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Log 1476

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: August 31, 1982

Forwarded to:

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

SAFETY RECOMMENDATION(S)

82-
A-106 through -111

On October 1, 1981, Sky Train Air, Inc., Gates Learjet 24, N44CJ, made an unexpected descent from its cruising altitude of flight level (FL) 450 (45,000 feet). No radio transmissions were received from the flightcrew just prior to and during the uncontrolled descent. The aircraft crashed near Felt, Oklahoma, and disintegrated on ground impact, fatally injuring the three company pilots onboard. 1/

Although air traffic control radar does provide information on altitude (assuming the altitude encoding transponder is operational and the aircraft signal is within range of a ground-based antenna), position, and ground speed, the data are very limited in their usefulness in an accident investigation. Data points are not sampled frequently enough, nor is the precision of the data good enough, to derive more than trend information regarding the flight. With regard to this accident, there was no radar capability in the vicinity of the accident site below 15,000 feet m.s.l. according to the Federal Aviation Administration (FAA). The last secondary radar (transponder beacon code Mode A and Mode C) return was received with the aircraft at FL 380. Further, all secondary radar returns were lost for a 37- to 40-second period during the initial loss-of-control period with the aircraft at FL 452.

The degree of aircraft destruction and the lack of cockpit voice recorder (CVR) and flight data recorder (FDR) information prevented the Safety Board from determining precisely the circumstances of the accident, which was similar to two other recent Learjet accidents involving uncontrolled descents from high cruise altitude flight. 2/ The safety of the flying public and the prevention of accidents through knowledge of the causes of previous accidents is a major concern of aircraft manufacturers, aircraft users, the FAA, and the Safety Board. The Safety Board's determination of probable cause in a number of accidents involving multiengine, turbine-powered aircraft that were not

1/ For more detailed information read Aircraft Accident Report--"Sky Train Air, Inc., Gates Learjet 24, Felt, Oklahoma, October 1, 1981" (NTSB-AAR-82-4).
2/ See appendix F, "Learjet Accident and Incident History," in Aviation Accident Report--"Northeast Jet Company, Gates Learjet 25D, N125NE, Gulf of Mexico, May 19, 1980" (NTSB-AAR-81-15).

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equipped with flight recorders since they were not subject to the requirements of 14 CFR 121.343 (FDR) or 14 CFR 121.359, 135.151, and 127.127 (CVR) has been severely hampered by the lack of FDR and CVR information. Our experience in air carrier accident investigation has proven that these devices are exceptionally valuable tools in identifying operational and mechanical problems, weather- and turbulence-induced occurrences, and other subtle human factor influences that can contribute to an accident. In the past 10 years, one or both of the recorders has provided investigators with the necessary clues to piece together the circumstances of the accident in virtually all cases. The availability of recorder information has clearly enhanced the aviation community's ability to improve flying safety and to prevent accidents.

Advances now being made in the design of complex aircraft intended for commercial, air taxi, and corporate flying operations, e.g., the use of composite materials for the airframe and critical control surfaces, the all-digital cockpit, and advanced automatic flight control systems, portend an even greater need for CVR and FDR information for accident/incident investigation purposes. With such innovations as all-digital cockpits, much information presented to crewmembers will no longer be in the form of mechanical displays or switch positions. Hence, clues such as impact marks on displays, selected autopilot mode, and frequency settings for navigation and communications receivers, will no longer be available to the investigator in postaccident cockpit documentation. Accordingly, crucial data should be earmarked early in the design process for storage by the FDR.

The 1981 Annual Report of the Regional Airline Association indicated that the U.S. Commuter fleet continued to grow in capacity and in the use of turboprop airplanes. Total available seat capacity was up 4.1 percent compared to the figures in the 1980 Annual Report, with airplanes having more than 20 seats providing almost 40 percent of the 1981 total. Seating capacity for turbine-powered airplanes was up 3.1 percent from 1980, representing over 76 percent of the total.

