National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 13, 2007

In reply refer to: A-07-55 and -56

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 12, 2005, about 2316 central daylight time, a Boeing 717-200, N910ME, operated by Midwest Airlines, Inc., as flight 490, experienced unreliable airspeed indications during climbout through 19,000 feet in heavy rain and icing conditions over Union Star, Missouri. The airplane experienced significant gains and losses of altitude[1] before the crew, having declared an emergency, was able to regain control and divert to Kirksville, Missouri. There were no injuries to the 2 certificated airline transport pilots, 2 flight attendants, and 76 passengers. Night instrument meteorological conditions prevailed for the flight, which was operating on an instrument flight rules flight plan conducted under 14 *Code of Federal Regulations* (CFR) Part 121.[2]

The National Transportation Safety Board's investigation of this event is focusing on the air data sensor heating system, which, when active, heats the pitot probes that provide airspeed indications to the captain and first officer.[3] The 717 does not have an automatic activation of the air data sensor heating system; pilots have to activate the system manually[4] as a pretakeoff checklist item.[5] A set of cockpit warnings and advisories assist the crew in remembering to

[1] Investigation determined that both pilots manipulated the flight controls during the event and that the altitude deviations observed during the event could reflect a combination of deficient coordination between the pilots and unreliable and erratic airspeed indications.

[2] More information about this event, NYC05MA083, is available at the National Transportation Safety Board's Web site at <http://www.ntsb.gov/ntsb/query.asp>.

[3] A blockage, such as ice, on any of the pitot probes would result in erroneous calibrated airspeeds (CAS) and airspeed differences, or splits, displayed to the flight crew. When the logic within the flight control system detects that the captain's and first officer's CAS are split by more than a specified airspeed tolerance, it will declare CAS invalid, and the autoflight system will disengage.

[4] In the 717, pilots activate the air data sensor heating system by pushing the air data heat (ADH) switch in the cockpit overhead panel to the "ON" position. An illuminated amber "OFF" message in the center of the switch extinguishes to confirm activation.

[5] Midwest Airline procedures required that the accident flight crew verify the activation of the ADH system before takeoff, with one crewmember stating aloud "ice protection panel," and the other confirming aloud "check." It is unknown whether the accident crew performed this check because the cockpit voice recording began later in the takeoff sequence.

activate the system.[6] However, the Safety Board was unable to determine from available evidence whether the pilots activated the air data heating system before the event. A postincident assessment of flight data recorder (FDR) data revealed evidence, such as differences in airspeed between the captain's and first officer's flight displays and rates of airspeed change, that is consistent with a lack of air data sensor heating while the airplane climbed into colder temperatures. Further, results of postincident tests of the air data system on the incident airplane found that the pitot/static system, air data sensor heating system, and related airspeed indication systems were capable of fully functioning. The absence of evidence of system deficiencies suggests that the lack of pitot probe heating preceding the upset was caused by human error in the flight crew's failure to activate the system. Further, the evidence indicates that the available cockpit warnings were ineffective at alerting the crew to the absence of air data heat (ADH) functioning.

During its investigation of the Midwest Airlines event, the Safety Board learned of a related event that occurred on March 5, 2002, in which the flight crew of a Boeing 717-200, operated by Hawaiian Airlines, experienced multiple flight deck alerts and a loss of autoflight functions along with a significant reduction in indicated airspeed while climbing through heavy rain and icing conditions. Subsequent activation of the ADH switch restored the airspeed displays and extinguished the alerts. Boeing's investigation concluded that the system anomalies were due to erroneous airspeed indications caused by ice buildup on the pitot probes. Again, it was not possible to determine whether the flight crew activated the air data sensor heating system before takeoff. The fact that the airspeed displays were restored when the flight crew activated the ADH switch suggests that the related systems were capable of fully functioning and that the lack of air data sensor heating in this event was also likely due to the flight crew's failure to activate the system before takeoff and, initially, the crew's failure to be alerted by the available cockpit warning systems.

