

6.4 ACCIDENT RECORD FOR MODELS 33 AND 36

The preceding discussion has focused on the V-tail and its sub-model accident history. In order to answer the question as to how the V-tail accident statistics compare to other similar aircraft, the V-tail data was compared to that for the conventional tail version of the same airplanes, the Model 33 and the Model 36. In terms of FIFAF accidents, the V-tail models built after 1960 had 57 while the Model 33, which was introduced in 1969, had only one. The V-tail models built after 1968 had 13 FIFAF accidents while the Model 36 had only two. It is also of interest to look at accidents other than those involving structural failure to see if the exaggerated difference still exists. The comparisons with the Model 33 were made for the 1960 to 1984 time period and for the V-tail those sub-models produced prior to 1960 were excluded. Similarly, comparison with the Model 36 was made for the period 1968 to 1984.

Summaries of the accident data for the V-tail and Model 33 are displayed in Table 6-11. The cumulative accident rates, as defined in Equation 6-1, are used to compare the records with bar charts in Figure 6-9. This graph clearly shows that the V-tail's overall accident rate and fatal accident rate as well as the FIFAF accident rate are significantly greater than for the Model 33. After 25 years, the V-tail Bonanza with 19 accidents per 1000 aircraft years of exposure had a rate seven times as high as the Model 33 which had a rate of 2.8 accidents per 1000 aircraft years.

The comparison of fatal accidents is made for all fatal accidents other than the FIFAF category. On this basis, the fatal accident rate comparison is similar, with the V-tail having a rate 6.5 times as high as the Model 33 after 25 years. The V-tail had 3.7 fatal accidents per 1000 aircraft years while the Model 33 had 0.6 fatal accidents per 1000 aircraft years.

The record of the Model 36 is not as outstanding as that for the Model 33. For accidents and fatal accidents other than airframe failures, it is very similar to that of the Model 35. The data for this comparison is presented in Table 6-12 and the accident rates for the seventeen year period are displayed on the bar graph in Figure 6-10. For this comparison, the V-tail total accident rate is 1.4 times as high as the Model 36 and the fatal accident rate excluding FIFAF accidents is the same.

6.5 CHARACTERISTICS OF V-TAIL FIFAF ACCIDENTS

The detailed accident summaries (Volume II) were examined to determine how various parameters related to the accident data base. The accidents were examined to determine the following:

- What structural component (s) failed?
- What was the pilot's experience?
- What were the weather conditions at the time of the accident?

The information available for each FIFAF accident was examined to determine

TABLE 6-11. COMPARISON OF MODELS "33" vs "35"

YEAR	MODEL "33"				MODEL "35"			
	# REG.	TOTAL ACC.	FATAL ACC.	FIFAF ACC.	# REG.	TOTAL ACC.	FATAL ACC.	FIFAF ACC.
1960	165	0	0	0	365	8	2	1
1961	325	0	0	0	603	23	1	1
1962	457	0	0	0	819	21	0	0
1963	594	0	0	0	1035	18	4	2
1964	679	8	0	0	1339	35	5	1
1965	809	6	0	0	1642	48	5	2
1966	1033	2	0	0	1922	66	6	3
1967	1145	3	0	0	2202	67	10	0
1968	1145	3	1	0	2402	57	10	3
1969	1178	3	1	0	2603	40	15	2
1970	1103	6	0	1	2685	37	9	2
1971	1186	4	1	0	2736	41	11	2
1972	1221	5	2	0	2788	44	11	0
1973	1283	3	1	0	2839	39	10	3
1974	1324	3	0	0	2891	52	18	8
1975	1376	5	0	0	2942	42	18	6
1976	1413	3	0	0	2994	31	16	2
1977	1468	8	3	0	3045	23	11	6
1978	1557	6	2	0	3096	81	11	3
1979	1592	8	2	0	3148	101	8	1
1980	1617	6	1	0	3199	103	8	2
1981	1617	9	4	0	3251	66	6	2
1982	1637	0	0	0	3302	51	8	1
1983	1669	0	0	0	3354	46	12	1
1984	1758	0	0	0	3389	18	6	3
TOTAL		91	18	1		1158	221	57

TABLE 6-12. COMPARISON OF MODELS "36" vs "35"

YEAR	MODEL "36"				MODEL "35"			
	# REG.	TOTAL ACC.	FATAL ACC.	FIFAF ACC.	# REG.	TOTAL ACC.	FATAL ACC.	FIFAF ACC.
1968	100	1	0	0	139	2	1	1
1969	149	4	0	0	330	5	1	0
1970	171	2	1	0	526	11	4	0
1971	205	2	1	0	598	11	1	0
1972	256	4	1	0	674	8	4	0
1973	338	2	0	0	785	13	2	1
1974	463	5	1	0	896	9	4	2
1975	589	8	4	0	985	16	5	2
1976	720	7	3	0	1079	7	5	0
1977	858	7	2	0	1144	10	3	2
1978	1089	11	3	0	1257	33	2	0
1979	1265	23	3	1	1330	40	6	1
1980	1473	18	5	0	1356	32	1	0
1981	1670	18	6	1	1373	32	3	0
1982	1757	18	4	0	1370	22	5	1
1983	1848	25	10	0	1387	16	6	1
1984	2114	19	8	0	1446	7	2	2
TOTAL	----	174	52	2	----	274	55	13

