6.0 ACCIDENT HISTORY

General aviation accidents, while not as newsworthy as an occasional commercial airline accident, are far more costly in terms of lives lost. All airplane accidents involving loss of life are investigated by the National Transportation Safety Board (NTSB). Prior to the formation of the NTSB in 1964, the Civil Aeronautics Board (CAB) performed this function. The records of these two organizations constitute the history of aviation accidents in the United States.

Studies of general aviation accidents that have been conducted in the past are based on data obtained from the NTSB and/or the CAB. Previous studies that are relevant to the V-tail Bonanza investigation are discussed in Section 6.1. This section emphasizes comparison of the accident records of the V-tail Bonanza with other general aviation aircraft.

The accident records from the NTSB and the CAB were used along with additional data from the FAA and Beech Aircraft Corporation to develop a complete data base for V-tail Bonanza in-flight airframe failure accidents. This is discussed in Section 6.2. The accident data base is used in Section 6.3 to present the accident history of the V-tail Bonanza. This includes the breakdown of the accidents by year and sub-model. Section 6.4 compares the accident history of the Beech V-tail Bonanza airplanes to the Model 33 and the Model 36 with conventional tails. Section 6.5 explores the possibility of common factors in V-tail fatal in-flight airframe failure accidents using the data base established in Section 6.2.

6.1 REVIEW OF PREVIOUS ACCIDENT STUDIES

This section presents pertinent data from earlier accident studies that included the V-tail Bonanza. In addition to preparing a report on every fatal airplane accident, the NTSB collects data for a permanent file. Periodically it has published reports that utilize its accumulated data file to pursue various themes with the intent of identifying trends or conditions that impact aviation safety. Aviation safety is also a major concern of the Federal Aviation Administration (FAA). The airplane certification and pilot certification processes for which the FAA is responsible are intended to protect the flying public from unnecessary safety risks. To support this role the FAA has also conducted and sponsored studies of aircraft accidents to identify potential safety concerns. The FAA's predecessor, the Civil Aeronautics Administration (CAA) performed this function prior to the formation of the FAA.

Beech Aircraft Corporation has conducted several internal studies of aircraft accidents that were prompted by concerns regarding structural in-flight failures of the Model 35 Bonanza. An "Aviation Consumer" article published on February 1, 1980 referenced four such studies conducted by Beech Aircraft in the 1950's[78].

One of the more recent and thorough studies was conducted by Systems Technology, Inc. (STI) under contract to the FAA. The report, "A Study of the Effects of Aircraft Dynamic Characteristics on Structural Loads Criteria," was published in November, 1978[83]. The study included an analysis of in-flight airframe failure (IFAF) accidents which occurred during a ten-year period from 1966 to 1975. All types of aircraft were considered but the primary interest here is the chapter devoted to general aviation accident data for in-flight airframe failures. In terms of the number of in-flight airframe failures, the Beech Model 35 V-tail Bonanza stands out with 76 accidents in the ten year period. All other general aviation aircraft, which included 12 twin engine models and 33 single engine models, had 207 accidents in the in-flight airframe failure category. The Beech Model 35 accident record was sufficiently noticeable that the authors chose to present summary data comparing it to all other general aviation aircraft. The only other airplane that came close in terms of the numbers of accidents in the category was the Piper PA-24 Comanche with 39. However, when aircraft exposure is taken into account, the initial perception that V-tail Bonanza is unusually accident prone is put into proper perspective as discussed below.

General aviation aircraft are broken down into three categories or groups for further comparative analysis in the STI study. The category of single engine aircraft with retractable landing gear, which includes the Beech Model 35, as well as Models 33 and 36, has the highest rate for the ten year period with 0.486 accidents per 100,000 hours flown. The twin engine group has a rate about one fourth that of the single engine retractable landing gear group (0.125 accidents per 100,000 flight hours). The safest group, which has a single engine and fixed landing gear, has less than one tenth the accident rate of the single engine retractable 0.0417 (accidents per 100,000 flight hours).

Within the group that includes single engine retractable landing gear aircraft, the Bonanza was found to be among those with a higher than average accident rate. This is shown in Table 6-1 which reproduces data from Reference 83. Three airplanes have a slightly higher rate than the Bonanza while six have a lower rate.

