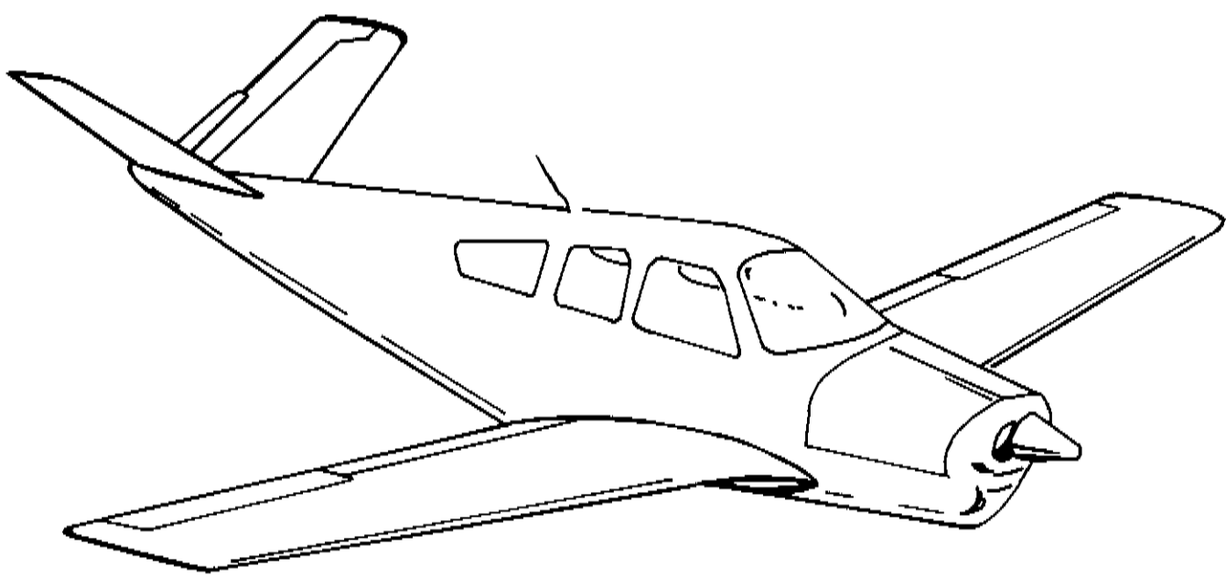
2nd PRINTING

U.S. Department
of Transportation
**Federal Aviation
Administration**

Task Force Report V-tail Bonanza Investigation

January 1986



Transportation Systems Center

U.S. Department
of Transportation
**Federal Aviation
Administration**

Central Region
Iowa, Kansas,
Missouri, Nebraska

601 E. 12th Street
Kansas City, Missouri 64106

March 7, 1986

FAA SMALL AIRPLANE DIRECTORATE FOREWORD

This report provides the results of an extensive study of the Beech Aircraft V-Tail Bonanza by the Transportation Systems Center (TSC), Cambridge, Massachusetts, as requested by the Federal Aviation Administration. The intent of this study was to provide an independent and unbiased evaluation to determine conclusively whether there were or were not characteristics in the design of the V-Tail Bonanza that contributed to in-flight structural failures. Conclusions of the evaluation were to include any recommendations for action to the FAA for consideration, based on the study's findings. TSC was requested to consider not only data available from FAA and other governmental agencies and the manufacturers, but to solicit and consider inputs from the aviation and academic communities as well.

Several structural modifications have been approved by FAA for installation on the V-Tail Bonanza by the FAA. The task force reviewed only the basic airplane as manufactured by the Beech Aircraft Corporation, and made no attempt to evaluate the effectiveness of any modification.

The study found that the V-Tail Bonanza met the structural requirements applicable at the time of initial FAA type certification. However, three recommendations for further action were made, as follows:

1. Limited tests should be conducted to determine, definitively, the tail failure mechanisms, and to define the actual structural margins of the Model 35 V-Tail Bonanza.

2. FAA should review airworthiness standards for general aviation aircraft to determine their adequacy to properly certify non-conventional tail aerodynamic configurations.

3. FAA should review pilot certification requirements for high performance, single-engine aircraft.

The study identified no immediate safety concerns, provided the airplane is operated within the approved flight envelope. Therefore, no mandatory airworthiness or other immediate action is being considered at this time.

