# NATIONAL TRANSPORTATION SAFETY BOARD
## WASHINGTON, D.C.

ISSUED: March 1, 1974

Forwarded to:

Honorable Alexander P. Butterfield
Administrator
Federal Aviation Administration
Washington, D. C. 20591

SAFETY RECOMMENDATION(S)

A-74-15 thru 17

The National Transportation Safety Board is concerned about the adequacy of information obtainable from aircraft flight data recorders which is applicable to accident investigations. Continuing sophistication of aircraft design, of ground-based navigation equipment, and of approach guidance equipment presents an extremely difficult challenge to the task of determining accident cause. Wreckage examination in many cases no longer produces sufficient information to assess the interrelationship of man, machine, and environment, particularly as they interact during a Category II- or Category III-landing approach. Reliance on avionics and electro-hydraulic servo hardware, which are contained in automatic flight control systems, airborne navigation receivers, and ground guidance signals, makes it especially imperative that all the facts relating to the operational status of this equipment be considered in the analysis of an accident situation. Necessary facts generally cannot be obtained from complex hardware and avionic circuits whose electrical power has been removed.

Consequently, the information that is recorded on the aircraft's flight data recorder has become increasingly important. As a result, the Board has reevaluated the requirements for these recorders, as specified in 14 CFR 121.343. The requirement for the minimum information which must be obtainable from the expanded parameter digital flight data recorder is described in paragraph (a)(2) of that regulation, which was adopted in September 1970. After considering the economic impact on the airline industry, the Board agreed to this compromise regulation.

Although the Board still believes that economic impact is a primary consideration, it, nevertheless, believes that the scope of the regulation is too narrow to serve the determination of cause and the prevention of similar accidents. This fact has been emphasized during several past accident investigations. The Eastern Air Lines L-1011 accident in Miami in December 1972, the Pan American B-707 accident in Boston in November 1973, the Northwest Airlines B-747 accident in Miami in December 1972, the Eastern Air Lines B-727 accident in Atlanta in December 1971, and the Alaska Airlines B-727 accident near Juneau in September 1971, are particularly good examples of accidents in which the investigation would have been more effective by information which can be readily recorded on a flight data recorder. In each of these accidents, a clearer understanding of the underlying causal factors might have produced more effective measures to prevent future accidents.

The Board believes it absolutely necessary to expand the flight data recorder capability so that those parameters described in Enclosure 1 are provided.

The advance in digital flight data recorder technology, particularly in those designed to the ARINC characteristic 573, makes the recording of additional data technically and economically feasible. Wide-bodied aircraft manufactured domestically are being delivered to foreign carriers with flight recorder installations which essentially provide the data proposed in Enclosure 1. In fact, such requirements will be imposed by the United Kingdom in 1975.

Moreover, the regulation, as adopted in September 1970, requires the installation of expanded parameter recorders only on aircraft whose type certificates were issued after September 1969. This compromise in the requirement was made because it was assumed that experience with those aircraft manufactured under type certificates issued before that date was sufficient to warrant lesser concern about accident investigation. Further, it was assumed that such aircraft would soon reach the end of their service lives. History now clearly indicates that these assumptions were not valid. New versions of the Boeing 727 and the Douglas DC-9 aircraft, which are still being manufactured, will continue to be used for many years. Also, the new aircraft will be operated in complex, all-weather approach environments.

The Board recognizes the difficulty of subjecting the expanded parameter flight data recorder to a cost-benefit analysis, since such a device is used primarily for accident investigation. The Board believes, however, that a catastrophic accident, which involves a wide-bodied aircraft with a large number of passengers, would create a high level of public concern. Both the Government and the aviation industry would certainly draw justifiable criticism if the facts related to such an accident cannot be determined precisely and rapidly. If the factors causing or contributing to the

accident were proved later to be recurring factors, loss of lives as the result would be all the more needless and tragic.

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

1. Amend 14 CFR 121.343 so that the requirements of paragraph (a)(2) apply to all aircraft manufactured after a specified date, regardless of the date of original type certification.

2. Amend 14 CFR 121.343 to require that all aircraft manufactured after a specified date, regardless of the date of original type certification, be equipped with one or more approved flight recorders that record data from which the information listed in Enclosure 1, in addition to the information presently specified in 14 CFR 121.343 paragraph (a)(2), can be determined. The implementation of this action obviates the need for compliance with recommendation number 1 above.

3. Amend 14 CFR 121.343 to require that all aircraft, issued an original type certificate after September 30, 1969, be equipped at the earliest practical specified date with one or more approved flight recorders that record data from which the information listed in Enclosure 1 can be determined, in addition to the requirements already imposed by paragraph (a)(2) of that regulation.

Personnel from our Bureau of Aviation Safety are available if any further information or assistance is desired.

McADAMS, THAYER, BURGESS, and HALEY, Members, concurred in the above recommendations. REED, Chairman, was absent, not voting.

By: John H. Reed
Chairman

THESE RECOMMENDATIONS WILL BE RELEASED TO THE PUBLIC ON THE ISSUE DATE SHOWN ABOVE. NO PUBLIC DISSEMINATION OF THE CONTENTS OF THIS DOCUMENT SHOULD BE MADE PRIOR TO THAT DATE.

Enclosure 1

RECOMMENDED ADDITIONS TO THE
EXPANDED PARAMETER FLIGHT DATA RECORDER

The National Transportation Safety Board believes that the following additional information is essential to the conduct of thorough and expeditious investigations of accidents involving modern, complex aircraft. We recommend that a requirement for data from which such information can be determined within reasonable ranges, accuracies, and recording intervals be added to the requirements for flight data recorders specified in 14 CFR 121.343.