This data suggests that the in-flight airframe failure rate of the V-tail Bonanza is somewhat typical of airplanes in the group with a single engine and retractable landing gear. The fact that this group has an accident rate that is clearly higher than the other two groups should not be ignored. It could be interpreted as evidence that flying in airplanes from this group involves an inherent risk that exceeds that of flying in airplanes from the other groups.

Further investigation of Table 6-1 reveals that the more accident prone sub-group, which includes the Beech Model 35 airplane, could be considered the norm, with eight airplanes having a FIFAF rate ranging from 0.256 accidents per 100,000 hours flown to 1.1577 per 100,000 flight hours. The safer planes would then be considered the exception with their remarkable records: the Mooney M20 had no FIFAF accidents (the wooden version was excluded) and the Beech Models 33 and 36, combined, had a rate of 0.0386 accidents per 100,000 flight hours. This FIFAF rate is an order of magnitude lower than that for the average single engine airplane with retractable landing gear.

These exceptions serve to demonstrate that it is possible to have a high performance single engine airplane without the attendant risk generally associated with this category. Rather, the similarity and/or commonality of the design and handling characteristics of the Beech Model 35 Bonanza and the Beech Model 33 Debonair lead to a focus on the two major differences: the empennage configuration and the accident records. These differences are addressed in Section 6.4 which compares the accident records of the V-tail Bonanza with the accident records of the conventional tail Models 33 and 36. While it should be the goal of both government and industry to make all airplanes safer, it is important to remember that the Model 35 accident record is typical of that class of airplanes and the Model 33 is remarkably accident free.

TABLE 6-1. IFAF ACCIDENT RATE STATISTICS FOR SINGLE-ENGINE AIRCRAFT WITH RETRACTABLE LANDING GEAR (1966 - 197
(Reproduced from Reference 6-2)

MANUFACTURER & MODEL	FATAL/ALL ACCIDENTS	ACCIDENT RATES		10^5 HOURS FLOWN	USE BREAKDOWN (PERCENTAGE)				EXCLUDED FATAL/ALL ACCIDENTS
		FATAL	ALL		PERSONAL	BUSINESS	INSTRUC-TION	OTHER	
Mooney M20	0	0	0	65.6	49.9	36.6	4.8	8.7	7/12
Beech 33, 36	1/1	0.0386	0.0386	25.9	*	*	*	*	0
Cessna 177RG (Cardinal RG)	1/1	0.256	0.256	3.9	----	----	----	----	0
Cessna 210	11/14	0.303	0.385	36.3	33.2	51.8	1.8	13.2	1/4
Piper PA-28R (Cherokee Arrow)	10/10	0.401	0.401	25.0	----	----	----	----	0
Piper PA-24 (Comanche)	35/39	0.645	0.719	54.2	44.7	39.1	4.8	11.4	2/4
Beech 35 (Bonanza)	71/76	0.728	0.779	97.5	38.8	49.4	2.0	9.8	2/2
Navion	9/9	0.812	0.812	11.1	72.0	22.9	1.9	3.2	1/1
Bellanca 14-19, 17-30, 17-31	7/9	0.711	0.914	9.8	42.5	49.3	1.6	6.6	0
Beech 24R	2/2	1.157	1.157	1.7	----	----	----	----	0
GROUP	147/161	0.444	0.486	331.1	43.0	44.0	3.0	9.9	18/23

* Model 35,33 and 36 data are combined; see Beech 35.

Another recent and important study, "Single-Engine Fixed-Wing General Aviation Accidents," was published May 31, 1979, by the National Transportation Safety Board[84]. Factors associated with 17,312 general aviation accidents which occurred from 1972 through 1976 were explored. Four of the five years covered in the NTSB study were included in the ten year study by STI. The scope and objectives for the two studies were different, however: STI focused on in-flight airframe failures for a wide variety of aircraft; NTSB focused on light, single engine fixed-wing aircraft for a wide variety of accidents.

