NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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Forwarded to:

Honorable J. Lynn Helms
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-82-64 through -67

On July 9, 1982, a Pan American Boeing 727 (flight 759) crashed into a residential area in Kenner, Louisiana, killing 145 persons on board the aircraft and 8 persons on the ground. The Safety Board's preliminary investigation indicates that wind shear may have been a factor. Analysis of the aircraft performance in this accident, as in all other air carrier accidents, depends heavily on the information received from the flight data recorder (FDR). In this case, the oscillographic, or foil, FDR carried on the accident aircraft lacks a number of basic and important parameters such as pitch and roll attitude, engine thrust, airplane configuration, and control positions -- all of which are necessary to determine the extent to which wind shear may have affected aircraft performance. In addition, the recorder itself is technologically obsolete. The limitations in the quality and quantity of data obtained from foil recorders is a matter of record. In addition, the mechanical complexity of this type recorder requires costly and frequent maintenance to ensure proper operation.

The inadequacies of the foil recorder were also brought to light in the Air Florida, Inc. Boeing-737 accident at Washington National Airport, January 13, 1982. A significant timing disparity between the CVR and FDR was eventually traced to a faulty control spring assembly after months of investigative work by the Safety Board and the recorder manufacturer. The lack of engine, attitude, and acceleration data lengthened the investigative process considerably by necessitating a costly and lengthy simulator study.

In general, the foil recorder requires a great deal of time-consuming interpretation to convert the scribed analog information for only four parameters to engineering units versus time. Recorder manufacturers have recently introduced cost-effective digital recorders to replace the foil recorders, thus making practical the installation and use of digital recorders in all aircraft currently requiring a recorder.

Two of the three domestic oscillographic recorder manufacturers are now marketing second generation digital recorders that can replace the foil recorders without an aircraft modification. The third manufacturer is currently developing a similar recorder. These new recorders have the capability of also operating in aircraft equipped with first generation digital recording systems, thus allowing air carriers operating aircraft certificated before and after September 30, 1969, the initial date when digital recorders were required, to use the same recorder for the entire fleet, an option that is impossible with a mixture of the oscillographic and first-generation digital recorders.

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The modern digital recorder requires much less maintenance than its aged foil counterpart and does not require the replacement of the expensive foil recording medium every 250 to 800 hours, depending on the model. At least six domestic air carrier operators have recognized the benefits of the digital replacement recorders. All six are currently operating a number of these recorders and two have plans to convert their entire fleets.

The international aviation community has long recognized the benefits of digital recorders. Canada, Australia, Portugal, Greece, and Italy are some of the countries now operating digital recorders on aircraft certificated before September 30, 1969. The United Kingdom requires all new or second-hand aircraft brought into registration to be equipped with digital recorders. The Civil Aviation Authority, in a letter to operators dated December 11, 1980, has ordered that "it will no longer be prepared to accept foil or frequency modulated recorders as satisfying the requirements of scale P 1/ for aircraft, new or second hand, to be first brought onto UK register after the 1st July 1981."

The five-parameter set was predicated upon the assumption that aircraft certificated before September 30, 1969, would soon reach the end of their service lives. History has now clearly indicated that this assumption was not valid. New series aircraft that will incorporate new technologies such as digital cockpits are now being considered for manufacture under the old-type certificates. The Boeing Company plans to begin delivery in November 1984 of its newly announced 737-300 series aircraft with such innovations as laser-gyro inertial reference equipment and the digital cockpit which will incorporate some features of the -757 and -767, but with a five-parameter recording system. The Safety Board has noted that significant modifications are being planned for the design of this previously certificated aircraft with no regard at all for a modern flight data recording system except as a customer option.

The installation of new engines on the DC-8 aircraft and the proposed change of the B-727 from a 3-engine to a 2-engine aircraft will substantially increase expected service lives. It is also clear that the industry is experiencing a growing acceptance of the practice of installing updated engines in old airframes so that eventually other older aircraft may have their service lines significantly extended. It is our understanding that both the new series and aircraft with updated engines will be fitted with the old five-parameter recording system, even though the engineering work for the expanded parameter system has already been done for European customers. Therefore, if current standards are maintained, we can expect to see 1950's flight recorders well into 21st century aircraft.

Although aircraft certificated after September 30, 1969, are required to record more than five parameters, the current list of required parameters is in serious need of updating. The Safety Board expressed its concern in this area in 1974 when it issued Safety Recommendations A-74-15 through -17. All three recommendations were eventually rejected by the Federal Aviation Administration and classified by the Safety Board as "Closed—Unacceptable Action." Since then we have reexamined our proposed list of parameters in light of subsequent accident investigations and our renewed emphasis on human performance. We have concluded that the passage of time has not diminished the need for more information but, in fact, has strengthened it. The Safety Board is prompted once again to reaffirm the necessity of expanding flight data recording system capability so that the information in Table I can be determined as a function of time.

