



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: November 6, 2003

In reply refer to: A-03-48 through -50

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

The primary investigative use of the data recorded on the flight data recorder (FDR) is to accurately reconstruct the performance of an aircraft prior to and during an accident or incident. However, several notable accident investigations, including the ongoing investigation of American Airlines (AAL) flight 587, have highlighted some aspects of data recording that seriously hinder using data from the FDR to evaluate the performance of an accident aircraft's flight control systems. These data recording problems have included problems with sampling rates and problems with the filtering of recorded data.

Sampling Rate

In 1995, following its investigation of two fatal Boeing 737 accidents,¹ the National Transportation Safety Board issued Safety Recommendations A-95-25 through A-95-27, which called for a retroactive requirement to increase the minimum parameters for transport-category airplanes with an accelerated compliance date for Boeing 737s. The Federal Aviation Administration (FAA) responded by establishing an Aviation Rulemaking Advisory Committee Flight Data Recorder Working Group charged with the development of a Notice of Proposed Rulemaking (NPRM) to address the Board's recommendations. As a result, the final flight recorder rule, 14 *Code of Federal Regulations* (CFR) 121.344, Appendix M, issued August 19, 1997, required FDRs to record between 18 and 88 parameters, depending on the age and complexity of the airplane.² This rule included a retroactive requirement that flight control input and control surface positions be recorded and that accuracy requirements be demonstrated under static and dynamic conditions.

The revised rule also called for an increased sampling rate of flight control parameters. However, given the FDR technology available in 1997, FDR systems of limited capacity could

¹ National Transportation Safety Board, *Uncontrolled Collision with Terrain, United Airlines Flight 585, Boeing 737-200, N999UA, Four Miles South of Colorado Springs, Colorado, March 3, 1991*, Aircraft Accident Report NTSB/AAR-92-06, adopted 12/8/1992; revised report and probable cause issued as AAR-01-01 (Washington, DC: NTSB, 2001), and *Uncontrolled Descent and Collision with Terrain, USAir Flight 427, Boeing 737-300, N513AU, Aliquippa, Pennsylvania, September 8, 1994*, Aircraft Accident Report NTSB/AAR-99-01 (Washington, DC: NTSB, 1999).

² Although the Safety Board acknowledged that the rule changes represented an improvement in FDR requirements, it closed Recommendations A-95-25, -26, and -27 as unacceptable because neither the compliance dates nor the requirements in the rule were as stringent as those set forth in the recommendations.

not meet the increased parameter requirements. Therefore, it was necessary to record some of the highly dynamic parameters at sampling rates that were too low to provide an accurate and continuous time history for the full dynamic range of those parameters. As a result, such flight recorders did not accurately record the highly dynamic conditions and maneuvers that could arise during an accident or incident.

Although the increased storage capabilities available with current FDR technology have eliminated the need to under-sample these parameters, the Safety Board discovered during its investigation of the accident involving AAL flight 587 that data continue to be under-sampled, seriously hindering Board efforts to reconstruct and evaluate the performance of an accident aircraft's flight control systems.

On November 12, 2001, AAL flight 587, an Airbus A300-600, crashed shortly after takeoff from John F. Kennedy Airport, Jamaica, New York. Flight 587, operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a scheduled international passenger flight from JFK to Santo Domingo, Dominican Republic, experienced an in-flight separation of the vertical fin and rudder. The subsequent crash killed 2 pilots, 7 flight attendants, 251 passengers, and 5 persons on the ground. In this case, investigators are attempting to determine the flight control input time history and the associated aircraft response during extremely dynamic conditions.

Accurately reconstructing rudder surface and pedal position time histories is critical to the investigation of the flight 587 accident. The FDR recorded four rudder reversals during the final seconds of the recording. The FDR system on this model A300 records rudder surface and pedal positions twice a second. However, the rudder is capable of traveling at 39° per second, which means that it can travel 19.5° between samples. Because rudder travel is limited to $\pm 9.3^\circ$ at the speed of 250 knots (the speed the airplane was traveling at the time of the accident), the rudder could have gone from neutral to full travel between the samples recorded on the FDR. The sampling rate was therefore too low to record an accurate and complete time history of the rudder position.

The need for higher FDR sampling rates and more accurate recording of flight data has been recognized by other organizations. A paper titled "A Case for Higher Data Rates,"³ presented jointly by the National Aeronautics and Space Administration (NASA) and the FAA at the Safety Board's May 1999, International Symposium on Transportation Recorders, clearly identified the need for higher sampling rates for flight control parameters. The paper described the degradation of the information derived from data sampled at less than the optimum frequency and the potential for investigators to reach a wrong conclusion using such data. The European Organization for Civil Aviation Equipment, Working Group 50, referenced this paper in its "Minimum Performance Standards for Crash Protected Airborne Recorder Systems,"⁴ which recommends a recording interval of 0.0625 seconds (16 samples per second) for flight control input and surface position parameters.