The NTSB selected all aircraft makes and models with 500 or more active aircraft in the year 1976 for inclusion in their study. The 33 selected aircraft accounted for 89.3 percent of the 115,686,698 hours flown by the active single-engine aircraft fleet and 79.8 percent of the 17,312 single-engine aircraft accidents during the period.

The NTSB study grouped the Beech Models 33, 35, and 36 together and treated them as one of the 33 different models sampled. Of the 33 airplanes, the Beech 33, 35 and 36 had the lowest accident rate with 8.73 accidents per 100,000 flying hours. Table 6-2 shows the data presented in the NTSB report for the 33 selected aircraft listed in order of their accident rates.

When the 33 aircraft are ranked according to fatal accident rates, the Beech Bonanza type airplane moves up to become 20th of 33 with a fatal accident rate of 2.55 accidents per 100,000 flying hours. Again the tabulated ranking from the NTSB report is reproduced here for convenience in Table 6-3.

Among the various types of accidents for the 33 selected aircraft, in-flight airframe failure ranks as the least frequently occurring type of the 10 types of accidents tabulated in the study. Only 185 of the accidents were caused by airframe failure which translates into 1.3 percent of all accidents considered. Airframe failure caused 6.7 percent of all accidents for Beech models 33, 35, and 36. The Beech Models accounted for 40 of the 185 airframe failure accidents.

Of the 33 airplane models considered, the Beech Models 33, 35, and 36 rank seventh from the highest in in-flight airframe failure rates with 0.58 accidents per 100,000 flight hours. Table 6-4 reproduces tabular data from the NTSB report[84] which ranks these models for in-flight airframe failure rate.

Assessment of the significance of Table 6-4 leads to the general conclusion that the Beech Models 33, 35, and 36 are among the single-engine aircraft more susceptible to in-flight airframe failure. Of course, if the Model 35 were separated from the Models 33 and 36, the V-tail Bonanza would probably move up from seventh to sixth and Models 33 and 36 would drop to the lowest position or very close to it.

Some of the issues are somewhat clouded by the combination of complex and high-performance single engine aircraft with all other single engine general aviation aircraft in the NTSB study. Nonetheless, the general conclusions that are drawn are consistent with the FAA sponsored STI study. The additional conclusion that is suggested by the STI study relates to the apparent higher risk for in-flight airframe failure in the category of aircraft with single engine and retractable landing gear. This category generally corresponds to complex and/or high performance airplanes, suggesting that high performance airplanes should be evaluated in terms of factors affecting airframe safety.

TABLE 6-2. SELECTED AIRCRAFT RANKED BY ACCIDENT RATE
(Reproduced from Reference 84)

AIRCRAFT	ACCIDENT RATE PER 10^5 HOURS	FLYING HOURS 100,000 HOURS	ALL ACCIDENT RECORDS
Luscombe 8	45.68	5.539	253
Cessna 195	34.48	2.131	82
Globe (Stinson) 108	38.03	5.259	200
Globe GC-1	37.61	1.941	73
Aeronca 11	31.07	1.706	53
Cessna 120/140	28.69	11.150	320
Forney (Ercoupe)	28.51	6.209	177
Aeronca (Bellanca) 7	28.26	22.466	635
Piper PA-12	27.33	4.281	117
Cessna 170	27.21	11.100	302
Piper J-3	26.97	8.677	234
Grumman (Yankee) AA-1	26.24	11.586	304
Taylorcraft (BC)	24.80	4.194	104
Piper PA-18	23.09	20.747	479
Piper PA-22	21.40	20.281	434
Bellanca 14-19	21.36	6.693	143
Cessna 180	21.26	19.428	413
Cessna 185	17.72	9.535	169
Beech 23	17.58	18.429	324
Piper PA-24	16.80	26.011	437
Navion	16.12	5.523	89
Cessna 210/205	15.21	26.828	408
Cessna 175	15.13	6.014	91
Cessna 177	14.99	19.216	288
Grumman (Traveler) AA-5	14.99	6.803	102
Piper PA-32	14.21	21.189	301
Cessna 206	13.09	18.482	242
Cessna 182	11.32	77.556	878
Mooney M-20	11.32	32.433	367
Piper PA-28	10.49	175.767	1,830
Cessna 150	10.28	205.316	2,111
Cessna 172	9.07	151.422	1,373
Beech 33, 35, 36	**8.73**	**68.943**	**602**

