaluated the flight crew's decision to conduct an approach to an airport environment surrounded by severe convective activity in relation to contemporary industry standards and practices. Most airlines and flight training programs instruct pilots to avoid thunderstorms during routine operations. However, data from accidents and incidents demonstrate that pilots penetrate thunderstorms—in some cases with catastrophic results, as shown by the USAir flight 1016 and the Delta flight 191 accidents. In fact, in its final report on the Delta flight 191 accident, the Safety Board stated that "there is an apparent lack of appreciation on the part of some, and perhaps many, flight crews of the need to avoid thunderstorms and to appraise the position and severity of the storms pessimistically and cautiously."

A June 1999 report sponsored by NASA and conducted by research staff at the Massachusetts Institute of Technology's Lincoln Laboratory used weather radar and air traffic control (ATC) radar data sources to document flight crew behavior during 60 hours of observations in the Dallas/Fort Worth terminal area during convective activity. This research documented that pilots routinely penetrated thunderstorms with NWS precipitation intensity levels of 3 (strong), 4 (very strong), and 5 (extreme) rather than deviated around them, especially when approaching an airport to land. Of the 1,952 encounters with thunderstorm cells recorded in these data, pilots penetrated the thunderstorms 1,310 times (67 percent). However, the study did not include information from the pilots regarding the reasons for the actions documented by the flight data. The study concluded that pilots were more likely to penetrate a thunderstorm when they were flying after dark, flying within 10 to 16 miles of the airport, following another aircraft, or running behind schedule by more than 15 minutes. All but one of these factors (following another aircraft) applied to the accident flight.

In its final report on the Delta flight 191 accident, the Safety Board stated its concern that "the present training within the industry for windshear encounters on the final approach seems to advocate the philosophy that the retrieval of the approach profile is the desired end result and not escape from the environment." The results of the NASA study, which was completed 13 years after the Delta flight 191 accident report was issued, demonstrate that this industry philosophy can also apply to the penetration of severe thunderstorms.

Some air carriers, including American, provide their flight crews with only general, advisory information on severe weather avoidance. As a result, the individual flight crews are responsible for making decisions on whether an approach near convective activity should continue, and such decisions are typically based on the pilots' subjective assessment of the severity of the situation and their experience. The Safety Board is aware that some other air carriers provide their pilots with specific operational guidance, including decision aids and flow charts in quick reference checklists, from which flight crews can make "go" or "no go" decisions concerning operations near hazardous weather. Such information includes a detailed list of specific cues and operational criteria from which pilots can easily assess weather conditions and objectively determine whether they can safely continue or need to take a different course of action. As a result, the pilots do not have to rely on an open-ended decision-making process regarding whether and at what point to deviate around weather. Further, these explicit, formalized cue recognition and decision aids minimize the potential for thunderstorm penetrations resulting from impaired judgment and decision-making because of situational stress or fatigue.

In addition, as demonstrated in this accident, airborne weather radar does not always facilitate a flight crew's assessment of a thunderstorm regarding the storm's location and movement relative to the airport and its severity, including the potential for microburst conditions. The Safety Board is aware that recent technologies, such as moving airport map displays integrated with airborne weather radar displays and real-time wind readouts, are available in new-generation airplanes with "glass cockpits."[26] Also, NASA, the FAA, and avionics manufacturers are testing whether ground-based advanced weather graphics, such as regional radar mosaics and single Doppler radar images, can be up-linked to airplanes. These graphics can show enhanced detail of a thunderstorm (including its intensity, movement, and tops) and other weather information; therefore, they have the potential for providing flight crews with in-flight information to improve their situational awareness and decision-making regarding hazardous weather.

Because the NASA study showed no discernible differences among operators and airplane types regarding the propensity to penetrate thunderstorms, the Safety Board concludes that aircraft penetration of thunderstorms occurs industry-wide. Therefore, the Safety Board believes that the FAA should establish a joint Government-industry working group to address, understand, and develop effective operational strategies and guidance to reduce thunderstorm penetrations and should verify that these strategies and guidance materials are incorporated into air carrier flight manuals and training programs as the strategies become available. The working group should focus its efforts on all facets of the airspace system, including ground- and cockpit-based solutions. The near-term goal of the working group should be to establish clear and objective criteria to facilitate recognition of cues associated with severe convective activity and guidance to improve flight crew decision-making.

The Role of Fatigue

The CVR contained no statements to indicate that either pilot was tired, but the CVR did record a yawn at 2324:13 from one of the pilots. The first officer stated, after the accident, that it had been a long day and that he was getting tired but that he felt fine when flying to Little Rock. In addition, the first officer stated that he did not remember talking with the captain about whether he was tired, but the first officer was not concerned about the captain being fatigued. However, research indicates that self-assessment of fatigue impairment and detection of fatigue in others is inaccurate. Thus, the Safety Board examined whether cumulative sleep loss, continuous hours of wakefulness, and the time of the accident relative to the flight crew's normal schedule were consistent with the development of fatigue.[27]

First, the captain and the first officer reportedly received a normal amount of sleep the night before the accident; both went to sleep about 2200 and awoke about 0730. Also, there was no evidence that either pilot had experienced cumulative sleep loss in the days before the accident.

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[26] The term "glass cockpit" refers to cockpits with cathode ray tubes or flat plate screens that integrate multiple sources of flight information formerly displayed on analog dials and gyro instruments. An example of a glass cockpit system is the Enhanced Flight Information System.

[27] In its final report on the American International Airways flight 808 accident in Guantanamo Bay, Cuba, the Safety Board explained that these three background factors are commonly examined for evidence related to fatigue. For more information, see National Transportation Safety Board. 1994. *Uncontrolled Collision With Terrain, American International Airways Flight 808, Douglas DC-8-61, N814CK, U.S. Naval Air Station, Guantanamo Bay, Cuba, August 18, 1993*. Aircraft Accident Report NTSB/AAR-94/04. Washington, DC. For additional information on fatigue-related factors, see Federal Aviation Administration. 1998. *An Overview of the Scientific Literature Concerning Fatigue, Sleep, and the Circadian Cycle. Prepared for the FAA's Office of the Chief Scientific and Technical Advisor for Human Factors.*

Second, at the time of the accident (2350:44), the captain and the first officer had been continuously awake for at least 16 hours.[28] Research indicates that the normal waking day is between 14 and 16 hours and that lapses in vigilance increase and become longer if the normal waking day is extended.[29] In addition, the Safety Board's 1994 study of flight crew-related major aviation accidents[30] found that flight crews that had been awake for an average of about 13 hours made significantly more errors, especially procedural and tactical decision errors, than crews that had been awake for an average of about 5 hours. Thus, the flight crew's extended continuous hours of wakefulness was consistent with the development of fatigue.

Third, the 2350:44 accident time was nearly 2 hours after the time that both pilots went to bed the night before the accident and the captain's routine bedtime (between 2130 and 2200). According to a recognized expert in fatigue research who reviewed the flight and duty time and CVR data associated with this accident, because the flight crewmembers were conducting an approach at a time of night when they would have normally been asleep, their circadian systems were not actively promoting alertness in the last hours of their duty period. Thus, the time at which the accident occurred was consistent with the development of fatigue.[31]

Research indicates that the ability to consider options decreases as people who are fatigued become fixated on a course of action or a desired outcome (which is also the case with situational stress, as discussed earlier in this letter) and that it can be more difficult for a fatigued person to remember whether tasks have been accomplished.[32] In this accident, the flight crew did not consider delaying or diverting the landing, the first officer did not ensure that the autospoilers had been armed for landing, and the captain did not realize that he had not called for flaps 40. Also, automatic processes (such as radio calls and routine behavior) are affected less by fatigue than controlled processes (such as more complex behavior, responses to new situations, and decision-making);[33] in this accident, however, both automatic and controlled processes were affected during the flight. Further, fatigue deteriorates performance on work-paced tasks that are characterized by time pressure and task-dependent sequences of activities, as demonstrated by the flight crew's failure to properly perform routine tasks during the final approach phase of flight.

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[28] The flight crew had accumulated 7 hours 49 minutes of flight time during this period. Because of differences in check-in times, the captain had accumulated 5 hours 24 minutes of ground time, and the first officer had accumulated 5 hours 44 minutes of ground time. Therefore, when the accident occurred, the captain's duty day was 13 hours 13 minutes, and the first officer's duty day was 13 hours 33 minutes. Both pilots' total continuous time awake at the time of the accident was at least 16 hours 21 minutes.