Findings in the investigation of the Hawaiian Airlines event and the Safety Board's investigation of the Midwest Airlines event support the need to provide automatic activation of ADH systems on transport-category airplanes, as first recommended by the Board in 1995 following the March 2, 1994, accident involving a Continental Airlines McDonnell Douglas MD-82 airplane. The accident airplane sustained substantial damage when the captain rejected the takeoff at LaGuardia Airport, Flushing, New York. The airplane continued beyond the end of the runway and came to rest with the fuselage balanced on top of a dike and the underside touching a tidal flat of Flushing Bay. There were no fatalities or serious injuries reported among the 116 passengers and crew. The Safety Board determined that the probable cause of the accident was "the failure of the flight crew to comply with checklist procedures to turn on an operable pitot/static heat system, resulting in ice and/or snow blockage of the pitot tubes that produced erroneous airspeed indications, and the flight crew's untimely response to anomalous airspeed indications with the consequent rejection of takeoff at an actual speed of 5 knots above

[6] Title 14 CFR 25.1326, "Pitot Heat Indication Systems," requires that cockpit indications be provided to the flight crew when the pitot heating system is not operating. In accordance with this requirement, the 717 incorporates an indication system in which the amber OFF message on the activation switch remains illuminated if pilots fail to activate the ADH system. In addition, a MISC (or miscellaneous) cue switch on the system control panel illuminates and an amber visual alert at the bottom of the engine and alert display that reads AIR DATA HEAT OFF illuminates. The master caution light does not illuminate.

V_1."[7] As a result of this accident, the Safety Board recommended the following to the Federal Aviation Administration (FAA):

> Require the modification of transport-category airplanes to incorporate the automatic activation of air data sensor heating systems without flight crew action. (A-95-21)
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> Amend the requirements of Part 25.1323(e) to require that, for newly certificated airplanes, anti-ice protection for the air data sensor heating systems is provided automatically (without flight crew action) following engine start. (A-95-22)

In a February 18, 1997, response, the FAA indicated that it did not agree that the recommended actions were necessary, noting that "[c]urrent FAA regulations require a caution indication in the cockpit [that] alerts pilots that the air data sensor heating systems (pitot, static, angle of attack) are not activated" and that it therefore believed proper systems were already in place to alert a flight crew. The FAA also noted that a retrofit program to incorporate an automatic means to activate the sensor system heat as recommended in Safety Recommendation A-95-21 "would be very complex and expensive...yet not give an appreciable advantage to the warning indicators already available to the flight crew."

On June 19, 1997, the Safety Board responded "the Continental Airlines accident … provides an excellent example of the potential for tragic consequences if air data sensor heating systems fail or are not activated by the pilots." The Board's response also noted the lack of adherence to checklists and other human errors that were involved in the Continental Airlines accident and that "there is reason to believe that similar errors could be repeated in the future." The Board reiterated its belief that the FAA should require the automatic activation of air data sensor heating systems on all transport-category airplanes, stating that "a significant number of [newer transport-category] airplane models … for example, the MD-11, 757/767, 777, and A-320/330/340 airplanes, have automatic systems that do not require crew actions to ensure that pitot-static probes are heated." The Board classified Safety Recommendations A-95-21 and -22 "Open—Unacceptable Response" pending FAA reevaluation of the matter.

In a June 5, 1998, letter, the FAA maintained in regard to Safety Recommendation A-95-21 that "existing transport-category airworthiness standards provide for an adequate level of safety in alerting flight crews to nonactivated air data sensor heating systems." The FAA also stated that although "many of the more recently certificated airplanes have the automatic feature installed and are experiencing good performance and reliability … this feature was incorporated into the basic design concept of these aircraft and does not involve the retrofit or modification of the existing airframe and systems." Regarding Safety Recommendation A-95-22, the FAA indicated that it would "consider rulemaking action to revise 14 CFR Part 25" as recommended. In response, the Safety Board classified Safety Recommendation A-95-21 "Closed—Unacceptable Action" and Safety Recommendation A-95-22 "Open—Acceptable Response" on November 10, 1998.

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[7] For more information, see National Transportation Safety Board, *Runway Overrun Following Rejected Takeoff, Continental Airlines Flight 795, McDonnell Douglas MD-82, N18835, LaGuardia Airport, Flushing, New York, March 2, 1994*, Aircraft Accident Report NTSB/AAR-95/01 (Washington, DC: NTSB, 1995).

In a January 11, 2000, response to Safety Recommendation A-95-22, the FAA indicated that it continued its efforts to initiate rulemaking to revise 14 CFR Part 25 as recommended but that the aviation rulemaking advisory committee's workload and "other higher priorities" would take the effort several years to complete. In a February 25, 2000, response, Safety Recommendation A-95-22 remained classified "Open—Acceptable Response," but, noting 5 years of no FAA action on this issue, the Safety Board urged the FAA to initiate "a more expeditious program that will result in rulemaking within this fiscal year."

