log # 24108

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: December 6, 1993

In reply refer to: A-93-169
through -171

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

In the past year, Twin Commander 690 series airplanes have been involved in three accidents, two fatal and one nonfatal, after sustaining structural failure during descent at relatively high speeds. Two of the accidents involved airplanes operated by Medic Air, Incorporated. Although the airplane involved in the last of these accidents incurred substantial empennage structural damage, the airplane was landed safely. The pilot was uninjured and provided a report of the operational circumstances that apparently precipitated the occurrence. This report and subsequent investigation by the National Transportation Safety Board prompt concern that these accidents and possibly others involving Twin Commander airplanes may have resulted, singularly or in combination, from inadequate inspection or lack of compliance with Twin Commander aileron control system rigging specifications, or from the design of the aileron control system which, under certain conditions, may induce a lateral control upset at relatively high speeds or in turbulence.

On August 26, 1993, a Twin Commander Model 690A, N706KC, operated by Medic Air, Inc., sustained an in-flight loss of lateral control at about 16,500 feet about 39 miles northwest of Bishop, California. The airplane was descending with the autopilot off when the pilot experienced a sudden uncommanded roll to the right. The roll excursion continued through 360° before recovery was effected. The flight continued to Bishop, where a successful landing was accomplished. The pilot noted during final approach to the airport that full-up elevator was required to maintain control of the airplane.

The Safety Board's investigation of the accident disclosed that an approximate 5 foot outboard section of the right horizontal stabilizer and elevator assembly had failed and folded in an upward and aft direction but remained attached to the airplane. Small compression buckles were noted on the lower left side of the vertical stabilizer assembly. The push-pull rod attachment brackets on both the left and right elevator torque tube assemblies bore evidence of having impacted adjacent bulkhead structure as a result of

gross overtravel of the elevators. There was no wrinkling or deformation of the airplane's wings, fuselage, or left horizontal stabilizer and elevator assembly. Both left and right aileron inboard hinges, particularly the right inboard hinge, exhibited evidence of contact with aileron cove structure, indicating aileron overtravel in an aileron trailing edge up direction.

A rigging check of the airplane disclosed that the electrically actuated trim tab on the left aileron had a free-play deflection of 0.230 inches, although the service specification indicates the maximum allowable free-play to be 0.100 inches (prior to 1981, maximum allowable free-play was 0.125 inches). The right aileron has a fixed, ground adjustable metal trim tab. The right and left maximum aileron control travel limits were also found to be incorrect.

There were no nodal signatures or other visible evidence of airframe flutter, and the degree, direction, and asymmetry of the failure loads precluded gust loading as a causal mechanism. Moreover, the former certificate holder for the 690 series airplanes, Gulfstream Aerospace Corporation, concluded that the atmospheric vertical gusts specified in applicable airworthiness requirements were of insufficient magnitude to cause structural failure of the horizontal stabilizers, even at maximum operating speed (243 KCAS). A metallurgical examination of the failed empennage structure disclosed no evidence of metal fatigue or other strength or material defects.

Based on the foregoing, the Safety Board believes that the empennage structural damage to N706KC occurred during and because of the uncommanded roll excursion. The uncommanded roll may have been precipitated by adverse aeroelastic effects on the ailerons due to the incorrect aileron travel and/or excessive free-play in the aileron trim tab. The Twin Commander 690 series airplanes are configured with Frise-type ailerons, which deflect 25° up and 17° down. A significant portion of the leading edge of the Frise aileron extends forward of the hinge line and this forward area is subjected to the force of the slipstream when the aileron is deflected trailing edge up. This results in a balancing hinge moment and reduces the maneuvering wheel control force required for lateral control. However, when using Frise or other types of balancing ailerons, maintenance of correct aileron and trim tab rigging, cable tension, and other system parameters is essential to provide proper aileron synchronization and wheel force gradients.

On December 31, 1992, a Twin Commander Model 690B, N300CP, also operated by Medic Air, Inc., sustained an in-flight structural failure and crashed near Herlong, California, killing both the pilot and a flight nurse. An in-flight weather advisory for occasional moderate turbulence was in effect, and the accident occurred during a descent in visual meteorological conditions (VMC).

On December 22, 1992, a Twin Commander Model 690C, N81TR, operated by Casper Air Service, sustained an in-flight structural failure and crashed near Golden, Colorado, killing the pilot, the only person aboard the airplane. The accident occurred during a descent at high speed in VMC. Moderate to severe turbulence had been reported in the area at the time of the accident.

