8.0 TASK FORCE STUDY RESULTS

The task force study results are based on a six month investigation of the V-tail Bonanza conducted by the Transportation Systems Center which included a detailed review of the accident records and the supporting documentation for the aircraft certification process. The results also draw from previous studies, where appropriate. The conclusions are stated briefly in Section 8-1. Section 8-2 presents the findings which include a more complete version of the conclusions along with observations that support the conclusions. Section 8-3 presents the task force recommendations.

8.1. CONCLUSIONS

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 for the Beech Model 33 is significantly better than for other 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.

8.2 FINDINGS

The findings, or expanded version of the conclusions, are grouped according to subjects that generally correspond to chapters of this report as follows:

Structural Integrity

- The Model 35 airframe meets the requirements of the applicable CAR airworthiness standards.

- Aerodynamic loads that might be experienced by the tail surface of a V-tail operating within allowable flight conditions could exceed the maximum computed loads as specified in the certification requirements. The combined loading on the tail resulting from longitudinal balance loads and yaw maneuver loads is a condition that is unique to the V-tail and is not explicitly required for consideration in the certification standards.

- These standards establish a 1.5 factor of safety, i.e., the airframe is 50 percent stronger than required to survive the maximum expected airplane loads. The factor of safety is intended to account for dynamic amplification and unpredictable effects such as variations of manufacturing quality, minor design changes that nominally have no influence on strength, and unusual but seldomly occurring flight loads. There is no CAR/FAR requirement for additional strength beyond the 1.5 factor.

- Most airplanes, and that includes the Model 35, also have a structural margin beyond the requirements of the CAR/FAR airworthiness standards. However, the margin is different for different components (wing versus tail), for different modifications of the airplane, and for different loading conditions. The wing strength was increased when the airplane was recertified from Normal to Utility Category (Model A35 and later). The wing strength was further increased in subsequent models. The structural margin in the empennage was decreased when the wide-chord tail was first introduced (Model C35); in subsequent models the empennage strength was increased by introducing increased component thicknesses. The history of these structural margins is also a function of the growth in airplane gross weight, speed, and installed power.

- Retrofit modifications such as stub-spar kits and leading-edge collars can increase the empennage strength with respect to some but not all loading conditions.

- Effective utilization and practical limitations of tension patches used for structural loading of aerodynamic surfaces during tests are not well defined.

- The Model 33 stabilizer has a slightly greater structural margin than the Model 35 stabilizer when loads are estimated as specified in the airworthiness standards. However, if the combined loading condition for the V-tail were included, the Model 35 margin would be further reduced.

<u>Aeroelasticity</u>

- Undamaged and properly maintained Model 35 airframes are not subject to static aeroelastic divergence or divergent flutter within the permissible flight envelope.

- Under certain extreme maneuvering loads, the stabilizer torque box may buckle which by itself is not detrimental under static loads. However, buckling weakens the torsional rigidity which could lead to torsional divergence of the stabilizer. This effort is especially critical for tails with the wide chord.

- Improperly balanced ruddevators may be subject to limit-cycle flutter under permissible flight conditions. Such flutter may damage the airframe if prolonged. Low tension in ruddevator cables or tab cables will not cause flutter within the permissible flight envelope because flutter speed is independent of cable tension level, provided it is not zero. A slack condition in the cables could cause flutter within the permissible flight envelope.

Handling and Stability Characteristics

- The risk of fatal in-flight airframe failure (FIFAF) accidents also depends on some but not all of the airplane's handling characteristics.

- Clean airplanes in dives or divergent spirals can reach speeds well in excess of the red line speed, thus increasing the risk of aerodynamic loads exceeding the airframe strength. The Bonanza is a clean airplane.

- In easily handled airplanes with low stick forces there is an inherent risk of causing aerodynamic overload during an attempted recovery maneuver. The V-tail Bonanza is noted as having a low stick force.

- Characteristics which contribute to increased work load for the pilot could indirectly increase risks of FIFAF accidents:

    - Many airplanes (including the V-tail Bonanza) have a tendency to dive from a large angle of yaw. The yaw-dive characteristic involves a straight dive, however, from which the airplane will recover without pilot control inputs.