[29] Kruger, G.P. 1989. "Sustained Work, Fatigue, Sleep Loss, and Performance: A Review of the Issues." *Work and Stress*. Vol. 3, pp. 129-141.

[30] National Transportation Safety Board. 1994. *A Review of Flightcrew-Involved Major Accidents of U.S. Air Carriers, 1978 Through 1990.* Safety Study NTSB/SS-94/01. Washington, DC.

[31] Continuous hours of wakefulness and accident time were also factors in the August 1997 Korean Air flight 801 accident in Guam. The captain had been awake for 11 hours at the time of the crash, which occurred after midnight in the flight crew's home time zone (0142 Guam local time). The time of the crash was also several hours after the captain's (the flying pilot) normal bedtime. For more detailed information, see section 1.18.6 in the subject accident report.

[32] Caldwell, J.A. 1997. "Fatigue in the Aviation Environment: An Overview of the Causes and Effect as Well as Recommended Countermeasures." *Aviation, Space, and Environmental Medicine*. Vol. 68, pp. 932-938.

[33] Humphrey, D.G.; Kramer, A.F.; and Stanny, R.R. 1994. "Influence of Extended Wakefulness on Automatic and Nonautomatic Processing." *Human Factors.* Vol. 36, pp. 652-669.

Therefore, the Safety Board concludes that the flight crew's degraded performance was consistent with known effects of fatigue.

Fatigue in transportation operations has been on the Safety Board's list of Most Wanted Safety Improvements since the list's initiation in September 1990. In May 1999, the Board issued a safety report that evaluated the Department of Transportation's (DOT) efforts to address operator fatigue among the transportation modes, including aviation. (The Board first asked the DOT to upgrade flight and duty times and hours-of-service regulations for all modes in 1989.) The Board's report concluded that, despite acknowledgement by the DOT that fatigue is a significant factor in transportation accidents, little progress has been made to revise the hours-of-service regulations to incorporate the results of the latest research on fatigue and sleep issues. As a result, the Board issued Safety Recommendation A-99-45, asking the FAA to "establish within 2 years scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements."

On July 15, 1999, the FAA stated that, on December 11, 1995, it issued Notice of Proposed Rulemaking (NPRM) 95-18, "Flight Crewmember Duty Period Limitations, Flight Time Limitations and Rest Requirements." The NPRM proposed amending existing regulations to establish one set of duty period limitations, flight time limitations, and rest requirements for flight crewmembers involved in air transportation. At an October 7, 1999, meeting with the Safety Board, FAA representatives stated that the FAA would not be able to meet the recommendation's time requirement for a new rule. On January 3, 2000, the Board indicated that, even though the NPRM was issued over 4 years earlier, the existing regulations concerning flight time regulations and rest requirements had not been upgraded. On December 5, 2000, the FAA stated that it planned to issue, in spring 2001, a supplementary NPRM that would address the issue of fatigue "concretely" and give the airlines the flexibility they need to operate. On April 26, 2001, the Board indicated that, in the 5 years since the issuance of NPRM 95-18 and the 1 1/2 years since the need for a supplemental NPRM was first communicated, the FAA has not taken action. As a result, Safety Recommendation A-99-45 was classified "Open—Unacceptable Response."

In a May 14, 2001, press release, the FAA stated that it "is confident that, overall, the airline industry complies with current FAA rules on pilot time limitations and rest requirements." The press release also stated the following:

> On Nov. 20, 2000, the FAA responded to a letter from the Allied Pilots Association that set forth specific scenarios that could affect a very small number of all commercial pilots. The FAA's response was consistent with the agency's long-standing interpretation of the current rules. In summary, the FAA reiterated that each flight crew member must have a minimum of eight hours of rest in any 24-hour period that includes flight time. If a pilot's actual rest was less than nine hours in the 24-hour period, the next rest period must be lengthened to provide for the appropriate compensatory rest. Ensuring that all pilots, especially those on reserve duty, receive adequate rest is key to maintaining a safe aviation system.

On May 17, 2001, the FAA published a notice in the *Federal Register* that reiterated its interpretation of pilot flight time and rest rules. The notice stated that the FAA intended to enforce its rules in accordance with the interpretation and that, 6 months after the issuance of the notice, the FAA would review airline flight scheduling practices and deal stringently with any violations.[34]

The Safety Board is encouraged by the FAA's increased efforts to enforce the current pilot flight time and rest rules. However, the Little Rock accident and the May 1999 American Eagle flight 4925 accident in New York[35] highlight the need to expedite efforts to comprehensively address the issue of fatigue in aviation. Therefore, the Safety Board reiterates Safety Recommendation A-99-45.[36]

Weather Information Provided by the Local Controller

The local controller was working all of the tower cab positions on the night of the accident and was not handling any other in-flight traffic, so flight 1420 had virtually his full attention. The controller responded promptly to all of the flight crew's requests. The CVR indicated that, between 2339:59 and 2340:12, the first officer and the controller discussed a change from runway 22L to 4R (after the wind shift to the northwest) and that the controller responded at 2340:20 with a heading change for vectors to the runway 4R ILS approach course. At 2344:30, the first officer informed the controller that the visual approach to runway 4R could not continue because of a cloud between the airplane and the airport, and the controller provided vectors for the ILS approach at 2344:39. The first officer told the controller, at 2345:47, that the airplane was getting close to the storm, and the controller returned with a new heading at 2345:52.

The controller also provided the flight crew with ongoing information about the wind direction and speed, including the two windshear alerts, while the airplane was approaching the airport and updated the wind information four times while the airplane was on final approach. The controller also kept the crew apprised of the progress of the thunderstorm. When the crew made initial contact with the tower, the controller indicated that a thunderstorm located northwest of the airport was moving through the area. He also informed the crew when the second part of the storm was moving through the area and when heavy rain was falling at the airport. Further, the controller alerted the crew when the RVR for runway 4R had decreased first to 3,000 feet and then to 1,600 feet and when automatic terminal information service Romeo was no longer valid. The Safety Board could not find any instance in which the controller did not provide the flight crew with aviation weather information that was available to him in the tower or any delay in relaying this information, which is especially noteworthy considering that the weather conditions were rapidly changing during the last several minutes of flight 1420's approach to the airport.

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[34] In June 2001, the Air Transport Association and the Regional Airline Association asked the U.S. Court of Appeals for the District of Columbia to stay the pending enforcement of the FAA's interpretation of pilot flight time and rest rules, citing that enforcement of these rules constituted illegal rulemaking. On September 5, 2001, the U.S. Court of Appeals granted the Air Transport Association's and the Regional Airline Association's request for a stay of enforcement. As of October 29, 2001, the court was expected to hear arguments on this case in January 2002.

[35] The description for this accident, NYC99FA110, can be found at the Safety Board's Web site at <http://www.ntsb.gov>.

[36] The Safety Board notes that this safety recommendation asked the FAA to take the recommended action "within 2 years." By reiterating this safety recommendation, the Board is not suggesting that the recommended action should occur within 2 years from the data of this reiteration. Rather, because the original 2-year period has already expired, the Board urges the FAA to expedite its efforts to accomplish the action specified in this recommendation.

The Safety Board concludes that the local controller provided appropriate, pertinent, and timely weather information to the flight crew regarding the conditions on approach to and at the airport. The controller's actions after the crash occurred are discussed later in this letter.

Weather Information Depiction on Air Traffic Control Radar Systems

Although the controller accurately reported the weather information available in the tower, he appeared to lack confidence in the tower's radar weather depiction. For example, the controller asked the flight crew how the final approach to runway 22L looked on the airplane's radar presentation because the airplane's radar was "a lot better" than what he had available in the tower. In addition, the ATC transcript indicated that a controller from the Memphis air route traffic control (ARTCC) called the local controller to determine whether flights headed toward Little Rock would be able to land. As part of his response to this query, the local controller said, "my radar is not that good by the weather you know." The center controller's response to this comment was "better than ours."

The Safety Board notes that the radar used in ATC facilities was designed to depict air traffic; it was not designed to show weather. If near-real-time color weather radar had been available at ATC facilities, the Little Rock local controller would likely have been able to relay to the flight 1420 crew that a thunderstorm with extreme reflectivities had moved over the airport. In this case, the Board cannot determine whether such a report would have changed the flight crew's course of action because of the workload at the time that the report would have been received, as well as the flight crewmembers' impaired performance. Nevertheless, ATC near-real-time color weather radar information would enable controllers to provide flight crews with a better source of weather information than is currently available in the tower.