FAA is concerned with the potential for misunderstanding of the degree of conservatism employed and of the intent of TSC in using certain assumptions. The FAA appreciates the intent behind making these assumptions but believes that a technically validated method of calculation would have provided a more fundamentally realistic assessment consistent with established engineering practice. The additional testing being pursued in response to Recommendation 1 should provide data necessary to address the concerns.

Beech has reviewed the draft version of the study report to enable them to assure that proprietory data shared with the contractor was not violated. From that review Beech also developed considerable concern with the report's conservative assumptions in the analysis of the V-Tail Bonanza wing span loading at the fuselage and the tail maneuvering limit envelope, and possible misperception of the scenarios thus developed. It can be expected that the aforementioned test program will provide more conclusive information on these issues.

The Small Airplane Directorate in Kansas City, Missouri, is responsible for the continued type certification of the V-Tail Bonanza and those associated aspects of this study. Any questions or other contacts regarding this study should be addressed to this Directorate, contact phone (816) 374-6937, attention Aircraft Certification Division.

Original Signed By
Barry D. Clements

Barry D. Clements
Manager, Aircraft Certification
Division, Central Region

Regarding Recommendation 1, and considered from the outset as a potential second phase of the study, the FAA developed from the preliminary TSC findings a proposed structural and flight test plan including appropriate test instrumentation, flight configurations and desired wing and tail loads information. Subsequent to the TSC study, Beech Aircraft Corporation has initiated a subcontracted flight test program to obtain additional wing and empennage flight loads data from an instrumented Model 35 airplane. Beech has agreed to incorporate all essential provisions of the FAA plan into their contracted test program, with FAA participation and oversight as appropriate. Beech is also arranging wind tunnel testing and possibly selected static structural testing as appropriate to supplement the flight testing program. Any subsequent FAA action necessary to address this issue will be determined from the results of this completed test program.

Prior to the TSC study, the FAA had formed a joint FAA/Industry working group to review nonconventional tail aerodynamic load assumptions and certification criteria. Recommendation 2 of the study is being addressed by this working group and the FAA will initiate any rulemaking action found appropriate.

Recommendation 3, that FAA review pilot certification requirements for high performance, single-engine airplanes, will be considered during the next FAR Part 61 review.

While the TSC study provided a very comprehensive and thorough review of an extremely broad spectrum of data, FAA's direction did not impose a sensitivity analysis task nor did the FAA dictate the assumptions or methodology to be employed by TSC in developing their conclusions or recommendations. Assumptions were used in two areas of TSC's study, namely distribution of wing loads and tail maneuvering loads, that TSC identified as being conservative, for the purpose of allowing the presentation of a complex problem in a way that trends and concerns can be relatively easily understood by the reader.

In calculating lift, TSC used a simplified method that is inconsistent with the methodology generally accepted by the aviation community and FAA certification engineers for determining aerodynamic loads. TSC also developed a chart and data in the report which estimates boundaries for design limit loads on the tail in particular flight conditions indicating that operations exceeding those boundaries would cause the tail to exceed limit loads. TSC acknowledges in the report that such conditions might not be attainable in actual operation, and that some data points exceed those required for type certification. The results of these analyses are retained, however, to maintain the independent nature of the report.

TASK FORCE REPORT

V-TAIL BONANZA INVESTIGATION

Prepared for

the

Federal Aviation Administration

VOLUME I

January 1986

Prepared by

U. S. Department of Transportation
Transportation Systems Center
Cambridge, Massachusetts

FAA Small Airplane Directorate Foreword dated 3/7/86 is part of this Report and should be attached.

PREFACE

This task force report was prepared in two volumes for the Federal Aviation Administration to provide an objective assessment of the facts associated with the controversy over the in-flight failure rate of the accident records and the certification process for the V-tail Bonanza. Volume I presents the assesment while Volume II contains the accident records.

The study was conducted by the Transportation Systems Center with some contract support from industry and universities. The cooperation of many persons in government, industry, academia and the private sector who voluntarily provided their time in support of this effort contributed significantly to the completeness of the study. The task force would like to thank staff members of the Federal Aviation Administration in the Central Region as well as in Washington, DC and members of the National Transportation Safety Board, who were consistently helpful in providing historical data for the study. The documentation for certification, test and analyses that was requested from and provided by Beech Aircraft Corporation required a substantial effort which was essential to completing the study.