Additionally, since 1976, Twin Commander 690 series airplanes have been involved in nine other accidents (foreign and domestic) because of in-flight structural failure.

Excessive free-play in the aileron trim tab and/or improper aileron primary and balance cable tensions may result in gross aerodynamic overbalance at high speeds and loss of lateral control. An excerpt from "Airplane Aerodynamics" (Dommasch, Sherby, and Connolly) summarizes the potential aeroelastic problem:

> Very careful synchronization of the up-deflected and down-deflected ailerons is required to achieve the degree of balance desired. Stretch in the control-system linkages under load, particularly at high angles of attack, or distortion and flexing of the wings under load may destroy the normal static relation of the two ailerons. This usually results in a sudden abnormal overbalance of the ailerons as they are deflected. This phenomenon is called *snatch* and is dangerous. Frise balances are not recommended for large or high-performance airplanes, but have their particular utility for the small and moderate-sized airplanes of moderate performance characteristics.

During descent, turbine-powered Twin Commander 690 series airplanes tend to be operated at or near their maximum certificated operating speed, making an encounter with turbulent, gusty air particularly severe. Increasing wing angle of attack at any speed tends to change the hinge moments of the Frise aileron in an overbalance direction. In addition, cable stretch, wing bending, and local changes in angle of attack induced by high speeds and/or turbulence adversely affect aileron synchronization. Moreover, because of the relatively long moment arms of the aileron's aft-set hinges, the static geometric wing-to-aileron relationship may change significantly under load due to wing/aileron bending. This may induce flow separation and erratic wheel control forces or otherwise adversely affect aerodynamic balance.

In addition to their important effect on Frise aileron synchronization and aerodynamic balance, aileron rigging and trim tab free-play limitations must also be strictly adhered to in order to avoid aileron/wing flutter at high speeds or in turbulence. For example, control surface flutter speeds associated with small aileron deflections and linear aerodynamic hinge moments are, generally, relatively high and outside an airplane's normal operating envelope. However, aileron/wing flutter speeds may be substantially reduced for large aileron deflections that result in nonlinear hinge moments. Fortunately, the requisite large aileron deflections associated with flutter under these conditions, even at these reduced speeds, require high wheel force inputs and may normally be unattainable in operation because of limitations associated with pilot strength or maximum wheel force input. Abnormal overbalance of the Frise ailerons under these conditions could be hazardous. Therefore, to avoid potential loss of lateral control and structural overload,

due either to reduced wheel force gradients or flutter, it is important to ensure that no aerodynamic overbalance or wheel force lightening occurs at the high maximum allowable cruise speeds associated with flight operation of Twin Commander 690 series airplanes.

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

> Issue an Airworthiness Directive, applicable to Twin Commander 690 series airplanes with Frise ailerons, requiring a check of aileron control system rigging and synchronization, primary and balance cable tensions, adjustment of mechanical control stops, and rigging and free-play deflection of the aileron trim tab, in accordance with Twin Commander maintenance procedures to ensure proper lateral wheel force control gradients. (Class I, Urgent Action)(A-93-169)
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> Direct the FAA Principal Maintenance Inspector to review and surveil the service procedures and maintenance facilities of Medic Air, Incorporated, particularly in connection with the maintenance, balancing, and rigging of Twin Commander flight control surfaces, to assure the operator's compliance with all applicable airplane inspection and airworthiness requirements. (Class I, Urgent Action)(A-93-170)
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> Conduct an engineering design review of Frise aileron control systems installed in Twin Commander 690 series airplanes to ascertain the adequacy of lateral control wheel force gradients, particularly as they might be affected by improper aileron synchronization, rigging, cable tension, or free-play of the aileron trim tab. Other related parameters that should be considered include the following: effects/limitations (on synchronization and hinge moments) of the right aileron ground adjustable trim tab; variable cable tension due to temperature effect, particularly at cold temperatures and/or high altitude; aeroelastic effects at high speed; and deformation of wing-aileron structure and aileron hinges in turbulence or at high speed or load factor. An Airworthiness Directive should be issued to correct any deficiencies noted, and if appropriate, the manufacturer should be required to include new or amended aileron control system rigging and synchronization procedures in the respective maintenance manuals (Class II, Priority Action)(A-93-171)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HAMMERSCHMIDT, and HALL concurred in these recommendations.

By: Carl W. Vogt
Chairman