With the continued growth in the numbers of complex aircraft in commercial, air taxi, and corporate operations, the Safety Board believes that broader use of recorders is urgently needed. In fact, the Safety Board believes that these recorders are as justified as those required to be installed in the air carrier fleet since 1959. At that time, high speed, increased reliance on avionic equipment, and lack of eyewitnesses combined to limit the investigative evidence and often eliminated the possibility of determining causation. These same factors are hindering today's investigations of accidents involving complex aircraft in commercial, air taxi, and corporate operations, with a resultant adverse effect on the safety of flight.

The Safety Board realizes that presently available air carrier-type recording systems are generally unsuitable for the smaller lightweight aircraft comprising much of the fleet not already covered by requirements for FDRs and CVRs. On the other hand, we continue to believe that smaller, lighter, lower cost recorders using up-to-date technology are needed and should be required.

The Safety Board issued Safety Recommendations A-78-27 through -29 on April 13, 1978, which called for the development and installation of recorders on such complex aircraft because of its concern with the number of accidents involving these aircraft about which many of the accident circumstances could not be ascertained with confidence. Recommendation A-78-27 called for the development of flight recorder standards. Recommendation A-78-28 called for research and development of low-cost recorders and asked that installation guidelines be established. Recommendation A-78-29 called for an interim requirement that cockpit voice recorders be installed on turbine-powered aircraft certificated to carry six or more passengers which are required by their certificate to have two pilots. The Safety Board considers these recommendations so important that it has reiterated them eight times since their original issue. 3/

In its Special Study titled "Commuter Airline Safety 1970-1979" (NTSB-AAS-80-1), the Safety Board said: "The FAA response to recommendation A-78-29 was considered unacceptable when the FAA determined [in promulgating 14 CFR 135.151] that it would require CVRs on turbojet aircraft certificated for 10 passengers or more rather than on turbine-powered aircraft certificated for 6 passengers or more." In response to the fact that recommendation A-78-29 was also directed to aircraft other than those operating under Part 135, the FAA published its intention (45 FR 13341) to issue a notice of proposed rulemaking (NPRM) in February 1980 proposing that a CVR be required on all turbojet-powered airplanes configured with six or more passenger seats (14 CFR 23, 25, 91, and 121). However, no such NPRM was published, and no other regulatory activity has been initiated.

FAA last responded to Recommendation A-78-29 on June 30, 1982 with an analysis which concluded that the benefit-to-cost ratio was 0.4 based on a number of assumptions, among them that "CVR benefits accrue where safety improvements arise from accidents in which cause/factor data were obtainable from no source other than the CVR." In addition, the dollar values used in the study were: replacement cost of an air commuter aircraft: $213,000; replacement cost of an air taxi aircraft: $137,000.

The Safety Board disagrees with both sets of assumptions and the conclusions of the FAA's cost benefit analysis, as documented in our August 30, 1982 letter to the Administrator of the FAA. The Safety Board has never considered the information obtained from the CVR in isolation, but has used it primarily as a tool in uncovering (sometimes) subtle clues to assist in determining probable cause and in making recommendations for preventing future accidents. The FAA, by selecting only those accidents where the CVR would have provided the <u>only</u> information available to determine probable cause, has severely biased the cost-benefit analysis against the CVR in arriving at a benefit-to-cost ratio of only 0.4.

Between 1971 and 1980 (the last year complete data are available), there were 180 fatal general aviation accidents in the U.S. involving multiengine, turbine-powered aircraft. In 88 percent of these, the aircraft was destroyed, and in 53 percent of those destroyed the aircraft suffered fire after impact. We maintain that the condition of the wreckage in these cases coupled with the lack of cockpit voice recorder and flight data recorder information has prevented the Safety Board from fully and accurately assessing all of the factors associated with these accidents. Although the Safety Board assigned a