The Safety Board concludes that, if near-real-time color weather radar showing precipitation intensity were available, it would provide air traffic controllers with improved representation of weather conditions in their areas of responsibility. Therefore, the Safety Board believes that the FAA should incorporate, at all ATC facilities, a near-real-time color weather radar display that shows detailed precipitation intensities. This display could be incorporated by configuring existing and planned Terminal Doppler Weather Radar (TDWR) or Weather Systems Processor (WSP) systems with this capability or by procuring, within 1 year, a commercial computer weather program currently available through the Internet or existing stand-alone computer hardware that displays the closest single-site Weather Surveillance Radar 1988 Doppler (WSR-88D) data or regional mosaic images.

Additional En Route Weather Information

Dispatch Office Weather Radar

After flight 1420 was underway (about 2240), the flight dispatcher transitioned from a flight-releasing to a flight-following role, which required him to provide the pilot-in-command with any safety-of-flight information that was pertinent to the flight's operation. However, the FAA does not generally provide Part 121 flight dispatch offices with access to TDWR real-time weather radar information. Although American's dispatchers receive high-resolution weather radar mosaic updates every 15 minutes on their workstations, the mosaics are delayed several minutes so that a clutter-free image can be presented. Even though the 15-minute updates indicate the organization and intensity of weather activity, the inherent delay in displaying the information (so that images can be compared with other weather observations and corrected for beam height and distance errors) prevents it from being depicted to the dispatcher in a timely manner. In this accident, the thunderstorm activity was moving rapidly, and the 15-minute radar updates could not adequately portray to the dispatcher the real-time conditions that flight 1420 could encounter.

Dallas/Fort Worth is 1 of the 41 airports at which the FAA has installed TDWR; Little Rock airport does not have the system, and the FAA does not plan to install the system there. The availability of TDWR data to the flight dispatcher would not have affected the outcome of the accident because TDWR presents only site-specific data; thus, the TDWR at Dallas/Fort Worth would not have provided the dispatcher with information about the weather conditions in the Little Rock airport area. However, for those airports equipped or planned to be equipped with TDWR, information from that radar system relayed by dispatchers would allow flight crews to have more detailed current weather information en route than their airborne weather radar systems are able to depict. This information would also help the dispatchers in planning, releasing, and following flights. WSP systems, when they become available (which the FAA expects to be in mid-2002), could provide the same benefits as TDWR for dispatchers located at airports without TDWR. (Little Rock is not among the airports that will be receiving the WSP system.)

The Safety Board concludes that the ability of flight dispatchers to provide timely and accurate weather support would be enhanced if they had access to TDWR information at airports where it is available and WSP information when the system becomes available. Therefore, the Safety Board believes that the FAA should provide U.S. air carriers operating under 14 CFR Part 121 access to TDWR, at airports where the system is available, and access to the WSP system, when it becomes available, so that their flight dispatch offices can use this information in planning, releasing, and following flights during periods in which hazardous weather might impact safety of flight.

Center Weather Service Unit Staffing

Flight 1420 was handled by the Memphis ARTCC before the flight entered Little Rock airspace. The controllers at this center did not have access to real-time weather radar data, and no internal meteorological support was available to them because the center weather service unit (CWSU) had closed. The CWSU at the Memphis center was not staffed for 24-hour operation and had closed on the night of the accident about 2130, even though severe weather was predicted to affect the center's airspace. The CWSU meteorologists have access to WSR-88D[37] weather products and thus could have provided the center controller with better information regarding the line of thunderstorms moving into the area. However, the availability of this information likely would not have affected the outcome of the accident because of the flight crew's impaired performance.

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[37] A WSR-88D system located in North Little Rock (6 miles north-northwest of the airport) provides a three-dimensional volume scan of the atmosphere at varying degrees of elevation and within a range of 240 miles.

In its final report on the USAir flight 1016 accident, the Safety Board issued Safety Recommendations A-95-48 and -52, which asked the FAA and NWS, in cooperation with each other, to reevaluate the CWSU program and develop procedures to enable meteorologists to immediately disseminate information about rapidly developing hazardous weather conditions to Terminal Radar Approach Control and tower facilities. On October 22, 2001, and August 7, 2001, the Board acknowledged that the FAA and NWS, respectively, were working to address the actions specified in the recommendations but expressed concern that the work was not scheduled to be completed in a timely manner. Pending completion of the FAA's and NWS' planned actions, Safety Recommendations A-95-48 and -52 were classified "Open—Acceptable Response" and "Open—Unacceptable Response," respectively.

Even after the FAA and NWS have completed actions to address these recommendations, their intent cannot be fully achieved unless the CWSUs are adequately staffed at all times when rapidly developing hazardous weather conditions are possible. (In letters to the Safety Board regarding the progress in implementing these safety recommendations, neither agency has described such staffing for CWSUs.) The Safety Board concludes that CWSUs should be staffed at all times when any significant weather is predicted to affect their areas of operation, even if the weather is predicted to occur before or after normal operating hours. Therefore, the Safety Board believes that the FAA, in cooperation with the NWS, should ensure that CWSUs are adequately staffed at all times when any significant weather is forecast.

Airport Weather Equipment

Runway Visual Range System

Although the new-generation RVR system at Little Rock was designed to provide a more accurate reading than that provided by the previous RVR system, the Safety Board has two concerns about the new system. First, the RVR data were not directly transmitted to the ASOS. Second, the Board did not have access to 1-minute RVR data for this accident because an event log was not started.

The 1-minute RVR data were not included in the FAA's initial specifications for ASOS recorded data. As a result, certified weather observers are required to contact tower controllers to obtain the 10-minute average RVR readings, and the weather observers use this information in preparing METARs [meteorological aerodrome forecasts] and SPECIs [special weather observations]. However, it is a recommended practice, under Annex 3 to the Convention on International Civil Aviation, for RVR data to be included in automated weather observation systems because of the data's importance to takeoff and landing operations.

This accident demonstrates how an RVR reading can decrease drastically in a short timeframe; the RVR reading of 3,000 feet at 2346:52 had decreased to 1,600 feet less than 1 1/2 minutes later. Because a change in visibility is one of the conditions that generates a SPECI, the Safety Board concludes that RVR data should be directly reported to automated weather systems. Therefore, the Safety Board believes that the FAA should modify automated weather systems to accept RVR data directly from RVR sensors.

In addition, an RVR event log presents a total of 12 hours of the system's data. When an event log is started, the previous 2 hours of recorded RVR data are saved, and the next 10 hours of RVR data are recorded and saved. Thus, after this accident, an event log needed to be started no later than 0150 on June 2, 1999, to preserve 1-minute RVR data before and at the time of the accident. Because an event log was not started, these data were overwritten by newer data. Airways facility personnel are responsible for starting event logs; however, these personnel are not always present in the 2 hours after an event occurs. This small timeframe during which personnel are required to start event logs does not account for the possibility that RVR data will need to be retrieved.

The Safety Board concludes that the current 2-hour RVR archiving capability is inadequate to ensure that data can be preserved for future use. Therefore, the Safety Board believes that FAA should maintain at least a 48-hour archive of 1-minute RVR data. Such an archive could be accomplished either by modifying RVR systems or by interfacing RVR systems with local automated weather systems.

Low Level Windshear Alert System

The Low Level Windshear Alert System (LLWAS)[38] alerts about 2339 and 2347 correctly detected actual windshear conditions associated with the gust front and other wind surges. No windshear alerts were current or were being issued at the time that flight 1420 touched down.[39]

LLWAS centerfield wind sensors are typically mounted between 70 and 100 feet above field elevation; at Little Rock, the sensor is mounted at 70 feet. ASOS wind sensors are mounted at a standard height of 32 feet; thus, ASOS wind data may be more representative of the surface winds that will be present when an airplane is landing. At the time that flight 1420 landed on runway 4R, the ASOS was measuring the wind from 290° at 16 knots with gusts to 22 knots, resulting in a 5-knot tailwind component upon touchdown that increased the airplane's speed on the runway and affected the airplane's directional control and braking performance. The controller's last wind report of 320° at 23 knots (at 2349:53) would not have indicated to the flight crew the possibility of a tailwind at touchdown. Thus, the LLWAS centerfield wind information does not always reflect surface wind conditions, and the difference in height between LLWAS and ASOS sensors, in some cases, may be critical.