TABLE 6-3. SELECTED AIRCRAFT RANKED BY FATAL ACCIDENT RATE (Reproduced from Reference 84)

AIRCRAFT	FATAL ACCIDENT RATE PER 10^5 HOURS	FLYING HOURS 100,000 HOURS	FATAL ACCIDENT RECORDS
Globe GC-1	9.27	1.941	18
Bellanca 14-19	5.68	6.693	38
Aeronca 11	5.28	1.706	9
Luscombe 8	5.06	5.539	28
Grumman (Yankee) AA-1	4.83	11.586	56
Piper J-3	4.73	8.677	42
Aeronca (Bellanca) 7	4.58	22.466	103
Piper PA-18	4.00	20.747	83
Forney (Ercoupe)	3.87	6.209	24
Navion	3.80	5.523	21
Cessna 195	3.75	2.131	8
Piper PA-12	3.50	4.281	15
Piper PA-22	3.28	20.281	66
Cessna 170	3.15	11.100	35
Cessna 210/205	3.09	26.828	83
Grumman (Traveller) AA-5	2.94	6.803	20
Piper PA-24	2.92	26.011	76
Piper PA-32	2.74	21.189	58
Taylorcraft (BC)	2.62	4.194	11
Beech 33, 35, 36	**2.55**	**68.943**	**176**
Beech 23	2.50	18.429	46
Mooney M-20	2.44	32.433	79
Globe (Stinson) 108	2.28	5.259	12
Cessna 177	2.19	19.216	42
Cessna 182	2.02	77.556	157
Piper PA-28	1.97	175.767	347
Cessna 175	1.83	6.014	11
Cessna 120/140	1.70	11.150	19
Cessna 206	1.68	18.482	31
Cessna 185	1.47	9.535	14
Cessna 172	1.47	151.422	222
Cessna 150	1.34	205.316	276
Cessna 180	1.29	19.428	25

TABLE 6-4. IN-FLIGHT AIRFRAME FAILURES
(Reproduced from Reference 84)

AIRCRAFT	RATE*	ACCIDENTS
Bellanca 14-19	1.49	10
Globe GC-1	1.03	2
Forney (Ercoupe)	0.97	6
Cessna 195	0.94	2
Navion	0.90	5
Aeronca 11	0.59	1
Beech 33, 35, 36	**0.58**	**40**
Luscombe 8	0.54	3
Piper PA-24	0.42	11
Cessna 170	0.36	4
Cessna 210/205	0.34	9
Cessna 180	0.31	6
Piper PA-22	0.30	6
Aeronca (Bellanca) 7	0.27	6
Beech 23	0.27	5
Cessna 120/140	0.27	3
Piper PA-32	0.24	5
Taylorcraft (BC)	0.24	1
Piper J-3	0.23	2
Mooney M-20	0.18	6
Piper PA-28	0.16	28
Cessna 177	0.16	3
Cessna 182	0.12	9
Cessna 206	0.11	2
Grumman (Yankee) AA-1	0.09	1
Cessna 172	0.03	4
Cessna 150	0.02	5

*No. of ACCIDENTS / 100,000 FLIGHT HOURS

For the three categories of general aviation aircraft, demands on the pilot's training and experience vary dramatically. Single-engine fixed landing gear aircraft are the least demanding and twin engine retractable landing gear aircraft are the most demanding. If the comparison is limited to these two groups, an explanation of accident rates is straightforward. Twin engine aircraft have two and one half times as many fatal in-flight airframe failures as single engine airplanes with fixed landing gear because twin engine airplanes are more difficult to fly[78]. Following this logic, FIFAF accident rates for single engine airplanes with retractable landing gear should lie between the rates for the other two groups. This is not the case. As discussed earlier, the FIFAF accident rate for single engine airplanes with retractable landing gear is ten times higher than that for single engine aircraft with fixed landing gear and exceeds that for twin engine airplanes by a factor of four. Differences in pilot proficiency may contribute to this discrepancy.