3/ Aviation Accident Reports--"Columbia Pacific Airlines, Beech 99, Richland, Washington, February 10, 1978" (NTSB-AAR-78-15); "Champion Home Builders Company, Gates Learjet 25B, Sanford, North Carolina, September 8, 1977" (NTSB-AAR-79-15); "Inlet Marine, Inc., Gates Learjet 25C, Anchorage, Alaska, December 4, 1978" (NTSB-AAR-79-18); "Massey-Ferguson, Inc., Gates Learjet 25D, Detroit, Michigan, January 19, 1979" (NTSB-AAR-80-47); "Downeast Airlines, Inc., deHavilland DHC-6-200, Rockland, Maine, May 30, 1979" (NTSB-AAR-80-5); "Cascade Airways, Inc., Beechcraft 99A, Spokane, Washington, January 20, 1981" (NTSB-AAR-81-11); "Texasgulf Aviation, Inc., Lockheed Jetstar, White Plains, New York, February 11, 1981" (NTSB-AAR-81-13); and Special Study--"Commuter Airline Safety 1970-79," issued July 22, 1980 (NTSB-AAS-80-1).

probable cause for most of these, the body of the NTSB accident reports explains the degree of uncertainty associated with each, and the necessity for recorders.

There were 18 fatal Gates Learjet model 23, 24, and 25 accidents between 1971 and 1980. In these, 17 (94 percent) airplanes were destroyed, one was damaged substantially, 10 suffered postimpact fire, and no probable cause could be determined for 4 (22 percent) of them. Because of the number and frequency of these accidents, the FAA undertook a costly certification review of the Learjet from June 1980 to January 1981. Although several airworthiness directives were issued, all recertification efforts and recent investigations have not been successful in preventing more accidents. We do not know what has been happening in the cockpits. "Smoking holes" reveal little in terms of accident cause. Obviously, important causal factors are being overlooked.

Can a Learjet model 23, 24, or 25 be replaced for $137,000 or $213,000? The dollar figures upon which FAA based its analysis also severely biased its cost-benefit analysis against the CVR.

Sources in the insurance industry tell us that the replacement value of an aircraft can be estimated by assuming 33 to 50 percent of the present new-market value, and if finance costs are included the percentage should be increased by an additional 15 to 20 percent. The Safety Board notes that the most inexpensive turboprop airplane on the new-airplane market today 4/ costs over $800,000 (Piper Cheyenne I) and this price does not include radios or avionics equipment necessary for commuter and air taxi operations; the airplane contains 6 to 7 seats. The Fairchild/Swearingen Merlin III C-23 turboprop can be configured for 8 to 11 seats (this includes pilot seats) and sells for over $1.7 million. Again, this cost does not include avionics equipment.

The most inexpensive turbojet airplane costs over $1.6 million (Cessna Citation I), and has 7-8 seats. The Gates Learjet 55 sells for $5 million and has 10 seats (this includes pilot seats).

The Safety Board does not accept the FAA's cost benefit analysis as demonstrating that its recommendation is not feasible and has classified the response to recommendation A-78-29 as "Closed—Unacceptable Action."

Industry acceptance of the proposed requirement for installation of FDRs and CVRs up to this time has been limited to a few airframe manufacturers and corporate aircraft operators who have installed recorders and to persons who have participated in the development of recorder standards, including representatives of several airframe manufacturers. The Safety Board has encouraged the development of standards for small, lightweight, less expensive recorders specifically designed for complex aircraft, and has been working closely with the Society of Automotive Engineers (SAE) in developing standards intended primarily for multiengine, turbine-powered, fixed-wing aircraft and rotorcraft.

On this basis, the Safety Board has made a number of recommendations to manufacturers (A-82-101 through -103) and users (A-82-104 and -105) of multiengine, turbine-powered airplanes and rotorcraft that FDRs and CVRs be installed on these aircraft.

4/ 1982 General Aviaiton Aircraft Directory, AOPA Pilot, Vol. 25, No. 3, March, 1982.