On June 7, 2002, the FAA responded that it did not believe that there was "sufficient safety justification to proceed immediately" and that review of newly certificated airplanes provided "further assurance that newly certificated airplanes are often designed to activate the air data sensor heating systems automatically without flight crew action, even in the absence of a specific regulatory requirement." In a November 1, 2002, response, the Safety Board stated that it disagreed with the FAA's evaluation and noted that the pitot probe heaters were likely not turned on in an April 7, 1999, accident involving a Turkish Airlines Boeing 737-400 that lost control while operating in an area of severe thunderstorms and crashed shortly after takeoff from Adana, Turkey.[8] The Board stated "although we understand that most newly certified aircraft have pitot tube heaters, the Board continues to believe that this should be a requirement on all aircraft." Because the FAA did not intend to take the recommendation action, Safety Recommendation A-95-22 was classified "Closed—Unacceptable Action."

As a result of FAA inaction, the Safety Board is again revisiting this issue. The Board notes that despite the FAA's belief that newly certificated airplanes are designed to activate these systems automatically, the 717, certificated in 1999, was certificated without such automatic activation of the system.[9] Boeing issued Alert Service Bulletin (ASB) 717-30A0003, Revision 2, on November 28, 2006, describing procedures for installing modifications to the 717-200 air data sensor heating system design, which partially addressed the lack of automatic functionality. The improved design ensures that no single failure or likely combination of failures will cause the simultaneous loss of pitot heating to the captain's, auxiliary, and first officer's pitot probes and that the pitot heating system is continuously powered after takeoff in the event that the crew fails to activate the system manually. On February 14, 2007, the FAA issued a notice of proposed rulemaking (NPRM), titled "McDonnell Douglas Model 717-200 Airplanes," proposing to require the incorporation of the modified system design described in Boeing ASB 717-30A0003 for all McDonnell Douglas Model 717-200 airplanes. As the Safety Board noted in its March 30, 2007, response to the NPRM, the Board fully supports the adoption of this NPRM.[10] At the same time, the Safety Board recognizes that the upgrade proposed in the NPRM represents only a partial solution because it would not automate the activation of the pitot heat system for the 717 airplane during the takeoff roll.

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[8] The Directorate General of Civil Aviation – Turkey conducted the investigation of this accident and issued a report on April 4, 2002. In accordance with Annex 13 to the Convention on International Civil Aviation, the Safety Board participated in the investigation as a representative of the State of manufacture. The investigation of this accident concluded that the pitot static anti-ice system was probably not activated during preparations for flight and that the crew failed to recognize the cause of erratic airspeed indication. A brief description of this accident, DCA99RA053, can be found on the Safety Board's Web site at <http://www.ntsb.gov/ntsb/query.asp>.

[9] The 717 airplane is a derivative of the DC-9/MD-80/MD-90 family of airplanes.

[10] The comment period for this NPRM closed April 2, 2007.

Further, as demonstrated by the April 7, 1999, Turkish Airlines accident and the following voluntary pilot reports to the National Aeronautics and Space Administration's aviation safety reporting system (ASRS), [11] this safety issue also extends to the 737-400 and 737-800, which also lack automatic activation of the air data sensor heating system: [12]

- In November 2002, the flight crewmembers of a 737-800 reported that they failed to activate the air data sensor heating system after being deiced and were unaware that the system was inactive until the airplane experienced probe icing during climbout.
- In January 2003, the flight crew of a 737-800 reported rejecting a takeoff at 30 to 40 knots when the master caution illuminated. The air data sensor heating system had not been activated.
- In February 2003, the flight crew of a 737-800 reported rejecting a takeoff at about 90 knots when the master caution and engine lights illuminated. The air data sensor heating system had not been activated.

The Safety Board notes that the activation of anti-ice protection is critical for safe flight, must be performed before every flight, and requires no human judgment; rather, it requires only simple recall and monitoring. Studies have shown that humans are often deficient at such tasks[13] and are susceptible to forgetting to perform intended actions no matter how critical due to a break in normal checklist flow.[14] By contrast, the success of current automatic systems for activating the air data sensor heating systems on newer transport-category airplanes indicates that they are practical and workable systems. The automation of pitot heat activation represents an excellent use of automation to relieve pilots from having to remember to perform a critical task. It requires no human judgment and provides a specific example of a general certification shortcoming addressed by the Safety Board in a 2006 safety report,[15] which examined the need

[11] The ASRS database consists of voluntary reports submitted by pilots and other aviation professionals about safety issues experienced during line operations. Although ASRS reports are useful for identifying safety issues, they do not provide a basis for determining the magnitude of a problem since additional professionals may experience the same safety issue without submitting a report.

[12] If pilots fail to activate the 737 air data sensor heating system, an amber warning illuminates in the overhead panel indicating which probes are off, and the amber master caution and right system annunciator light illuminate on the pilot's glareshield. The ADH warning system of the 737-800, a derivative airplane certified in 1998, is identical to that of the 737-400.