1/ Scale P is the minimum parameter list for United Kingdom registered aircraft certificated before September 1969; the following data, "by reference to a time-scale," are required to be recorded: indicated airspeed, indicated altitude, vertical acceleration, magnetic heading, pitch and roll attitudes, engine power, and flap position.

The continuing evolution of modern aircraft has placed an added emphasis on the capabilities and limitations of the human being in the overall man-machine-environment system. The techniques of aircraft accident investigation must also evolve if investigation is to remain an effective means of accident prevention.

Digital avionics, introduced into the cockpit in recent years, are a prime example of an innovation that is having a dramatic effect on the manner in which postaccident documentation is conducted. As programmed electronic chips with no moving parts replace the functions of rods, cables, dials, and gears, clues such as impact marks on displays or frequency settings for navigation and communication receivers will no longer be available. Thus, the flight recorder is the only viable means of retaining this vital information. Such crucial data should be earmarked early in the design process for storage by the flight recorder system.

Airframe manufacturers have demonstrated their awareness of the need to record additional information on flight recorders. McDonnell-Douglas is offering a list of parameters for its DC-9-80 that goes well beyond what is required by the current regulation. A member of the Boeing accident investigation staff has recently introduced a proposal to develop and certify a video tape recording system that would be used to record the cockpit environment for accident investigation purposes. This innovative approach stems directly from his concern over the availability of crucial information following an accident involving the new generation of large turbojet aircraft that will use cathode ray tubes (CRT) as the primary source of flight and engine information.

The Safety Board also notes that the use of sophisticated rotorcraft is expanding, both in the United States and worldwide. Major airlines have begun introducing helicopter shuttle services between airports and downtown locations. Again, the continuing evolution of modern rotorcraft utilizing new materials and displays, and in terms of human performance considerations, requires that the same measure of safety apply to persons traveling in large rotorcraft as to those traveling in large airplanes. The time has come to acknowledge that safety is served by requiring digital recorders on these aircraft. Hence, systems capable of recording information so that the items in Table II can be determined as a function of time should be installed on rotorcraft operating under 14 CFR 127.

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

> Amend 14 CFR 121.343 so that, after a specified date, all turbojet aircraft manufactured before that date and type-certificated before September 30, 1969, be required to have installed a suitable digital recorder system capable of recording data from which the minimum following information may be determined as a function of time within the ranges, accuracies, and recording intervals specified in Table I--altitude, airspeed, heading, radio transmitter keying, pitch attitude, roll attitude, vertical acceleration, longitudinal acceleration, stabilizer trim position, engine thrust, and pitch control position. (Class II, Priority Action) (A-82-64)

At an early date and pending the effective date of the recommended amendment of 14 CFR 121.343 to require installation of digital flight data recorder systems capable of recording more extensive parameters, require that operators of all aircraft equipped with foil flight data recorders be required to replace the foil recorder with a compatible digital recorder. (Class I, Urgent Action) (A-82-65)

Amend 14 CFR 121.343 so that, after a specified date, all aircraft manufactured after that date, regardless of the date of original type certificate, be equipped with one or more approved flight recorders that record data from which the information listed in Table I can be determined as a function of time. For newly type-certificated aircraft, any dedicated parameter which may be necessary because of unique features of the specific aircraft configuration and the type design should also be required. (Class II, Priority Action) (A-82-66)

Amend 14 CFR 127, Subpart H, to require that all rotorcraft manufactured after a specified date, regardless of the date of original type certificate, be equipped with one or more approved flight recorders that record data from which the information listed in Table II can be determined as a function of time. For newly type-certificated rotorcraft, any dedicated parameter which may be necessary because of unique features of the specific configuration and type design should also be required. (Class II, Priority Action) (A-82-67)

BURNETT, Chairman, GOLDMAN, Vice Chairman, McADAMS, BURSLEY, and ENGEN, Members, concurred in these recommendations.

Jim Burnett

By: Jim Burnett
Chairman

TABLE I

PARAMETER LIST (14 CFR 121)