We believe that many recipients of these recommendations will voluntarily comply in the interests of greater safety. However, we also strongly believe that regulation remains the only positive means of ensuring universal usage of recorders in these aircraft. Hence, we shall continue to recommend regulations to require recorders on complex aircraft.

The SAE is currently reviewing a document which defines minimum performance standards for "general aviation" flight recorders. 5/ This specification allows for the use of separate CVR and FDR equipment or a combination CVR/FDR. Presently being considered are CVRs that will record two channels of audio information for a period of at least 15 minutes and FDRs that will be capable of recording many flight data parameters digitally as a function of time for a period of at least 15 minutes, plus storing critical data from the takeoff regime. This document, when approved by the SAE, should serve as the basis for an FAA Technical Standard Order (TSO) on "general aviation" recorders. 6/

Several recorder manufacturers have indicated that such recorders have been under development for some time, and could be produced and marketed within 7 to 12 months after issuance of the TSO. While exact figures are unavailable until the issuance of the TSO, the recorder manufacturers indicate that prices for this equipment should be compatible with other general aviation equipment and, thus, acceptable to the industry.

At least two manufacturers have already tested their prototype recorders to the crash and fire survivability standards of TSO-C51a. Because there is, very often, little physical evidence with which to work after a fatal accident involving a multiengine, turbine-powered aircraft, the Safety Board believes that the new TSO should specify crash and fire survivability standards which are at least as stringent as those of TSO-C51a. In the Felt, Oklahoma, accident, for example, the aircraft struck a level plowed field in a steep nosedown attitude at high speed. The aircraft disintegrated when it struck a layer of bedrock, and formed an impact crater 48 feet long, 17 feet wide, and 2 to 3 feet deep. Wreckage was scattered in a fan-shaped pattern about 900 feet long and 850 feet wide.

In view of the fact that 88 percent of fatal accidents involving multiengine, turbine-powered aircraft have resulted in destroyed aircraft, and 53 percent of those destroyed have involved fire after impact, the survival of the CVR and FDR is of the utmost importance.

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

> Encourage timely adoption of the Society of Automotive Engineers (SAE) standard for "general aviation" flight recorders (intended for installation in multiengine, turbine-powered fixed-wing aircraft and rotorcraft in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight data recorder), and issue a Technical Standard Order (TSO) covering such recorders immediately after the SAE document is approved. Include in the TSO requirements that:

5/ In the context of this letter, this terminology means CVRs and FDRs intended for installation in complex fixed-wing aircraft and rotorcraft in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight data recorder.

6/ The recommendations to follow are made independently of the SAE proposed standard; the SAE has not endorsed the lists presented in Tables I and II.

a) specify a cockpit voice recorder (CVR) of high enough audio quality to render intelligible recorded data on each of two channels which reserves one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone;

b) specify all flight data recorder (FDR) parameters, ranges, accuracies, and sampling intervals cited in Tables I and II (attached);

c) specify crash and fire survivability standards for CVRs and FDRs which are at least as stringent as those of TSO-C51a for Type I (nonejectable) and Type III (ejectable) recorders as appropriate.

(Class I, Urgent Action) (A-82-106)

Require that all multiengine, turbine-powered, fixed-wing aircraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 121.343, 121.359, and 135.151 to have a cockpit voice recorder and/or a flight data recorder, be prewired to accept a "general aviation" cockpit voice recorder (if also certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table I (attached) as a function of time. (Class II, Priority Action) (A-82-107)

Require that all multiengine, turbine-powered rotorcraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 127.127 to have a cockpit voice recorder and/or a flight data recorder, be prewired to accept a "general aviation" cockpit voice recorder (if also certificated for two-pilot operation) with at least one channel for voice communications transmitted from or received in the aircraft by radio, and one channel for audio signals from a cockpit area microphone, and a "general aviation" flight data recorder to record sufficient data parameters to determine the information in Table II (attached) as a function of time. (Class II, Priority Action) (A-82-108)