Numerous individuals provided supplementary background information and technical data and their efforts were appreciated. The list includes Mike Smith of Mike Smith Aero, Inc., Professor Ronald Stearman of the University of Texas, Dr. Brent Silver, Aviation Consultant, Mr. Ralph Harmon, the designer of the original V-tail Bonanza, Dr. Roger Hoh of Systems Technology Inc., Dr. Russ Westmann of Failure Analysis Associates, and Mr. Rod Wingrove at NASA Ames.

FAA Small Airplane Directorate
Forwarding Letter 2/7/86 is part
of this report and should be
attached.

TABLE OF CONTENTS

Volume I

Volume II

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

EXECUTIVE SUMMARY

Since 1947 when Beech Aircraft Corporation introduced the V-tail Bonanza, there has been an ongoing debate between advocates of the V-tail and its performance and those who believe the record of in-flight structural failures suggests that the plane is unsafe. More than 200 of the 10,405 airplanes produced have been involved in fatal in-flight airframe failure accidents. There have been several studies in the past to determine whether the V-tail Bonanza airplane has a greater statistically significant occurrence rate of in-flight structural failures than other airplanes of similar size and performance, and accident statistics have been used convincingly to make a case for both sides of the argument.

In the summer of 1984, the FAA Administrator, in response to a request from the American Bonanza Society, initiated an investigation. In September 1984, the FAA Central Region asked the Transportation Systems Center to conduct a study to define actions necessary to determine conclusively that there are or that there are not deficiencies inherent in the design of the Beechcraft V-tail Bonanza that contribute significantly to in-flight airframe failures.

The six-month study, which began on October 1, 1984, has included two related activities. The accident records were reviewed and analyzed in the search for a better understanding of the factors contributing to in-flight structural accidents. A concurrent activity involved a detailed review of the V-tail Bonanza certification history. This involved a review of structural analyses and tests that have been conducted by Beech Aircraft Corporation throughout the 38 year history of the aircraft. Various experts familiar with some aspect of the V-tail history were sought out and interviewed. The NTSB, FAA, and Beech Aircraft Corporation and others provided information and support as required to carry out this investigation.

The conclusions of the task force study are summarized as follows:

1. The V-tail Bonanza has satisfied the structural requirements for certification appropriate for each model according to accepted practices at the time of certification.

2. The aircraft certification requirements do not adequately address the unique characteristics of the V-tail configuration in establishing maximum tail loads.

3. The handling and stability characteristics of the V-tail Bonanza could contribute to a situation where an inexperienced or inattentive pilot could exceed the allowable flight envelope.

4. The fatal in-flight airframe failure accident rates for most single engine airplanes with retractable landing gear (including the V-tail Bonanza) are significantly higher than for other categories of general aviation aircraft.

5. The safety record of the Beech Model 33 is significantly better than for other high performance single engine aircraft (including the V-tail Bonanza).

6. The in-flight failure accident record of the more recent models of the V-tail Bonanza is significantly better than that for some of the earlier models and correlates with structural improvements that have been incorporated.

The task force recommends the following:

1. Limited tests should be conducted to determine definitively the tail failure mechanisms and to define the actual structural margin of the Model 35 V-tail Bonanza.

    - o Establish aerodynamic loads on the tail of the V-tail Bonanza, including load distribution, for various conditions (flight test and/or wind tunnel test). Include combined longitudinal and lateral loads.

    - o Establish the structural strength of the tail of the V-tail Bonanza using static load tests. Include the possible effect of load redistribution due to aeroelastic effects.

    - o Conduct static load tests on the Model 33 tail to establish the failure mode for comparison with the failure mode of the Model 35 tail.

2. Review airworthiness standards for General Aviation Aircraft.

    - o Review requirements for the V-tail configuration (currently underway by the Small Airplane Empennage FAA/Industry Loads Working Group).

    - o Expand effort to review techniques for predicting aerodynamic loads on non-conventional tails to include a review of the same techniques for conventional tail configurations.

3. Review pilot certification requirements for high performance single engine aircraft to assure pilot proficiency.