³ "A Case for Higher Sampling Rates" presented by Ralph A. Harrah, NASA HQ, and George Kaseote, FAA HQ, at the National Transportation Safety Board's International Symposium on Transportation Recorders, May 3-5, 1999, Arlington, Virginia. Paper is available at http://ntsb.gov/events/symp_rec/symp_rec.htm.

⁴ EUROCAE ED112, which may be purchased at <http://eurocae.org>.

To address the problem of inadequate sampling, the Safety Board believes that the FAA should require that all newly manufactured transport-category aircraft that are required to carry a flight data recorder be fitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate possible. The Safety Board also believes that the FAA should require that all existing transport aircraft that are required to carry a flight data recorder be retrofitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate expected. A 4-year timeframe seems reasonable for completing the retrofit action.

Filtered Data

In addition to the problems encountered as a result of inadequate sampling rates, the AAL flight 587 investigation was further hindered by filtered FDR data. Safety Board investigators discovered that the system data analog converter (SDAC), which supplies the flight control surface position data that are input to the FDR system on all Airbus A300-600 aircraft, digitizes and then filters the analog signals from the flight control surface position sensors before outputting the signals to the FDR system. The presence of filtered data came as a surprise to accident investigators, given FAA's actions on Safety Recommendations A-94-120 and A-94-121, which the Safety Board issued as a result of investigations into three accidents involving Boeing B-767 aircraft.⁵ These recommendations called for the elimination of filtered flight control position parameters on Boeing 757/767 airplanes, an increase in the sampling rates of flight control parameters, and a review of other airplane designs to ensure that flight control position data were not filtered.

To address A-94-120, the FAA issued Advisory Circular (AC) 20-141, *Airworthiness and Operational Approval of Flight Data Recorder Systems*, on August 4, 1998, which provided detailed guidance on recording filtered data. Section 7 of AC 20-141, titled "Type Certification," reads as follows:

- (1) The applicant must identify any parameters that are filtered before they are recorded. For these parameters, the applicant must show, by test, that there is no significant difference between the recorded parameter data under both static and dynamic (parameter undergoing change at the maximum rate expected when operating the aircraft in accordance with the flight manual) conditions.

⁵ These accidents, which were cited in the Safety Board's June 16, 1994, recommendation letter to the FAA, included the following: the January 16, 1992, Asiana Airlines accident at Cheju Island, South Korea; the October 27, 1992, accident, American Airlines flight 957 (N365AA), at Sao Paulo International Airport, Sao Paulo, Brazil; and the December 31, 1993, accident, involving a Polish-registered (SP-LPA) airplane, at Okecie International Airport, Warsaw, Poland. These accidents were investigated by the governments of South Korea, Brazil, and Poland, respectively.

Based on the issuance of the 1997 FDR rule changes and AC 20-141, the Safety Board classified Safety Recommendation A-94-120 “Closed—Acceptable Action” on May 11, 2000.

To address A-94-121, the FAA surveyed Aerospatiale, CASA, Cessna, Grumman, Gulfstream, Israel Aircraft Industries, Lockheed, and SAAB regarding the flight control position data supplied to the FDRs on their aircraft. In a letter dated November 20, 1996, the FAA reported that the survey had shown that the FDRs in these aircraft were not recording inaccurate, filtered data. Based on this response, and the FAA’s position that publication of FDR rule changes, issuance of AC 20-141, and efforts by its principal inspectors would ensure that operators would not record filtered FDR data, the Safety Board classified Safety Recommendation A-94-121 “Closed—Acceptable Action” on August 9, 2000.

In closing the recommendations, the Safety Board had relied on FAA assurances regarding the filtering of FDR data. In its letters of February 9, 1998, and April 4, 2000, the FAA stated in part, “The final rule [14 CFR 121.344, Appendix M] precludes the use of a filter and specifies the seconds-per-sampling interval for all parameters.” The FAA’s April 2000 letter also stated, “The final rule affects the majority of all domestic 14 CFR Parts 121, 125, and 135 aircraft and precludes the use of a filter.” However, as indicated above, the investigation of flight 587 revealed that the filtered data supplied by the Airbus A300-600 SDAC do not meet the accuracy requirements under dynamic conditions called for in 14 CFR 121.344, Appendix M.