Require that "general aviation" cockpit voice recorders (on aircraft certificated for two-pilot operation) and flight data recorders be installed when they become commercially available as standard equipment in all multiengine, turbine-powered fixed-wing aircraft and rotorcraft certificated to carry six or more passengers manufactured on or after a specified date, in any type of operation not currently required by 14 CFR 121.343, 121.359, 135.151, and 127.127 to have a cockpit voice recorder and/or a flight data recorder. (Class III, Longer Term Action) (A-82-109)

Require that "general aviation" cockpit voice recorders be installed as soon as they are commercially available in all multiengine, turbine-powered aircraft (both airplanes and rotorcraft), which are currently in service, which are certificated to carry six or more passengers and which are required by their certificate to have two pilots, in any type of operation not currently required by 14 CFR 121.359, 135.151, and 127.127 to have a cockpit voice recorder. The cockpit voice recorders should have at least one channel reserved for voice communications transmitted from or received in the aircraft by radio, and one channel reserved for audio signals from a cockpit area microphone. (Class II, Priority Action) (A-82-110)

Require that "general aviation" flight data recorders be installed as soon as they are commercially available in all multiengine, turbojet airplanes which are currently in service, which are certificated to carry six or more passengers in any type of operation not currently required by 14 CFR 121.343 to have a flight data recorder. Require recording of sufficient parameters to determine the following information as a function of time (see Table I (attached) for ranges, accuracies, etc):

altitude
indicated airspeed
magnetic heading
radio transmitter keying
pitch attitude
roll attitude
vertical acceleration
longitudinal acceleration
stabilizer trim position
or pitch control position.

(Class III, Longer Term Action) (A-82-111)

BURNETT, Chairman, and McADAMS and BURSLEY, Members, concurred with these recommendations. GOLDMAN, Vice Chairman, did not participate. ENGEN, Member, dissented.

G. H. Patrick Bursley
By: Jim Burnett
for Chairman

Member ENGEN filed the following dissenting statement:

I have expressed an agreement for the need to increase the use of FDRs and CVRs in general aviation aircraft, particularly with emphasis through GAMA. I have voiced my exception to additional regulations making these recorders mandatory in aircraft carrying less than 10 passengers.

TABLE

PARAMETER LIST (FIXED WING AIRCRAFT)

PARAMETERS	RANGE	INSTALLED SYSTEM 1/ MINIMUM ACCURACY (TO RECOVERED DATA)	SAMPLING INTERVAL (PER SECOND)
Relative Time (from recorder on prior to takeoff)	8 hrs. minimum	$\pm$0.125% per hour	1
Indicated Airspeed	V_{SO} to V_D (KIAS)	$\pm$5% or $\pm$10 kts., whichever is greater. Resolution 2 kts. below 175 KIAS	1
Altitude	-1,000 ft. to max cert. alt. of A/C	$\pm$100 to $\pm$700 ft. (see Table I, TSO C51-a)	1
Magnetic Heading	360^{o}	$\pm 5^{o}$	1
Vertical Acceleration	-3g to +6g	$\pm$0.2g in addition to $\pm$0.3g maximum datum error	4 (or 1 per second where peaks ref. to 1g are recorded)
Longitudinal Acceleration	$\pm$1.0g	$\pm$0.05g in addition to max. datum error of $\pm$0.1g	2
Pitch Attitude	100% of usable range	$\pm 2^{o}$	1
Roll Altitude	$\pm 60^{o}$ or 100% of usable range, whichever is greater	$\pm 2^{o}$	1
Stabilizer Trim Position	Full range	$\pm$3% unless higher accuracy uniquely required	1
OR			
Pitch Control Position	Full range	$\pm$3% unless higher accuracy uniquely required	1

1/ When data sources are aircraft instruments (except altimeters) of acceptable quality to fly the aircraft, the recording system excluding these sensors (but including all other characteristics of the recording system) shall contribute no more than half the values in this column.