The FAA's Aeronautical Information Manual (AIM) Section 1, "Meteorology," Part 7, "Safety of Flight," includes only general information on the LLWAS. The information does not indicate that, in some circumstances, LLWAS centerfield wind information alone may not accurately represent the winds that are present at the runway surface. The information also does not caution that the LLWAS alerts at some airports (including Little Rock) currently do not distinguish between windshear and microburst events. (A future software change to LLWAS will allow all system models to differentiate between microburst and windshear alerts, but the only LLWAS systems that currently make this differentiation are those that are integrated with TDWR

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[38] Little Rock National Airport is equipped with an FAA Type FA-10240 LLWAS, which uses six sensors at remote stations located around the airport to collect wind speed, direction, and gust data.

[39] The LLWAS first detected winds associated with the microburst at 2351:30 and issued alerts from 2352:10 to 0005:10.

systems. Airports with such LLWAS systems include Dallas/Fort Worth, Chicago O'Hare, Denver International Airport, and Atlanta Hartsfield.)

In addition, at the public hearing on this accident, the expert on LLWAS from the Massachusetts Institute of Technology's Lincoln Laboratory indicated his concern that pilots may be disregarding LLWAS alerts and continuing to operate into the terminal area because they perceive that the alerts are false and that no windshear threat exists. This situation may be occurring because pilots may not realize that the LLWAS sensors in use today are not the same as those used in the late 1970s through the late 1980s, which alerted when normal gusting winds were present. The latest LLWAS sensors include technologies to reduce such false alerts, yet this information also does not appear in the AIM.

The Safety Board concludes that, if detailed information on the LLWAS were contained in the FAA's AIM, pilots could have a better understanding of the system. Therefore, the Safety Board believes that the FAA should provide additional information on the LLWAS in the AIM, including that an LLWAS alert is a valid indicator of windshear or a microburst.

Emergency Response

The local controller reported that he called the Aircraft Rescue and Fire Fighting (ARFF) units on the crash phone about 2352 after several attempts to contact the flight crew after the airplane landed. The controller indicated the possibility of an accident at the end of runway 4R but did not specify which end of the runway. The ARFF units proceeded to the approach end of runway 4R, but the airplane was off the departure end of the runway. As a result, the ARFF units had to travel back to the taxiway at which they entered the runway and then proceed to the other end of the runway. The ARFF units located the airplane about 0003, 11 minutes after the initial call from the local controller. However, they did not arrive on scene until 5 minutes later, about 0008 (16 minutes after the initial notification), because they had to travel in the opposite direction to an access road, turn onto a perimeter road back in the direction of the accident site, stop to manually unlock a perimeter security gate, and then continue on the perimeter road to the accident site.

If the ARFF units had known the approximate location of the airplane when they left the fire station, the time spent traveling from the taxiway to the approach end of the runway and back would have been saved. The ARFF units reported that they were initially traveling very slowly because of the limited visibility toward the approach end of the runway and the unknown location of the airplane. The Safety Board recognizes that the controller could have provided a more precise description of the accident location to the ARFF units, especially since he knew the direction in which the airplane was landing and had seen the airplane travel past midfield. However, the Board also recognizes that the ARFF personnel could have queried the controller to see if he knew any additional information about the airplane's location.

The Safety Board concludes that part of the delay in locating the flight 1420 wreckage was preventable and that several minutes in the emergency response time might have been saved if the ARFF units had proceeded directly to the departure end of runway 4R. Because the delay can be partly attributed to the incomplete location information provided to the ARFF units by the local controller, the Safety Board believes that the FAA should issue a mandatory briefing item to tower controllers that describes the circumstances of this accident, including the interactions between the controller and ARFF crews. This briefing item should emphasize that location information provided to ARFF crews should be as complete and specific as possible to minimize opportunities for confusion. The Safety Board also believes that the FAA should amend FAA Order 7110.65, "Air Traffic Control," to require controllers to monitor the progress of ARFF crews responding to emergencies to ensure that the response is consistent with known location information. In addition, the Safety Board believes that the FAA should amend FAA Order 7210.3R, "Facility Operation and Administration," to direct tower managers to establish mutual annual briefings between ATC and ARFF personnel to ensure that these personnel have a common understanding of the local airport emergency plan and sections of the FAA's Advisory Circular (AC) 150/5210-7C, "Aircraft Rescue and Firefighting Communications," that are applicable to local ATC/ARFF emergency response procedures.

The accident was not survivable for those who were seated on the forward left side of the airplane in the area of the collisions with the runway 22L approach lighting structure (the captain and the passengers in seats 3A and 8A) and those who were immediately exposed to lethal impact forces (seats 17B and 18A and B) or fire (seats 19A, B, and C) in the area where the fuselage separated.[40] The accident, however, was potentially survivable for the passenger fatalities in seats 27E and 28D.[41]

Because the accident was potentially survivable for the passengers in seats 27E and 28D, the Safety Board considered whether a shorter ARFF response time could have prevented the fatalities but determined that the passengers' lives would not have been saved if emergency responders had arrived on scene earlier. Even with the shortest possible response time, the passenger in seat 28D would have already received the second- and third-degree burns to over half of her body and the severe inhalation injury from which she later died. The passenger in seat 27E remained on the airplane and therefore needed to be rescued from the wreckage. However, the four ARFF personnel that responded to the accident were not available to enter the airplane because they were involved in positioning the fire trucks and operating fire suppression equipment.[42] Thus, an interior search of the airplane could not be conducted until off-airport firefighters arrived on scene about 0022.

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[40] In a 2001 safety report, the Safety Board defined a survivable accident as follows: "For the accident to be deemed survivable, the forces transmitted to occupants through their seat and restraint system cannot exceed the limits of human tolerance to abrupt accelerations, and the structure in the occupants' immediate environment must remain substantially intact to the extent that a livable volume is provided for the occupants throughout the crash." See National Transportation Safety Board. 2001. *Survivability of Accidents Involving Part 121 U.S. Air Carrier Operations, 1983 Through 2000*. Safety Report NTSB/SR/01-01. Washington, DC.

[41] The passenger in seat 27E died of smoke and soot inhalation. After stating "that's everyone— that's all" in response to another passenger's query about whether anyone was still inside the cabin, the passenger in seat 27E continued farther aft in the cabin (for undetermined reasons) and was overcome by smoke; his body was found in the extreme aft part of the cabin on the right side. The passenger would have most likely survived if he had evacuated the airplane when he was near the right aft overwing exit. The passenger in seat 28D received serious burns when she evacuated the airplane through the left aft overwing exit and died 15 days later of complications from the burn injuries. This passenger would have likely survived if she had exited the airplane through the right aft overwing exit or the tailcone exit. The Safety Board recognizes that three other passengers who used the left aft overwing exit survived the accident, one of whom was burned severely. The passenger in seat 28D may have experienced a more intense fire than the other passengers because of the variable winds that were present or the progression of the fire.

[42] The Safety Board recognizes that Little Rock airport is now staffed with six ARFF personnel at all times.

Aircraft Rescue and Fire Fighting Staffing Levels

The Safety Board could not determine whether the passenger in seat 27E would have survived if sufficient ARFF personnel had been available to perform a rescue. However, previous accidents in which the occupants' survival was aided by or depended on the abilities of rescue personnel to enter an airplane provide lessons learned that highlight the need for an adequate number of ARFF personnel to perform rescue operations.

The FAA's January 1997 final report, *Aircraft Rescue and Firefighting Services—Mission Response Study*, indicated that evacuation of an aircraft was a primary responsibility of the air carriers and that the carriers have crew complements trained for that function. This finding concerns the Safety Board because, in the event that crewmembers are incapacitated or the conditions aboard the airplane deteriorate to the point that the crew is forced to leave, the remaining airplane occupants must rely on ARFF personnel to assist in the evacuation. In fact, the first officer and two of the four flight attendants in the Little Rock accident sustained serious injuries and were unable to assist with the evacuation.

Title 14 CFR 139.319(j) requires that "sufficient rescue and firefighting personnel are available during all air carrier operations to operate the vehicles, meet the response times, and meet the minimum agent discharge rates required by this part." However, the regulation does not contain any specific staffing requirement for ARFF units. Thus, the regulation does not ensure that ARFF units will be staffed at a level that would allow timely entry into an airplane for rescue and firefighting activities.

Insufficient ARFF staffing levels were demonstrated in two recent events. First, on October 10, 2000, a Canadair Challenger Model 604, C-FTBZ, owned by Bombardier Inc., and being operated as a test flight, crashed into terrain and collided with an airport perimeter fence during a failed takeoff from runway 19 at the Wichita Mid-Continent Airport, Kansas.[43] A fuel-fed fire erupted after the collision. Two ARFF fire trucks and three ARFF personnel responded within about 90 seconds and applied a mass application of firefighting agent to extinguish the exterior fire. The firefighters stated that they could hear screams for help coming from the cockpit. One of the ARFF trucks carried a "penetrating nozzle";[44] however, the nozzle could not be used because two trained firefighters were required to operate it, and only one was available. (Two of the three personnel were occupied in their vehicles with firefighting activities.) The pilot and flight test engineer were killed, the copilot received serious injuries and died more than 1 month later, and the airplane was destroyed.