1. Time (G.m.t.)

Time is an important and critical parameter in the evaluation of other recorded data, the derivation of dynamic changes and the correlation with other investigation data sources. As such, G.m.t. should be directly encoded in the DFDR tape. The current regulations require that time be controlled only to the extent that tape drive speed is maintained within specified accuracies. On some equipment, data loss is not reflected in DFDR-processed data printouts, and thus there is no correlation between lapsed time and actual time.

2. Automatic Flight Control System Status

Knowledge of the operating status of autopilot/autothrottle systems is essential in an investigation to determine the man-machine relationship during the accident. Since most of the avionic equipment has no memory, its status usually cannot be determined after power is interrupted. The role of such equipment during Category II and Category III approaches increases the importance of such knowledge. Engagement status and selected operating mode should be determinable.

3. Pilot Input/Control Surface Position - Three Axes

The current regulation requires that either control position or surface position be recorded. On those aircraft having aerodynamically boosted or electro-hydraulic servo-actuator-powered control systems, there is no positive relationship between control input and surface position. In fact, it is this relationship which might provide the only indication of flight control system malfunction. The control loops often mix a mechanical input from the pilot's control with an electrical input from an autopilot or stability augmentation system. System gains and positional relationships are often dependent upon control mode selection and operational conditions. Both parameters must, therefore, be measured to provide for an effective investigation.

Additionally, the resolution of the measurement must be small enough to provide meaningful data. The currently specified ±2° accuracy/minimum resolution is broad and masks normal control surface motions during many flight conditions.

4. Spoiler/Speedbrake Position

Intentional or inadvertent spoiler/speedbrake extension is an important factor which must be considered in the investigation of hard landing accidents. Conversely, the failure of ground spoilers to extend can be a causal factor in landing overrun accidents. Spoiler position cannot be determined accurately unless it is recorded by a flight data recorder.

5. Flight Director Mode Selection

The selected operating mode of the captain's and first officer's flight director system is a significant factor in the investigation of Category I approach accidents. The inadvertent selection of an improper mode might have been a contributing factor in at least one accident which the Board investigated. However, the absence of firm evidence precluded positive determination of cause.

6. Localizer/Glide Slope Deviation

The deviation or error signal which is generated by the localizer and glide slope facility should be recorded. These data would provide valuable clues regarding aircraft position, cockpit workload, automatic tracking accuracy, and performance or involvement of both airborne and ground-based equipment.

7. Hydraulic System Status

Many of the new generation aircraft depend upon hydraulic power for flight control. Even with the redundancy provided, the failure of one or more hydraulic systems can be a significant factor in accident investigations. There are cases on record in which three of four systems were lost. A signal input to the DFDR actuated by the low pressure warning light circuitry could be used to record this information.

8. Electrical Bus Status

The energized/deenergized status of those electrical buses which are essential for primary flight control, primary flight instrumentation, or actuation of emergency equipment, should be recorded, if not evident by other means such as loss of specific signal inputs to the FDR, or to the cockpit voice recorder.

9. Fire Warning/Pressurization System Failure

Discrete signals should be recorded when those cockpit warning lights illuminate which indicate an in-flight fire or a failure in the cabin pressurization system that would reduce the design performance capability of the aircraft.

10. Vertical Acceleration Recording Interval

14 CFR 121.343 specifies that vertical acceleration is to be sampled and recorded at maximum intervals of 0.25 second. The older metal foil recorders provide vertical acceleration data points at maximum intervals of 0.1 second. This shorter interval is extremely useful in the investigation of in-flight turbulence encounters and hard landing accidents.

Since the natural frequency of the fuselage of a large aircraft is generally between 3-4 Hz., an in-flight turbulence encounter is likely to be evidenced by a large amplitude load within this frequency range. A minimum recording frequency of 2.5 times the structural frequency is necessary to detect and to analyze such conditions.

11. Longitudinal Acceleration

Longitudinal acceleration is an important factor in aircraft performance analysis. Although it is derivable from airspeed values, the direct recording of longitudinal acceleration would enhance the accuracy of such analyses. Furthermore, the availability of data regarding positive and negative accelerations, in a region below the minimum recording threshold of the airspeed parameter, is particularly significant in the investigation of takeoff and landing accidents.

12. Outside Ambient or Total Air Temperature

Temperature data are extremely significant in the determination of airspeed, engine thrust, and other related performance data. Since reported meteorological data are not entirely accurate, actual values should be measured. Temperature data are also important to fix acurately the penetration of frontal systems, so that wind shifts can be determined and the ground track established more accurately. Temperature data can establish the presence of icing conditions in an accident.

13. Strut Extension/Retraction Switch

In investigating an accident occurring during the takeoff or landing phase, it is important to correlate the liftoff or touchdown time with the flight recorder data. A discrete signal to indicate liftoff or touchdown should be recorded. This signal could be actuated by the strut scissors switch.

14. Outer, Middle, and Inner Marker Passage

This parameter would make it possible to establish a correlation between aircraft position and a fixed point over the ground and flight recorder time. Such a correlation is significant in establishing cockpit activities and deviation from prescribed approach procedures. Although these data are sometimes available from the aircraft's voice recorder, cross-correlation is difficult.

15. Radio Altitude

The radio altimeter is an essential instrument during Category II and Category III approaches. Its operating status and indication could be essential to an investigation of an approach accident. Therefore, its operating status and indication should be a recorded parameter.