<u>Engine Power, Each Engine</u>			•
Fan or N_1 Speed or EPR or Cockpit Indications Used for Aircraft Certification	Maximum range	±5%	1
OR			
Prop. Speed and Torque (Sampled Once/Sec as Close Together as Practicable)			1 (prop speed) 1 (torque)
Altitude Rate 2/ (need depends on altitude resolution)	±8,000 fpm	±10%. Resolution 250 fpm below 12,000 ft. indicated	1
Angle of Attack 2/ (need depends on altitude resolution)	-20^{o} to $+40^{o}$ or 100% of usable range	$\pm 2^{o}$	1
Radio Transmitter Keying (Discrete)	On/Off		1
TE Flaps (Discrete or Analog)	Each discrete position (U,D,T/O,APP)		1
	OR		
	Analog 0-100% range	$\pm 3^{o}$	1
LE Flaps (Discrete or or Analog)	Each discrete position (U,D,T/O,APP)		1
	OR		
	Analog 0-100% range	$\pm 3^{o}$	1
Thrust Reverser, Each Engine (Discrete)	Stowed or full reverse		1
Spoiler/Speedbrake (Discrete)	Stowed or out		1
Autopilot Engaged (Discrete)	Engaged or Disengaged		1

2/ If data from the altitude encoding altimeter (100 ft. resolution) is used, then either one of these parameters should also be recorded. If, however, altitude is recorded at a minimum resolution of 25 feet, then these two parameters can be omitted.

TABLE II

PARAMETER LIST (ROTORCRAFT)

PARAMETERS	RANGE	INSTALLED SYSTEM 1/ MINIMUM ACCURACY (TO RECOVERED DATA)	SAMPLING INTERVAL (PER SECOND)
Relative Time (from recorder on prior to takeoff)	4 hrs. minimum	±0.125% per hour	1
Indicated Airspeed	V_{min} to V_D (KIAS) (minimum airspeed signal attainable with installed pitot-static system)	±5% or ±10 kts., whichever greater	1
Altitude	-1,000 ft. to 20,000 ft. pressure altitude	±100 to ±700 ft. (see Table I, TSO C51-a)	1
Magnetic Heading	360°	±5°	1
Vertical Acceleration	-3g to +6g	±0.2g in addition to ±0.3g maximum datum error	4 (or 1 per second where peaks ref. to 1g are recorded)
Longitudinal Acceleration	±1.0g	±0.05g in addition to maximum datum error of ±0.1g	2
Pitch Attitude	100% of usable range	±2°	1
Roll Attitude	±60° or 100% of usable range, whichever is greater	±2°	1
Altitude Rate	±8,000 fpm	±10%. Resolution 250 fpm below 12,000 ft. indicated	1

1/ When data sources are aircraft instruments (except altimeters) of acceptable quality to fly the aircraft, the recording system excluding these sensors (but including all other characteristics of the recording system) shall contribute no more than half the values in this column.

TABLE II (2)

Engine Power, Each Engine			
Main Rotor Speed	Max. range	$\pm 5\%$	1
Free or Power Turbine Speed	Max. range	$\pm 5\%$	1
Engine Torque	Max. range	$\pm 5\%$	1
Flight Control Hydraulic Pressure			
Primary (Discrete)	High/Low		1
Secondary-if applicable (Discrete)	High/Low		1
Radio Transmitter Keying (Discrete)	On/Off		1
Autopilot Engaged (Discrete)	Engaged/Disengaged		1
SAS Status-Engaged (Discrete)	Engaged/Disengaged		1
SAS Fault Status (Discrete)	Fault/OK		1
Flight Controls			
Collective	Full range	$\pm 3\%$	2
Pedal Position	Full range	$\pm 3\%$	2
Lat. Cyclic	Full range	$\pm 3\%$	2
Long. Cyclic	Full range	$\pm 3\%$	2
Controllable Stabilator Position	Full range	$\pm 3\%$	2