Second, on August 8, 2000, Air Tran flight 913, a DC-9-32, N838AT, made an emergency landing in Greensboro, North Carolina, because of dense smoke in the cockpit.[45] The airplane landed successfully, and an emergency evacuation was conducted. All occupants were able to evacuate the airplane. Four crewmembers received minor injuries from smoke inhalation

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[43] The description for this accident, CHI01MA006, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

[44] A penetrating nozzle is a tool that is used to puncture the skin of a burning airplane and apply extinguishing agent to the interior of the airplane.

[45] The description for this accident, DCA00MA079, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

in flight, 1 passenger received a minor injury during the evacuation, and 1 crewmember and 57 passengers were uninjured. As with the flight 1420 emergency response, three ARFF vehicles and four ARFF personnel responded to the Air Tran event. If the occupants aboard the Air Tran flight had not been able to evacuate, there would not have been adequate ARFF resources to enter the airplane and rescue individuals. In fact, no ARFF personnel entered the airplane until after off-airport emergency responders arrived, despite the fire progressing through the airplane.

The Safety Board concludes that ARFF units may not be staffed at a level that enables ARFF personnel, upon arrival at an accident scene, to conduct exterior firefighting activities, an interior fire suppression attack, and a rescue mission. Therefore, the Safety Board believes that the FAA should amend 14 CFR 139.319(j) to require a minimum ARFF staffing level that would allow exterior firefighting and rapid entry into an airplane to perform interior firefighting and rescue of passengers and crewmembers.

Crash Detection and Location Technology

The accident airplane was not equipped with a technology, such as an emergency locator transmitter (ELT), that might have assisted the controller in directing the ARFF units to the airplane's location after it crashed.[46] Also, the ARFF vehicles were not equipped with the Driver's Enhanced Vision System (DEVS), which was designed to help reduce emergency response times in poor visibility conditions such as those experienced after the flight 1420 crash. The DEVS includes a forward-looking infrared device, which searches for heat sources. Even though the heavy rain at the airport was cooling the plume of smoke from the postcrash fire, it is likely that the device would have detected the smoke plume sooner than the ARFF units were able to see it.[47]

The Safety Board has investigated other accidents in which the use of crash detection and location equipment would have significantly helped with the emergency response effort.[48] It is extremely important that ATC facilities receive immediate information about a downed aircraft and that ARFF units and other emergency responders arrive at the accident scene in the shortest possible time. ELTs, DEVS, and other current technologies that can be used to help detect, locate, or respond to downed aircraft offer the potential for improving emergency response times. The Safety Board concludes that a crash detection and location technology would help expedite the arrival of emergency responders at an accident scene, thus maximizing the possibility for saving lives and reducing the severity of injuries. Therefore, the Safety Board believes that the FAA should evaluate crash detection and location technologies, select the most promising candidate(s) for ensuring that emergency responders could expeditiously arrive at an accident scene, and implement a requirement to install and use the equipment.

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[46] Tower facilities monitor ELT frequencies at all times. The Little Rock ARFF units did not have an ELT receiver.

[47] The FAA requires a forward-looking infrared device to be installed on all of its new fire trucks that carry 1,500 or more gallons. DEVS is currently in use at Logan International Airport in Boston, Massachusetts.

[48] For detailed information, see section 1.18.7.2 in National Transportation Safety Board. 2001. *Runway Overrun During Landing, American Airlines Flight 1420, McDonnell Douglas MD-82, N215AA, Little Rock, Arkansas, June 1, 1999*. Aircraft Accident Report NTSB/AAR-01/02. Washington, DC.

Interagency Emergency Response Critique

Little Rock National Airport did not conduct a postaccident interagency emergency response critique shortly after the flight 1420 accident. Nine months after the accident, the airport completed individual critiques with all of the agencies involved with the emergency response and a group critique with some of these agencies. All of the agencies involved with the emergency response were invited to attend the group critique; however, the Little Rock Fire and Police Departments, the Little Rock Office of Emergency Services, and Metropolitan Emergency Medical Services did not attend. In addition, although the agenda for the group critique included many areas of discussion affecting all facets of an emergency response, the only documented information resulting from these discussions that was provided to the Safety Board was a summary of the hospitals' recommendation, observations, and concerns.

The FAA does not currently require airport operators to perform postaccident emergency response critiques. The Federal Railroad Administration (FRA), however, requires rail carriers to conduct postaccident emergency response critiques. Specifically, 49 CFR 239.105 requires that "each railroad operating passenger train service shall conduct a debriefing and critique session after each passenger train emergency situation" to determine the effectiveness of the railroad's emergency preparedness plan and amend or improve the plan according to the information gleaned. The FRA requires the critique to assess, among other items, how much time elapsed between the emergency situation and the notification to the emergency responders, whether the emergency responders arrived quickly on scene after receiving notification, and whether the emergency response was effective. The FRA further requires that the debriefing and critique session be conducted within 60 days after the passenger train emergency situation and that the railroad maintain records of the session (including the names of all the participants) and make these records available to FRA representatives.

Although a formal postaccident interagency emergency response critique was not required by 14 CFR Part 139, such a critique, if performed in a timely manner after an aviation accident, would enable participants to take immediate, appropriate actions to rectify any identified emergency response deficiencies.

The Safety Board investigated two aviation accidents, 3 years apart, at Dallas/Fort Worth International Airport that demonstrate how corrective actions implemented after one accident response prevented a recurrence of the problem during a subsequent accident response. In the August 2, 1985, Delta flight 191 accident investigation, the Board determined that, although the on-airport emergency response was timely and effective and contributed significantly to saving a number of lives, the amount of time required to complete all of the emergency notifications was excessive (45 minutes). The Board recommended that the Dallas/Fort Worth Airport Board improve its Airport Emergency Plan to provide for more efficient and timely notification of the mutual aid agencies and area hospitals.

On August 31, 1988, Delta flight 1141, a Boeing 727-232, N473DA, crashed during its takeoff roll.[49] Of the 108 airplane occupants, 14 were killed, 26 were seriously injured,

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[49] For more information, see National Transportation Safety Board. 1989. *Delta Air Lines, Inc., Boeing 727-232, N473DA, Dallas/Fort Worth International Airport, Texas, August 31, 1988.* Aircraft Accident Report NTSB/AAR/89-04. Washington, DC.

50 received minor injuries, and 18 were uninjured. The airplane was destroyed by impact forces and postcrash fire. In its final report on this accident, the Board found that the time to complete emergency notifications, including those to the mutual aid agencies and hospitals, had been significantly reduced (21 minutes). The decreased notification time was partly attributed to the installation and use of the Automated Voice Notification System in the airport's Emergency Operations Center. The Board concluded that the corrective actions taken by the Dallas/Fort Worth Airport Board after the flight 191 accident "greatly improved" the communications and coordination of the ARFF personnel and medical units responding to the flight 1141 accident.

The Safety Board concludes that a timely postaccident interagency emergency response critique that identifies deficiencies that need corrective action and successes that should be repeated in similar circumstances would be beneficial for all parties involved in an aviation accident response. Therefore, the Safety Board believes that the FAA should develop specific criteria, using the FRA's requirements as guidance, to be evaluated during a postaccident interagency emergency response critique and amend 14 CFR Part 139 to require airport operators to conduct this critique within 60 days after any air carrier accident and provide the results of the critique to the FAA.

Airport Factors

Runway Safety Areas

Runway 4R/22L, which was opened in September 1991, has runway safety areas of 1,000 feet at the departure end of 22L and 450 feet at the departure end of 4R. Although the FAA's June 5, 1991, version of AC 150/5300-13 stated that the standard runway safety area was 1,000 feet, runway 4R/22L was exempt from this standard under the provisions of 14 CFR 139.309(a)(1), which allowed runways that had a safety area on December 31, 1987, to be maintained, as long as no reconstruction or significant expansion of the runway had begun after January 1, 1988.[50] The Safety Board notes that, in this accident, an extra 550 feet at the departure end of runway 4R would not have prevented the airplane from departing the end of the runway or impacting the approach lighting system; however, the airplane's speed would have further decreased with an extra 550 feet at the end of the runway, resulting in a lower impact speed. Because safety areas of at least 1,000 feet would provide an extra margin of safety under most circumstances, the Board is concerned about runway safety areas that are less than the current FAA standard.