PARAMETERS	RANGE	ACCURACY (SENSOR INPUT TO DFDR READOUT)	SAMPLING INTERVAL (PER SECOND)
Time (GMT)	24 Hrs	±0.125% Per Hour	0.25 (1 per 4 seconds)
Altitude	-1,000 ft to max certificated altitude of aircraft	±100 to ±700 ft (See Table I, TSO-C51a)	1
Airspeed	50 KIAS to Vso, and Vso to 1.2 V_D	±5% ±3%	1
Heading	360°	±2°	1
Normal Acceleration (Vertical)	-3g to +6g	±1% of max range excluding datum error of ±5%	8
Pitch Attitude	±75°	±2°	1
Roll Attitude	±180°	±2°	1
Radio Transmitter Keying	On-Off (Discrete)		1
Thrust/Power On Each Engine	Full Range Forward	±2%	1 (per engine)
Trailing Edge Flap Or Cockpit Control Selection	Full Range Or Each Discrete Position	±3° Or As Pilot's Indicator	0.5
Leading Edge Flap Or Cockpit Control Selection	Full Range Or Each Discrete Position	±3° Or As Pilot's Indicator	0.5
Thrust Reverser Position	Stowed, In Transit, And Reverse (Discrete)		1 (per engine)
Ground Spoiler/Speed Brake Selection	Full Range Or Each Discrete Position	±2% Unless Higher Accuracy Uniquely Required	1
Marker Beacon Passage	Discrete		1
Autopilot Engagement	Discrete		1

TABLE 1 (2)

PARAMETERS	RANGE	ACCURACY (SENSOR INPUT TO DFDR READOUT)	SAMPLING INTERVAL (PER SECOND)
Longitudinal Acceleration	±1g	±1.5% Max Range Excluding Datum Error of ±5%	4
Pilot Input And Surface Position-Primary Controls (Pitch, Roll, Yaw)	Full Range	±2° Unless Higher Accuracy Uniquely Required	1
Lateral Acceleration	±1g	±1.5% Max Range Excluding Datum Error of ±5%	4
Pitch Trim Position	Full Range	±3% Unless Higher Accuracy Uniquely Required	1
Glideslope Deviation	±400 Microamps	±3%	1
Localizer Deviation	±400 Microamps	±3%	1
AFCS Mode And Engagement Status	Discrete (5 Bits Necessary)		1
Radio Altitude	-20 ft to 2,500 ft	±2 Ft Or ±3% Whichever Is Greater Below 500 Ft And ±5% Above 500 Ft	1
Master Warning	Discrete		1
Nav 1 and 2 Frequency Selection	Full Range	As Installed	0.25
DME 1 and 2 Distance	0-200 NM;	As Installed	0.25
Main Gear Squat Switch Status	Discrete		1
Angle of Attack (If Recorded Directly)	As Installed	As Installed	2
Outside Air Temperature	-90°C to +50°C	±2°C	0.5

TABLE I (3)

PARAMETERS	RANGE	ACCURACY (SENSOR INPUT TO DFDR READOUT	SAMPLING INTERVAL (PER SECOND)
Hydraulics, Each System Low Pressure	Discrete		0.5
Groundspeed	As Installed	Most Accurate System Installed (INS Equipped Aircraft Only)	1

TABLE II

PA _TER LIST (14 CFR 127)

PARAMETERS	RANGE	ACCURACY (SENSOR INPUT TO DFDR READOUT)	SAMPLING INTERVAL (PER SECOND)
Time (GMT)	24 hrs	±0.125% per hr	0.25 (1 per 4 seconds)
Pressure Altitude	-1,000 ft to max certificated altitude of aircraft	±100 to ±700 ft (See Table I, TSO-C51a)	1
Airspeed	As the installed measuring system	±3%	1
Heading	360°	±2°	1
Normal Acceleration (Vertical)	-3g to +6g	±1% of max range excluding datum error of ±5%	8
Pitch Attitude	±75°	±2°	2
Roll Attitude	±180°	±2°	2
Radio Transmitter Keying	On-off (Discrete)		1
Power on Each Engine: Free Power Turbine Speed and Engine Torque	0-130% (Power Turbine Speed) Full range (Torque)	±2%	1 speed 1 torque (per engine)
Main Rotor Speed	0-130%	±2%	2
Altitude Rate	±6,000 ft/min	As installed	2
Pilot Input - Primary Controls (Collective, Longitudinal Cyclic, Lateral Cyclic, Pedal)	Full range	±3%	2
Flight Control Hydraulic Pressure Low	Discrete, each circuit		1

TABLE II (2)

PARAMETERS	RANGE	ACCURACY (SENSOR INPUT TO DFDR READOUT)	SAMPLING INTERVAL (PER SECOND)
Flight Control Hydraulic Pressure Selector Switch Position, 1st and 2nd Stage	Discrete		1
AFCS Mode and Engagement Status	Discrete (5 bits necessary)		1
Stability Augmentation System Engage	Discrete		1
SAS Fault Status	Discrete		0.25
Main Gearbox Pressure Low	As installed	As installed	0.25
Main Gearbox Temperature High	As installed	As installed	0.5
Controllable Stabilator Position	Full range	±3%	2
Longitudinal Acceleration	±1g	±1.5% max range excluding datum error of ±5%	4
Lateral Acceleration	±1g	±1.5% max range excluding datum error of ±5%	4
Master Warning	Discrete		1
Nav 1 and 2 Frequency Selection	Full range	As installed	0.25
Outside Air Temperature	-90°C to +50°C	±2°C	0.5