[13] For more information, see E.L. Weiner and R.E. Curry, "Flight-Deck Automation: Promises and Problems" *Ergonomics* Vol. 23, 995-1011 (1980).

[14] For more information, see K. Dismukes and J. Nowinski (in press). "Prospective Memory, Concurrent Task Management, and Pilot Error" (In A. Kramer, D. Wiegmann, and A. Kirlik (Eds.) *Attention: From Theory to Practice*. New York: Oxford.

[15] National Transportation Safety Board, *Safety Report on the Treatment of Safety-Critical Systems in Transport Airplanes*, Safety Report NTSB/SR-06/02 (Washington, DC: NTSB, 2006). The Safety Board is currently evaluating the FAA's response to two recommendations that resulted from this report and that bear on the current discussion: Safety Recommendation A-06-37, which asked the FAA to "amend the advisory materials associated with 14 *Code of Federal Regulations* (CFR) 25.1309 to include consideration of structural failures and human/airplane system interaction failures in the assessment of safety-critical systems" and Safety Recommendation A-06-38, which asked the FAA to "adopt Society of Automotive Engineers ARP 5150 into 14 *Code of Federal Regulations* Parts 21, 25, 33, and 121 to require a program for the monitoring and ongoing assessment of safety-critical systems throughout the life cycle of the airplane. … Once in place, use this program to validate that the underlying

to further consider human/airplane system interaction issues in the certification of all new aircraft (both derivative and new designs).[16]

Based on the ASRS reports and events described in this letter, the Safety Board remains convinced that automatic activation of the air data sensor heating system is necessary and that, among current transport-category airplanes not equipped with automatic systems, cockpit warnings may not provide adequate alerting to the flight crew when the system is not activated. Therefore, the Safety Board believes that the FAA should require, on all new airplanes certificated under 14 CFR Part 25, that the air data sensor heating system automatically activate after engine start.

Service history has shown that, for existing airplanes without automatic activation,[17] the currently available systems and associated warnings may be inadequate to ensure that the air data sensor heating system is safely functioning for every flight. As noted in the 2006 safety report, the Safety Board believes that this operational history should be reviewed on an ongoing basis throughout the life cycle of every aircraft, as part of an effective safety assessment program, to validate assumptions used in certification, to identify critical events that should trigger a safety review, and to recognize when standards for safety-critical systems need to be upgraded. Further, in the case of the air data sensor heating system, there is existing automated technology that provides a wealth of practical knowledge and lessons learned that can be used to evaluate techniques for upgrading earlier airplane systems. Based on operational experience, lessons learned, and new knowledge, the Board believes that the FAA should require modification of existing airplanes certificated under 14 CFR Part 25 that currently require manual activation of the air data sensor heating system to incorporate, to the extent technically practical, the automatic activation of this system; for airplanes that cannot be modified, the FAA should require that cockpit warnings provide an upgraded warning associated with the failure to activate the heating system.

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

> Require, on all new airplanes certificated under 14 *Code of Federal Regulations* Part 25, that the air data sensor heating system automatically activate after engine start. (A-07-55)

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assumptions made during design and type certification about safety-critical systems are consistent with operational experience, lessons learned, and new knowledge."

[16] Discussions with manufacturers indicate that the A-380, 787, and Embraer Phenom and Lineage aircraft currently being developed are likely to employ automatic activation of air data sensor heating systems but that, since it is not required by regulation, this feature could be subject to change. Additional derivative models of the 737 appear likely.

[17] According to the manufacturers, transport-category airplanes that rely on pilot activation of the air data sensor heating system include Boeing 737, 727, and 707, McDonnell-Douglas DC-10/MD-11 and MD-80/90 series airplanes; Airbus A-300 and A-310 airplanes; Bombardier Dash 8 series airplanes; Challenger 600/601/604/605, CRJ 200/700/900 airplanes; and Embraer EMB-110 and -120 airplanes.

Require modification of existing airplanes certificated under 14 *Code of Federal Regulations* Part 25 that currently require manual activation of the air data sensor heating system to incorporate, to the extent technically practical, the automatic activation of this system; for airplanes that cannot be modified, require that cockpit warnings provide an upgraded warning associated with the failure to activate the heating system. (A-07-56)

Please refer to Safety Recommendations A-07-55 and -56 in your reply. If you need additional information, you may call (202) 314-6177.

Chairman ROSENKER, Vice Chairman SUMWALT, and Members HERSMAN, HIGGINS, and CHEALANDER concurred with these recommendations.

[*Original Signed*]

By: Mark V. Rosenker
Chairman