Another recent accident involved an overrun beyond the threshold of a runway with a nonstandard safety area. Specifically, on March 5, 2000, Southwest Airlines flight 1455, a Boeing 737-300, N668SW, departed the end of runway 8 during landing at Burbank-Glendale-Pasadena Airport, Burbank, California. The airplane traveled through a nonfrangible metal blast fence beyond the departure end of the runway and came to rest on a highway outside the airport perimeter. Of the 142 airplane occupants, 2 received serious injuries, 42 received minor injuries, and 98 were uninjured.[51] The runway safety area at the approach (west) end of runway 8/26 is

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[50] Construction of runway 4R/22L began as early as September 1982. Work on the runway continued after January 1, 1988, but none of the efforts involved reconstruction or significant expansion.

[51] The description for this accident, DCA00MA030, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

200 feet; no safety area exists at the departure (east) end of the runway. As with runway 4R/22L in Little Rock, runway 8/26 in Burbank was exempt, under 14 CFR 139.309(a)(1), from the 1,000-foot runway safety area standard in AC 150/5300-13.

On December 13, 1994, the Safety Board issued Safety Recommendation A-94-211, which asked the FAA, among other things, to require that substandard runway safety areas be upgraded to AC 150/5300-13 minimum standards wherever possible.[52] In its October 15, 1997, response, the FAA indicated that 25 percent of the runways at 14 CFR Part 139 certificated airports have safety areas that do not meet AC 150/5300-13 minimum standards but could with feasible improvements and that 17 percent have safety areas that could not be feasibly improved to meet the standard. However, the FAA stated that runway safety area improvement projects would be scheduled only as part of overall runway improvement projects because of the associated cost and infrequency of aircraft overruns and undershoots. On February 10, 1999, the Board expressed its concern that the delay in runway safety area upgrades would allow nonstandard conditions to continue and classified Safety Recommendation A-94-211 "Closed—Unacceptable Action."

The Safety Board recognizes that the design of some airport runways makes it difficult for runway safety areas to be upgraded to the standards of AC 150/5300-13 and that those airport runways that can be upgraded may not be improved for some time based on the FAA's current plans. However, those runways should provide equivalent runway protection. One way to achieve this goal is to install a type of soft-ground aircraft arresting system, such as the Engineering Materials Arresting System (EMAS). The safety benefit of EMAS was demonstrated by the American Eagle flight 4925 accident when the airplane departed an 8,400-foot runway but was stopped approximately 248 feet into a 400-foot EMAS.

According to a report by Engineered Arresting Systems Corporation, which developed EMAS, the flight 1420 airplane would not have been significantly slowed by a standard EMAS installed at the approach end of runway 22L because the airplane's track was outside the extended runway edges. Thus, the flight 1420 airplane would not have been able to use the full length of a standard EMAS. However, according to FAA AC 150/5220-22, "Engineered Materials Arresting System for Aircraft Overruns," most airplane runway overruns "come to rest within 1,000 feet of the runway end and between the extended edges of the runway." Therefore, the Safety Board continues to support the installation of EMAS, especially for those runways in which the safety area is less than the minimum standards established in AC 150/5300-13. The Board notes that an EMAS was installed at the departure end of runway 4R at Little Rock in the fall of 2000. The Board further notes that Little Rock airport is working with Federal and local government agencies to extend the runway safety area at the departure end of runway 4R to 1,000 feet by July 2002.

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[52] This recommendation was issued as a result of the April 27, 1994, Action Air Charters flight 990 accident in Stratford, Connecticut. For more information, see National Transportation Safety Board. 1994. *Impact With Blast Fence Upon Landing Rollout, Action Air Charters Flight 990, Piper PA-31-350, N990RA, Stratford, Connecticut, April 27, 1994.* Aircraft Accident Report NTSB/AAR-94/08. Washington, DC.

Nonfrangible Structures

The FAA determined that the runway 22L approach lighting system at Little Rock, which is located in a flood plain area of the Arkansas River, could not be retrofitted to a frangible design because of the possibility that moving water, ice, and floating debris would affect the structural integrity of the system. The Safety Board recognizes the current design limitations of this approach lighting system and acknowledges that, if the approach lighting system had been frangible, it is possible that the accident airplane would not have been stopped on the ground and would have gone into the Arkansas River. However, the Board also recognizes that frangible structures, because of their ability to break, distort, or yield on impact with aircraft, generally present less risk than nonfrangible ones. In this accident, the airplane's collision with the nonfrangible approach lighting system was the direct cause of the fatal blunt force trauma injuries sustained by the captain and the passengers in seats 3A and 8A and the destruction to the airplane on the left side of the fuselage.

In 1984, the Safety Board issued Safety Recommendation A-84-36, which asked the FAA to "initiate research and development activities to establish the feasibility of submerged low-impact resistance support structures for airport facilities and promulgate a design standard if such structures are found to be practical." The FAA conducted research in this area with the National Institute of Standards and Technology. In October 1996, the FAA concluded that, with the current technology, any submerged low-impact frangible structure would most likely be destroyed by wave motion from small storms. Because of the FAA's research activities, the Board classified the recommendation "Closed—Acceptable Action."

The FAA has had an effort underway for some time to replace selected nonfrangible structures with frangible ones. However, technological advances since the time of the FAA/National Institute of Standards and Technology research activities, especially those involving the use of new materials, might allow some additional nonfrangible structures to be replaced by frangible ones. The Safety Board concludes that the development of recent technologies to convert nonfrangible structures to frangible ones would provide a safety benefit to airport facilities. Therefore, the Safety Board believes that the FAA should conduct research activities to determine if recent technological advances would enable submerged low-impact structures and other nonfrangible structures at airports to be converted to frangible ones.

American Airlines

Stabilized Approach Criteria

At the time of the accident, American's only written guidance for MD-80 pilots regarding the stabilized approach concept was in the "Techniques" section of the DC-9 Operating Manual. The guidance indicated that the minimum recommended stabilized approach altitudes for IFR and visual flight rules (VFR) conditions were 1,000 and 500 feet, respectively, and that landing flaps were to be selected by 1,000 feet afl. The guidance also stated that, before descending below the specified minimum stabilized approach altitude, the airplane was to be in the final landing configuration (gear down and final flaps), on approach speed, on the proper flightpath, at the proper sink rate, and at stabilized thrust; these conditions were expected to be maintained throughout the rest of the approach. However, the guidance did not define what was meant by "on" approach speed, "on" the proper flightpath, and "at" the proper sink rate. In addition, the guidance did not describe the necessary flight crew actions if the stabilized approach criteria were not met. Further, information presented in the "Techniques" section was not considered by American to be required procedures but rather suggested ways of accomplishing a task.[53]

The Safety Board notes that American revised its stabilized approach criteria after the accident and included this information in both its Airplane Flight Manual and DC-9 Operating Manual. The revised company procedures state that the airplane must be "at approach speed (V_{ref} plus additives)" rather than "on approach speed." The procedures also state that the minimum stabilized approach height is 1,000 feet afl in instrument meteorological conditions and 500 feet afl in visual meteorological conditions rather than present minimum recommended stabilized approach altitudes for IFR and VFR conditions. In addition, the procedures explicitly state that a go-around is required if stabilized approach requirements cannot be maintained until landing.

At the public hearing on this accident, the first officer discussed the training and guidance that he had received at American concerning a decision to execute a go-around. The first officer indicated that this decision was based on the stabilized approach theory. He stated that, if the sink rate was excessive or if the airplane was deviated to the left or right of course (among other criteria), then the approach would not meet the stabilized approach definition and a go-around should be performed.

American's flight manual contains the only written guidance regarding the performance of a missed approach. At the time of the accident, the manual stated that, when a landing cannot be accomplished, the pilot must comply with the missed approach procedure, or an alternate missed approach procedure specified by ATC, upon reaching the missed approach point defined on the approach chart. The missed approach procedures were revised on August 15, 1999, to state that American Airlines has a "no-fault go-around policy" and recognize that a successful approach can end in a missed approach. The revised procedures require captains to execute or order a missed approach if the aircraft is not stabilized by 1,000 feet afl (in IFR conditions) or 500 feet afl (in VFR conditions) or if the captain believes that a safe landing cannot be accomplished within the touchdown zone or that the airplane cannot be stopped within the available runway length.