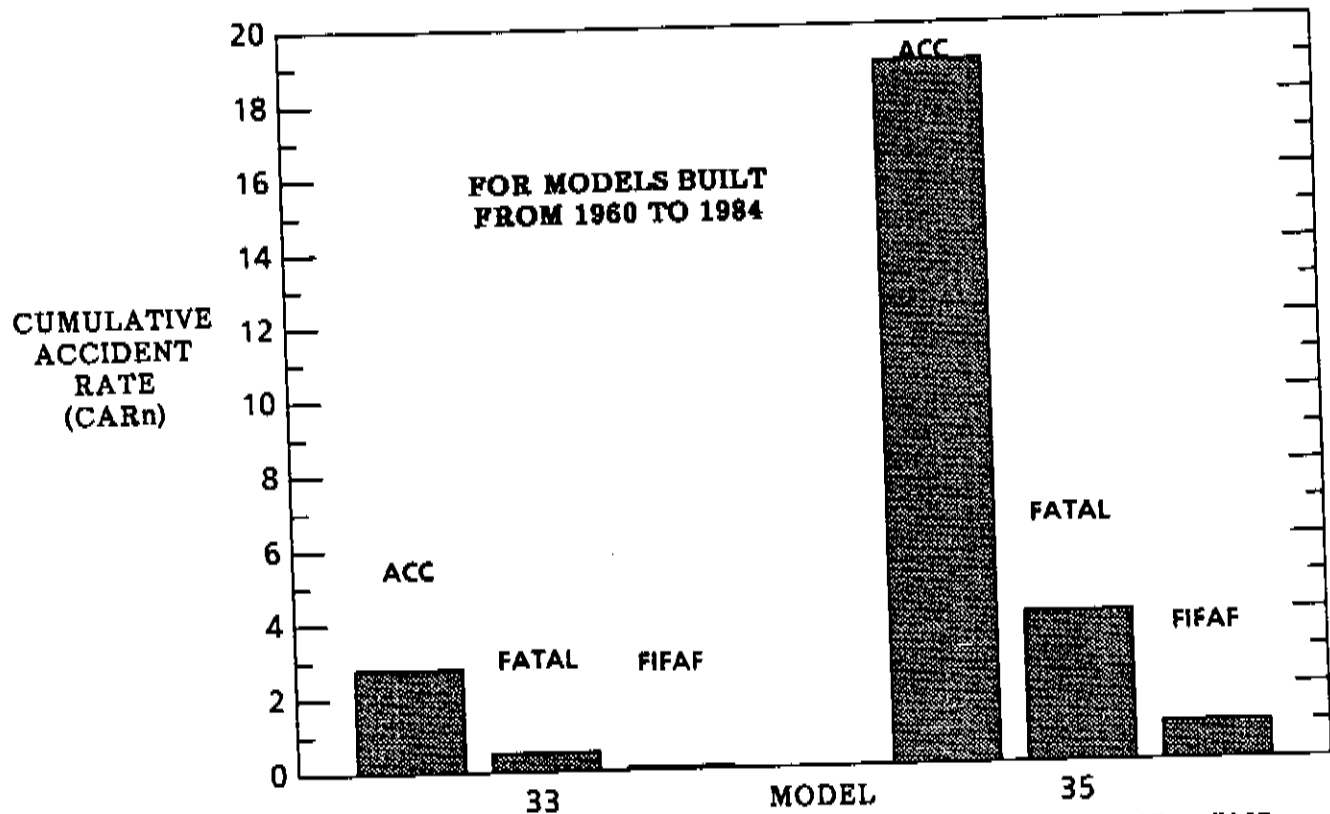


FIGURE 6-9. ACCIDENT RATE COMPARISON: MODEL "33" vs "35"