The proficiency requirements for pilot certification are essentially the same for all single engine aircraft, with the only additional requirement for high performance single engine aircraft being an instructor sign-off that the pilot is checked out in that category. In contrast, twin engine pilot certification requirements are defined in a separate section of the "FAA's Private Pilot Practical Test Standards,"[85]. A reevaluation of the pros and cons of having a separate section for high performance aircraft appears to be in order.

Another approach to reducing risks would be to have more conservative certification requirements for aircraft structures in the single engine high performance category. An argument can be made that a more forgiving structure is a substitute for pilot proficiency. A more balanced approach addressing both structural integrity and pilot proficiency could be considered.

6.2 ACCIDENT DATA BASE

The number of accidents for the V-tail Bonanza, and in particular the number of fatal in-flight airframe failures, have been reported for various portions of the 38-year history of the airplane. An Aviation Consumer article summarized all of the FIFAF accidents in the United States to date in February, 1980 (Reference 6-1). One of the intermediate objectives of this task force study was to assemble relevant accident summary data in a consistent format for the entire history of the V-tail Bonanza.

This involved collecting accident data from several sources with the preferred source being the responsible agency for investigating accidents. For the years 1947 through 1964 the information was obtained from reports and accident files prepared by the CAB. The available information from the CAB consisted of a brief narrative describing the circumstances and accounts of each accident. Where possible, complete accident files for these accidents were obtained and reviewed for additional information.

Beginning in 1964, the function of investigating general aviation accidents was transferred to the NTSB, which now maintains an extensive computerized data base with accident information for the period 1964 to the present. Accident Briefs (as they are called by NTSB) were obtained for each accident under consideration from 1964 through 1982 and preliminary reports were obtained from NTSB for accidents which occurred in 1983 and 1984. For those accidents where complete accident files were available, copies were obtained and reviewed. In general, detailed accident reports were obtained for all airframe failure accidents from 1977 to the present. The complete accident reports for accidents prior to 1977 have been destroyed by NTSB.

The FAA's accident data base (AIDS) also provided information about accidents from 1973 to 1982. This data base provided extensive information about each occurrence during that period. In addition, information about some accidents was obtained through the cooperation of Beech Aircraft Corporation and Dr. Brent Silver, Aviation Consultant.

Information from the above data sources was combined to determine the accident summary data found in Table 6-5. The table presents data for three categories: 1) All accidents; 2) Fatal accidents; and 3) In-flight airframe failures. Information on a number of the in-flight airframe failure accidents is incomplete with regard to fatalities and other accident specifics. Also note that, in the summary data for all accidents and fatal accidents, there is no data shown for the period 1952 through 1958 since data for this period was incomplete.

For each of the 234 V-tail accidents identified as a fatal in-flight airframe failure, a summary sheet was developed. The available information about the accident from the various sources mentioned above was combined to provide data about the aircraft, pilot, and weather conditions at the time of the accident. A narrative of the accident is included as well as probable causes and contributing factors. A typical accident summary is shown in Figure 6-1 and the entire set is included in Volume II. These summary sheets constitute the accident scenarios used to search for common factors that may have contributed to the structural failure as discussed in Section 6.5. The data base represented by the 234 summary sheets was also used for analysis of FIFAF accidents in the next two sections.

6.3 V-TAIL BONANZA FIFAF ACCIDENT RECORD

This section presents the results of a detailed examination of the available accident data related to the Beechcraft Model 35 V-tail Bonanza from 1947 through 1984. Comparison of V-tail accident histories with other general aviation aircraft was covered in the Section 6.1 using results of prior studies.

Using the V-tail accident data base, the FIFAF accidents for the Model 35 Bonanza were sorted by model and by year of occurrence. The results are given in matrix form in Table 6-6. The original 35 stands out with four times as many accidents as any other model. The original 35 also was produced in larger numbers and has been in existence longer than any other of the V-tail models. It is essential to compare on the basis of accident rates rather than total accidents.

There are numerous ways of calculating and presenting accident statistics. The subsequent discussion presents some variations on the V-tail FIFAF accident data as a function of year.