The Safety Board acknowledges that American revised its missed approach procedures to ensure that its pilots are aware that they will not be faulted if they perform a missed approach and that the revised procedures specify the altitude at which a go-around is required if an approach is not stabilized. However, the new stabilized approach requirements still do not explicitly state what is meant by "proper" flightpath and "proper" sink rate. Further, the requirements do not provide pilots with specific amounts of glideslope and localizer displacement for determining whether an approach is stabilized. The new requirements also do not contain specific, corrective actions for pilots to take if an approach becomes unstabilized before the required minimum

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[53] The Safety Board recognizes that American plans to integrate the "Techniques" section with the "Normals" section of the DC-9 Operating Manual, which contains required, rather than suggested, procedures for accomplishing tasks. However, American did not provide any timetable for combining the two sections, stating at the public hearing that it was "gradually" editing out the "Techniques" section. Thus, the minimal stabilized approach guidance that does exist may remain only as a suggested procedure for some time. Even after the information is placed in the "Normals" section, it will still lack the necessary specificity to assist pilots in recognizing an unstabilized approach.

stabilized approach heights.[54] Thus, the Safety Board concludes that American Airlines has insufficient guidance to assist its pilots in performing a stabilized approach and recognizing when an approach has become unstabilized.

On August 29, 1997, the Safety Board issued Safety Recommendation A-97-85, which asked the FAA to require all 14 CFR Part 121 and 135 operators to review and revise their company operations manuals to more clearly define terms that are critical for safety-of-flight decision-making, such as "stabilized approach."[55] On May 26, 1998, the FAA issued Flight Standards Handbook Bulletin for Air Transportation (HBAT) 98-22, "Stabilized Approaches," which directed 14 CFR Part 121 and 135 POIs to review operators' training and operations manuals to ensure that they addressed, among other things, the minimum requirements for a stabilized approach and the immediate actions that needed to be taken if the stabilized approach conditions were not met. On the basis of the FAA's actions, the Safety Board classified Safety Recommendation A-97-85 "Closed—Acceptable Action" on November 20, 1998.

The Safety Board is concerned that, even with the requirement for POIs to ensure that their carriers' stabilized approach guidance is in accordance with Flight Standards HBAT 98-22, some carriers may still have stabilized approach guidance that lacks specificity (as demonstrated by American's revised MD-80 stabilized approach guidance.) In addition, guidance to air carriers on stabilized approach criteria in the FAA's Air Transportation Operations Inspector's Handbook is not sufficiently detailed to ensure that carriers provide their pilots with defined guidelines for determining a stabilized approach and deciding when a missed approach is necessary. The Safety Board concludes that, because a stabilized approach is a critical part of safe flight operations, it is imperative that air carriers have specific stabilized approach criteria. Therefore, the Safety Board believes that the FAA should define detailed parameters for a stabilized approach, develop detailed criteria indicating when a missed approach should be performed, and ensure that all 14 CFR Part 121 and 135 carriers include this information in their flight manuals and training programs.

Spoiler and Braking Systems Procedures

At the time of the accident, American had not adopted Boeing's MD-80 spoiler deployment and autobrake procedures. Boeing's procedures recommended a "no spoilers" callout by the nonflying pilot if the spoiler handle did not move aft after touchdown and the use of maximum autobrakes for landings on wet or slippery runways. The flight crew's failure to detect that the spoilers had not deployed at touchdown might have been avoided if a procedure similar to Boeing's had been in place at American at the time. If the spoilers had deployed and the flight crew had selected maximum autobrakes for the landing, initial brake application could have occurred about 4 seconds sooner.

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[54] In the February 6, 1997, American Airlines flight 699 accident in St. John's, Antigua, the Safety Board determined that a contributing factor in the accident was American's inadequate procedures to address corrective actions for approaches that become unstabilized. The description for this accident, DCA97LA027, can be found on the Safety Board's Web site at <http://www.ntsb.gov>.

[55] This recommendation was issued as a result of the October 19, 1996, Delta Air Lines flight 554 accident in New York. For more information, see National Transportation Safety Board. 1997. *Descent Below Visual Glidepath and Collision With Terrain, Delta Air Lines Flight 554, McDonnell Douglas MD-88, N914DL, LaGuardia Airport, New York, October 19, 1996*. Aircraft Accident Report NTSB/AAR-97/03. Washington, DC.

At the public hearing on this accident, Boeing's MD-80 Chief Pilot for Flight Operations indicated that operators are not required to adopt the operating procedures in Boeing's FCOM and that operators, along with their POIs, can change the procedures. The Chief Pilot also indicated that most, if not all, of the domestic operators coordinate with the manufacturer—normally by requesting a letter of no technical objection—before making any changes to their flight manual, even though there is no legal requirement to do so. In an April 20, 2000, letter to the Safety Board, Boeing indicated that it could not find any record of issuing a letter of no technical objection to American regarding alteration of the manufacturer's recommended spoiler deployment or autobrake procedures.

On November 30, 1998, Safety Recommendation A-98-102 was issued because air carriers had the prerogative not to adopt certain manufacturer procedures without clear written justification.[56] Safety Recommendation A-98-102 asked the FAA to "require air carriers to adopt the operating procedures contained in the manufacturer's airplane flight manual and subsequent approved revisions or provide written justification that an equivalent safety level results from an alternate procedure." In response to this recommendation, the FAA issued, in May 1999, the Joint Flight Standards HBAT, Airworthiness, and General Aviation, Flight Standards Policy—Company Operating Manuals and Company Training Program Revisions for Compliance. The handbook bulletin directed that POIs encourage their operators to (1) have a reliable delivery system in place for flight manual revisions, which ensures that the operators receive the revisions within 30 calendar days of approval, and (2) develop an action plan to notify, in writing, respective POIs of new flight manual revisions within 15 days after receipt.

In addition, on July 7, 2000, the FAA stated that it had initiated an NPRM proposing to revise 14 CFR Part 121, Subparts N and O, to reflect the policy included in the May 1999 Joint Flight Standards HBAT, Airworthiness, and General Aviation, Flight Standards Policy—Company Operating Manuals and Company Training Program Revisions for Compliance. On January 12, 2001, the Safety Board acknowledged the FAA's actions and stated that, pending the issuance of the NPRM and implementation of the proposed regulation, Safety Recommendation A-98-102 was classified "Open— Acceptable Response." On August 2, 2001, the FAA stated that it was continuing to develop the NPRM.

At the public hearing on this accident, the POI for American indicated that a carrier might choose not to make a manufacturer's suggested change because of the way that the carrier has configured the particular airplane. However, it is critical that the carrier provide written justification to the FAA regarding the reasons for not making a change or for implementing an alternative procedure in case the manufacturer's performance data do not support the carrier's justification. It is also critical that the carrier make its POI and respective aircrew program manager (APM) aware of any manufacturer's recommended procedure that is not being adopted or is being altered.

The Safety Board recognizes that American, since the time of the accident, has revised its DC-9 Operating Manual to include spoiler deployment and autobrake procedures similar to

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[56] This recommendation was issued as a result of the January 9, 1997, Comair flight 3272 accident near Monroe, Michigan. For more information, see National Transportation Safety Board. 1998. *In-flight Icing Encounter and Uncontrolled Collision With Terrain, Comair Flight 3272, Embraer EMB-120RT, N265CA, Monroe, Michigan, January 9, 1997*. Aircraft Accident Report NTSB/AAR-98/04. Washington, DC.

Boeing’s. The Board further recognizes that the FAA has taken positive steps toward implementing the intent of this recommendation. However, this accident highlights the need for timely action to ensure that pilots are operating airplanes according to procedures that reflect the manufacturer’s safest operating practices. Therefore, the Safety Board reiterates Safety Recommendation A-98-102.

Federal Aviation Administration Oversight

Within the FAA’s Certificate Management Office for the AMR Corporation, the POI for American Airlines is responsible for the overall oversight of American’s training and line operations and for approving training and flight manuals and their revisions. At the public hearing, the POI stated that he needed more inspectors to conduct surveillance but that a hiring freeze was in effect. The POI also indicated that he needed almost double the number of air safety inspectors he had in his office at the time and that his inability to hire more inspectors had severely impacted his office’s surveillance activities. Further, the POI expressed concern that his office did not have geographic air safety inspectors in some locations where American has a large volume of operations.

An APM and an Assistant APM were responsible for providing oversight of American’s MD-80 fleet. This oversight responsibility included reviewing and approving the contents of the flight manuals, monitoring the training program, reviewing recommended changes to the manuals and training program, and monitoring daily line operations. The APM indicated that his ability to oversee American’s MD-80 fleet was affected by personnel constraints. For example, the APM stated that, because he and the Assistant APM were the only ones responsible for observing American’s MD-80 training, they were “spread thin” and found it “extremely difficult” to observe all facets of the training program. In addition, the APM stated that budget constraints had limited the amount of oversight that could be performed and the locations where it could be performed.