    - Dutch roll or "tail-wagging" characteristics in turbulence constitute an annoyance to the pilot. The V-tail Bonanza has a lightly damped tail-wagging characteristic. Attempts by the pilot to reduce tail-wagging could lead to conditions that cause excessive loads on the tail.

- More rigorous pilot proficiency standards for complex and/or high performance single-engine aircraft could be expected to reduce the number of FIFAF accidents in this category.

Accident History

- FIFAF accident rates for single engine airplanes with retractable landing gear are significantly higher than for other categories of general aviation aircraft.

- The Model 35 FIFAF accident rates are comparable to most airplanes in this category.

- FIFAF accident rates for the Beech Models 33 and 36 are exceptionally low.

- The original 35 and the group including models C35 through E35 have the highest FIFAF accident rates among the V-tail Bonanza models.

- The more recent models, from Model H35 to the present, have the lowest FIFAF accident rate among the Model 35 airplanes.

Risk Factors for In-Flight Airframe Failures

- Analysis of the data for Model 35 FIFAF accidents shows clearly that the FIFAF accident rate increases as the structural margin decreases, and vice versa. This is a particular result of a general situation, viz: all airframes possess some degree of structural failure risk, and the degree of risk rises as structural margins decrease.

- The original Model 35 wing and Models C35 through E35 empennage have a lower structural margin than that for other V-tail Bonanzas.

- The task force believes that the FIFAF accident rates for these models reflect the associated increased risk. This risk is not unique to the V-tail Bonanza. Whether such risk is acceptable is a question which lies outside the scope of this task force.

- For an airworthy airframe, the risk of FIFAF accidents stems from events which are not subject to design consideration under either past or present airworthiness standards. Such events can be classified in two general categories:

  - Moderate exceedence of the permissible flight envelope.

  - Rare conditions that are considered too unlikely to warrant being included in the certification requirements.

- Pilot error is frequently noted as the cause of exceeding the flight envelope. Analysis of the relevant accident data (high-speed ground impacts as well as FIFAF accidents) has identified the spiral divergence as likely scenario in this category. The typical errors which lead to this scenario are disorientation of VFR pilots flying into IFR weather and inattentiveness of qualified (but not highly proficient) IFR pilots when busy in the cockpit under IFR conditions. In such cases, it is likely that the pilot's first recognition of trouble is increased airspeed, and his first reaction may be an attempt to pull up before leveling the airplane's roll angle. Whether a given pilot in a given airplane crashes, breaks up in flight, or recovers will depend upon the rate of spiral divergence, the pilot's quickness in assessing and reacting to the situation, the airplane's speed at the time a recovery maneuver is attempted, and the airframe's structural strength.

- Combined maneuver and gust loads are unlikely to occur, but they could cause FIFAF accidents in rare cases. This type of event is not a pilot error. Individually, neither load will cause an airworthy airframe to fail. Whether an airframe survives or fails with the combined loads will depend upon the severity of the maneuver, the gust velocity, and the strength of the airframe.

- Severe gusts can occur at cruise speeds without sufficient warning for the pilot to reduce speed.

8.3 RECOMMENDATIONS

This six month study of the V-tail Bonanza raises questions about what loads the tail actually experiences and at what loading conditions the tail will fail. In order to answer these questions, tests will be required. Beech complied with the FAA standards, but it is not certain that the specified loading conditions for certification are adequate to describe the worst case condition. Until these questions are resolved it is believed that the aviation community will remain uncomfortable with the highly publicized accident record of the V-tail Bonanza.

The study points out that the V-tail Bonanza is typical of a class of high performance airplanes and is subject to the risks associated with that class of airplanes. This raised the issue of protecting the flying public with more restrictive standards for both pilots and manufacturers of high performance single-engine general aviation aircraft. This issue is beyond the scope of this study and any changes must be carefully weighed against the rights of pilots to choose and to fly higher performance airplanes that are not unnecessarily restricted by overly conservative standards.

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.

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

   - 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.

   - 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.

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

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

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

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