Most accident studies use accident rates based on exposure in terms of flight hours to facilitate comparison of different airplanes. Flight hours for the Model 35 are given in Table 6-7 for the years that they were available. Since 1977, flight hours have been estimated by a sampling procedure and are published annually in a "General Aviation Activity and Avionics Survey Report"[86] The data provided in Table 6-7 from 1977 to 1983 is from this source. Earlier data, from various accident studies is not complete and is not reproduced here. The available data from

Reference 90 was not broken down by V-tail sub-model, so the total V-tail flight hours are presented.

Unfortunately, the flight time data is not complete and appears to be somewhat erratic. The average annual V-tail flight time for the seven years from 1977 through 1983 is 132.8 hours and it has a standard deviation of 21.3 hours or 16 percent. The number of active airplanes can be established quite precisely, while the flight hours are based on sampling and even the samples are subject to the limitation of reporting accuracy.

To meet the objectives of this study, the number of active registered airplanes will be used to establish accident rates for comparison. Like flight hour history, the annual registration information was not broken down for various models of V-tail Bonanza for some years. However in this case, the missing data can be estimated with reasonable confidence, because the total registration for V-tail Bonanzas is known for each year and the number of each model manufactured by Beech is known exactly.

TABLE 6-5 MODEL "35" ACCIDENT DATA SUMMARY

YEAR	ALL ACCIDENTS	FATAL ACCIDENTS	FATAL AIRFRAME ACCIDENTS	CUMULATIVE AIRFRAME ACCIDENTS	YEAR	ALL ACCIDENTS	FATAL ACCIDENTS	FATAL AIRFRAME ACCIDENTS	CUMULATIVE AIRFRAME ACCIDENTS
1947	59	14	4	4	1966	309	35	10	128
1948	105	20	5	9	1967	325	42	8	136
1949	106	19	5	14	1968	204	45	7	143
1950	127	29	11	25	1969	163	46	4	147
1951	82	14	6	31	1970	155	36	3	150
1952			4	35	1971	145	32	6	156
1953			10	45	1972	129	35	3	159
1954			3	48	1973	152	53	10	169
1955			7	55	1974	139	41	13	182
1956			7	62	1975	122	36	11	193
1957			7	69	1976	103	27	3	196
1958			3	72	1977	86	34	9	205
1959	263	29	6	78	1978	288	44	8	213
1960	251	25	8	86	1979	331	20	3	216
1961	268	19	5	91	1980	332	22	5	221
1962	276	17	10	101	1981	215	24	4	225
1963	106	22	4	105	1982	164	23	2	227
1964	284	29	2	107	1983	131	25	2	229
1965	303	47	11	118	1984	43	11	5	234
----	----	----	----	----	TOTAL	5766	915	234	234

reports were obtained for all airframe failure accidents from 1977 to the present. The complete accident reports for accidents prior to 1977 have been destroyed by NTSB.

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Reference 90 was not broken down by V-tail sub-model, so the total V-tail flight hours are presented.

Unfortunately, the flight time data is not complete and appears to be somewhat erratic. The average annual V-tail flight time for the seven years from 1977 through 1983 is 132.8 hours and it has a standard deviation of 21.3 hours or 16 percent. The number of active airplanes can be established quite precisely, while the flight hours are based on sampling and even the samples are subject to the limitation of reporting accuracy.

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1948	105	20	5	9	1967	325	42	8	136
1949	106	19	5	14	1968	204	45	7	143
1950	127	29	11	25	1969	163	46	4	147
1951	82	14	6	31	1970	155	36	3	150
1952			4	35	1971	145	32	6	156
1953			10	45	1972	129	35	3	159
1954			3	48	1973	152	53	10	169
1955			7	55	1974	139	41	13	182
1956			7	62	1975	122	36	11	193
1957			7	69	1976	103	27	3	196
1958			3	72	1977	86	34	9	205
1959	263	29	6	78	1978	288	44	8	213
1960	251	25	8	86	1979	331	20	3	216
1961	268	19	5	91	1980	332	22	5	221
1962	276	17	10	101	1981	215	24	4	225
1963	106	22	4	105	1982	164	23	2	227
1964	284	29	2	107	1983	131	25	2	229
1965	303	47	11	118	1984	43	11	5	234
----	----	----	----	----	TOTAL	5766	915	234	234