During the course of the flight 587 investigation, Airbus brought the SDAC filter to the Safety Board’s attention. Subsequent aircraft performance studies conducted independently by the Board and by Airbus have confirmed that the filtered data recorded by the FDR do not reflect the actual flight control surface position time history during the critical final seconds of the flight. As a result, Safety Board flight 587 investigators had to thoroughly evaluate and validate the filtered flight control surface position data from the accident FDR against other FDR and engineering flight simulator data before they could analyze critical aircraft performance parameters for the flight 587 investigation. Accordingly, the lack of accurate, unfiltered data has delayed the development of FDR findings critical to determining probable cause and identifying corrective actions.

On October 1, 2002, the FAA met with Airbus and the Safety Board to discuss compliance with FDR rules as they pertain to the recording of filtered data on Airbus aircraft and to discuss the FAA’s response to Safety Recommendation A-94-121, which had called for a review of airplane designs to ensure that flight control data are accurately recorded on the FDR and that inaccurate, filtered data are not substituted. The meeting also addressed the FAA’s pending flight recorder NPRM and the possible impact of filtering and sampling on that rulemaking package. The FAA stated that its survey, conducted from 1994 to 2000 in response to Recommendation A-94-121, was “flawed” in that it did not adequately define “data filtering” and not all manufacturers fully responded. As a result, the FAA reported on March 6, 2002, that it had initiated a new manufacturer survey that included definitions for “filtered data” and “readily retrievable.” The FAA indicated that Phase I of the new survey would be complete upon receipt of Airbus survey results. The FAA stated further that, with 98 percent of the fleet surveyed, only Boeing had reported that it recorded filtered data, and that was for four parameters on one model of limited fleet size. Airbus explained that its understanding of the regulatory requirements pertaining to filtered data differed from the intent of the rule, but that it was willing to work with the FAA to correct the problem.

In an October 25, 2002, letter to the FAA, Airbus provided the results of its survey, which indicated that the A310 and A300-600 models recorded five filtered parameters [all speed aileron (left and right), rudder, elevator, and stabilizer position]. This letter also stated that Airbus was willing to develop a service bulletin to increase the sampling rate for flight control parameters on existing and newly manufactured Airbus airplanes. Airbus reiterated its position in the following closing statement:

In conclusion, we would like to emphasize our proposal to offer a change of the recorded data, which are filtered on the A310/A300-600 FAR 121 fleet in conjunction with the requirements stipulated in the upcoming NPRM/final rule.

FAA staff recently reported that the survey of aircraft manufacturers has been completed, and that the Airbus A310/A300-600 and Boeing B747-400 are the only aircraft that record filtered FDR data. At this time, Boeing has not indicated what action it intends to take regarding the filtering of data.

Accordingly, the Safety Board believes that the FAA should require that within 2 years, all Airbus A300-600/A310 and Boeing 747-400 airplanes and any other aircraft that may be identified as recording filtered data be retrofitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate possible.

Recommendations

The Safety Board is concerned that additional FAA action is required to address the data recording problems described in this letter: that data are not recorded frequently enough to reconstruct an accurate time history of dynamic airplane and control surface motion parameters and that filtering produces data of questionable accuracy. The Board has found that these data problems severely hamper its ability to analyze aircraft performance and flight control system operation. The Board is also concerned that current data recording methods do not fully satisfy the purpose of the FDR systems, which is to accurately record the time history of airplane motion and control systems during accident scenarios when many of these parameters change at the maximum rates achievable.

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

Require that all newly manufactured transport-category aircraft that are required to carry a flight data recorder be fitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate possible. (A-03-48)

Require that all existing transport aircraft that are required to carry a flight data recorder be retrofitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of

each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate expected. (A-03-49)

Require that within 2 years, all Airbus A300-600/A310 and Boeing 747-400 airplanes and any other aircraft that may be identified as recording filtered data be retrofitted with a flight data recorder system capable of recording values that meet the accuracy requirements through the full dynamic range of each parameter at a frequency sufficient to determine a complete, accurate, and unambiguous time history of parameter activity, with emphasis on capturing each parameter's dynamic motion at the maximum rate possible, including reversals of direction at the maximum rate possible. (A-03-50)

Please refer to Safety Recommendations A-03-48 through -50 in your reply. If you need additional information, please call (202) 314-6177.

Chairman ENGLEMAN, Vice Chairman ROSENKER, and Members CARMODY, GOGLIA, and HEALING concurred with these recommendations.

By: Ellen G. Engleman
Chairman