The APM said that a thorough job of oversight required many personnel, which he did not have. According to the APM, selected check airmen from American Airlines, named aircrew program designees, performed most of the airman certification activities under the APM’s supervision. Also, senior designated examiners at American were responsible for observing every company check airman and simulator instructor at least once a year. Further, the APM relied heavily on American Airlines to ensure standardization in its simulator training program.

It is clear that the FAA’s oversight responsibilities for American’s MD-80 training were highly dependent on the work of American’s check airmen, aircrew program designees, and senior designated examiners. Although the Safety Board acknowledges that American and the FAA’s Certificate Management Office for the AMR Corporation have developed a cooperative working relationship with each other, the Board is concerned about the lack of direct FAA oversight of American’s MD-80 fleet. The problems found during observations of American’s simulator training sessions (for example, the students’ use of reverse thrust above 1.3 EPR on wet runways and failure to notice the lack of spoiler extension) might have been detected earlier if the FAA had been directly monitoring the training.

In its final report on the USAir flight 1016 accident, the Safety Board expressed its concern about the relationship between USAir and the FAA POI for USAir. Specifically, the Board faulted the POI for relying entirely on USAir to rectify a situation in which many pilots were not in compliance with a standard operating procedure. The Board stated that "overreliance on the air carrier to carry out its [the FAA's] responsibility could limit the POI's ability to maintain an adequate oversight program and monitor the operation for noncompliance." The flight 1420 accident has brought attention to another circumstance of FAA overreliance on a carrier to perform oversight activities. Independent oversight for American's MD-80 fleet is necessary, especially because three-quarters of the new upgrade captains and one-half of the new hire pilots are assigned to the MD-80 fleet, according to the APM.

The Safety Board concludes that effective FAA oversight of American Airlines' MD-80 flight training and flight operations has not occurred. In light of the comments made by the POI for American at the public hearing, the Board is concerned that similar oversight problems might be occurring in the company's other fleets. Therefore, the Safety Board believes that the FAA should provide additional personnel to accomplish direct oversight of American Airlines' flight training and flight operations and include the POI for American in decisions regarding where these personnel are to be placed. In addition, the Board encourages the FAA to review oversight staffing levels at all Part 121 and 135 carriers and make appropriate changes to ensure that effective oversight of flight training and flight operations is occurring.

Therefore, the National Transportation Safety Board recommends to the Federal Aviation Administration:

> For all 14 *Code of Federal Regulations* Part 121 and 135 operators of airplanes equipped with automatic spoiler systems, require dual crewmember confirmation before landing that the spoilers have been armed, and verify that these operators include this procedure in their flight manuals, checklists, and training programs. (A-01-49)
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> For all 14 *Code of Federal Regulations* Part 121 and 135 operators, require a callout if the spoilers do not automatically or manually deploy during landing and a callout when the spoilers have deployed, and verify that these operators include these procedures in their flight manuals, checklists, and training programs. The procedures should clearly identify which pilot is responsible for making these callouts and which pilot is responsible for deploying the spoilers if they do not automatically or manually deploy. (A-01-50)
>
> Issue a flight standards information bulletin that requires the use of 1.3 engine pressure ratio as the maximum reverse thrust power for MD-80 series airplanes under wet or slippery runway conditions, except in an emergency in which directional control can be sacrificed for decreased stopping distance. (A-01-51)
>
> Require principal operations inspectors of all operators of MD-80 series airplanes to review and determine that these operators' flight manuals and training programs contain information on the decrease in rudder effectiveness when reverse thrust power in excess of 1.3 engine pressure ratio is applied. (A-01-52)

Require all operators of MD-80 series airplanes to require a callout if reverse thrust power exceeds the operators' specific engine pressure ratio settings. (A-01-53)

For all 14 *Code of Federal Regulations* Part 121 and 135 operators, require the use of automatic brakes, if available and operative, for landings during wet, slippery, or high crosswind conditions, and verify that these operators include this procedure in their flight manuals, checklists, and training programs. (A-01-54)

Establish a joint Government-industry working group to address, understand, and develop effective operational strategies and guidance to reduce thunderstorm penetrations, and verify that these strategies and guidance materials are incorporated into air carrier flight manuals and training programs as the strategies become available. The working group should focus its efforts on all facets of the airspace system, including ground- and cockpit-based solutions. The near-term goal of the working group should be to establish clear and objective criteria to facilitate recognition of cues associated with severe convective activity and guidance to improve flight crew decision-making. (A-01-55)

Incorporate, at all air traffic control facilities, a near-real-time color weather radar display that shows detailed precipitation intensities. This display could be incorporated by configuring existing and planned Terminal Doppler Weather Radar or Weather Systems Processor systems with this capability or by procuring, within 1 year, a commercial computer weather program currently available through the Internet or existing stand-alone computer hardware that displays the closest single-site Weather Surveillance Radar 1988 Doppler data or regional mosaic images. (A-01-56)

Provide U.S. air carriers operating under 14 *Code of Federal Regulations* Part 121 access to Terminal Doppler Weather Radar, at airports where the system is available, and access to the Weather Systems Processor, when it becomes available, so that their flight dispatch offices can use this information in planning, releasing, and following flights during periods in which hazardous weather might impact safety of flight. (A-01-57)

In cooperation with the National Weather Service, ensure that Center Weather Service Units are adequately staffed at all times when any significant weather is forecast. (A-01-58)

Modify automated weather systems to accept runway visual range (RVR) data directly from RVR sensors. (A-01-59)

Maintain at least a 48-hour archive of 1-minute runway visual range data. (A-01-60)

Provide additional information on the Low Level Windshear Alert System (LLWAS) in the Aeronautical Information Manual, including that an LLWAS alert is a valid indicator of windshear or a microburst. (A-01-61)

Issue a mandatory briefing item to tower controllers that describes the circumstances of this accident, including the interactions between the controller and Aircraft Rescue and Fire Fighting (ARFF) crews. This briefing item should emphasize that location information provided to ARFF crews should be as complete and specific as possible to minimize opportunities for confusion. (A-01-62)

Amend Federal Aviation Administration Order 7110.65, “Air Traffic Control,” to require controllers to monitor the progress of Aircraft Rescue and Fire Fighting crews responding to emergencies to ensure that the response is consistent with known location information. (A-01-63)

Amend Federal Aviation Administration (FAA) Order 7210.3R, “Facility Operation and Administration,” to direct tower managers to establish mutual annual briefings between air traffic control (ATC) and Aircraft Rescue and Fire Fighting (ARFF) personnel to ensure that these personnel have a common understanding of the local airport emergency plan and sections of the FAA’s Advisory Circular 150/5210-7C, “Aircraft Rescue and Firefighting Communications,” that are applicable to local ATC/ARFF emergency response procedures. (A-01-64)

Amend 14 *Code of Federal Regulations* 139.319(j) to require a minimum Aircraft Rescue and Fire Fighting staffing level that would allow exterior firefighting and rapid entry into an airplane to perform interior firefighting and rescue of passengers and crewmembers. (A-01-65)

Evaluate crash detection and location technologies, select the most promising candidate(s) for ensuring that emergency responders could expeditiously arrive at an accident scene, and implement a requirement to install and use the equipment. (A-01-66)

Develop specific criteria, using the Federal Railroad Administration’s requirements as guidance, to be evaluated during a postaccident interagency emergency response critique, and amend 14 *Code of Federal Regulations* Part 139 to require airport operators to conduct this critique within 60 days after any air carrier accident and provide the results of the critique to the Federal Aviation Administration. (A-01-67)

Conduct research activities to determine if recent technological advances would enable submerged low-impact structures and other nonfrangible structures at airports to be converted to frangible ones. (A-01-68)

Define detailed parameters for a stabilized approach, develop detailed criteria indicating when a missed approach should be performed, and ensure that all 14 *Code of Federal Regulations* Part 121 and 135 carriers include this information in their flight manuals and training programs. (A-01-69)

> Provide additional personnel to accomplish direct oversight of American Airlines' flight training and flight operations, and include the principal operations inspector for American in decisions regarding where these personnel are to be placed. (A-01-70)

Also as a result of its investigation, the Safety Board issued Safety Recommendations A-01-71 and -72 to the National Weather Service.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these safety recommendations.

Original Signed

By: Marion C. Blakey
Chairman