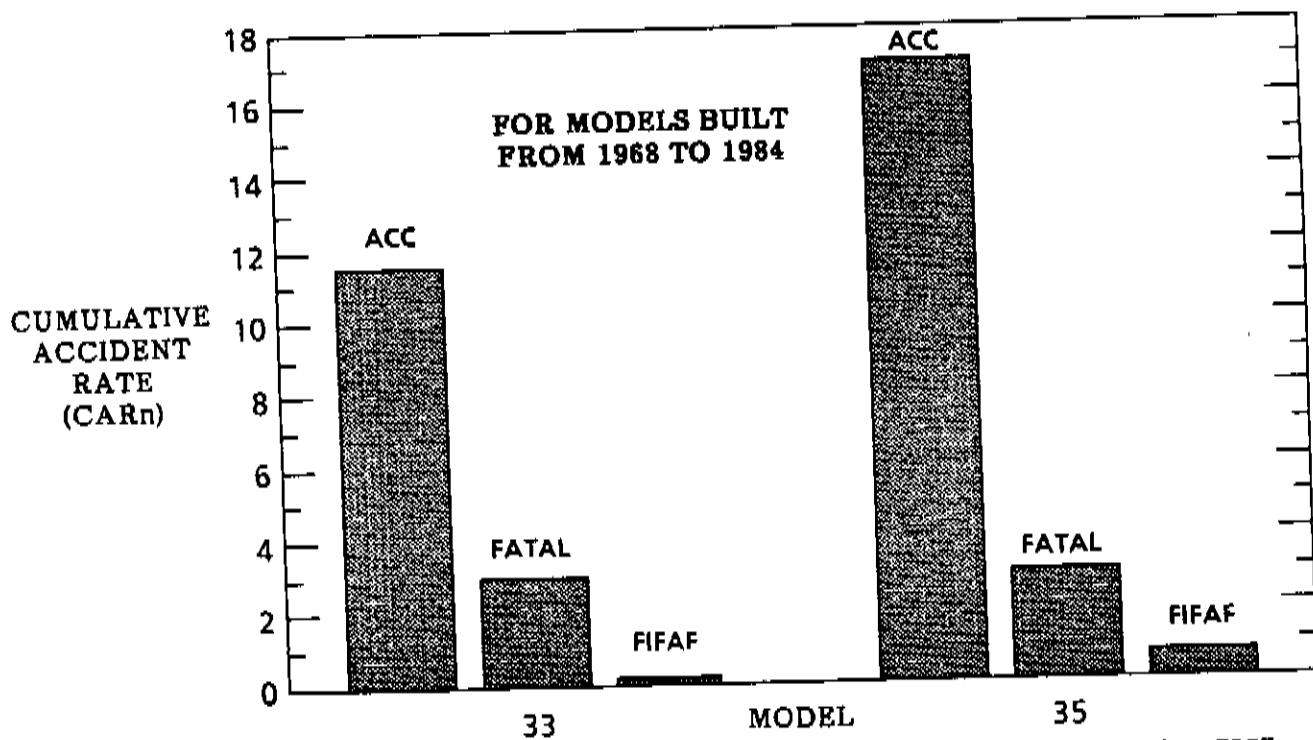


FIGURE 6-10. ACCIDENT RATE COMPARISON: MODEL "36" vs "35"

what structural components were known to have failed. Although some accident accounts indicated that a wing or tail failed first, more often than not several structural components were noted as having failed but the order of failure was not known. In some instances the failure was listed as "unknown" and in others it was listed as "general disintegration". In Table 6-13 the structural failures for all 234 FIFAF accidents are listed. If an accident report indicated that two or more components failed, then both appear in the table. For those accidents in which the structural failure was to a single component this too was noted in the table. Failure of one or both wings occurred in 169 of the 234 accidents considered. In addition, wing failure was noted as the only structural failure in 95 of the accidents. Tail or empennage failures ranked second among failures and was cited in 86 accidents. However, tail failures were the sole failure in only 13 of these accidents.

Pilot age and experience were also examined and the results are found in Figure 6-11 and Table 6-14. The distribution of accidents relative to the pilot's age is basically bell shaped with the 36-40 and 46-50 categories highest with 30 accidents each. Eighty-eight of the FIFAF accidents are distributed in the age bracket from 36-50, and only thirty of the pilots were older than fifty. The average age of the pilots for the 167 accidents in which information was available was 42. Experience of the pilots (both total and in-type flight hours) was examined and the results are also shown in Table 6-14. Only 17.2 percent of the pilots had less than 250 total flight hours and over 54 percent had more than 500. FIFAF accidents cost the lives of 14 pilots with experience in excess of 5000 flight hours. In-type experience is significantly different with 75.3 percent of all FIFAF accidents involved pilots with less than 250 hours of experience with the V-tail. Another 10.3 percent of the accidents involved pilots with 251 to 500 hours of experience and the remaining 14.4 percent of the accidents happened with pilots who had between 501 to 3000 hours of experience in-type.

Weather definitely appears to be a factor in most of the accidents recorded. A majority of the accidents originated in overcast weather with visual flight rules in effect. Typically, the pilot encountered adverse weather somewhere during flight. Frequently the weather had been forecast, but in a number of cases the thunderstorm or severe turbulence was not expected. In some cases however, the pilot had neglected to obtain weather forecasts before take-off or had not availed himself of updates during flight. In addition, a few accident reports indicate that the pilot ignored forecasts of severe weather and negligently flew his plane into adverse weather.

TABLE 6-13. FIFAF STRUCTURAL FAILURE SUMMARY

STRUCTURAL FAILURE CLASSIFICATION	FAILED COMPONENT(S)	NUMBER OF ACCIDENTS	# OF ACCIDENTS MOST LIKELY FIRST FAILURE
General Disintegration	Unknown	19	---
Component Failure	Fuselage	3	2
	Wing(s)	169	101
	Empennage	86	17
Unknown		23	---

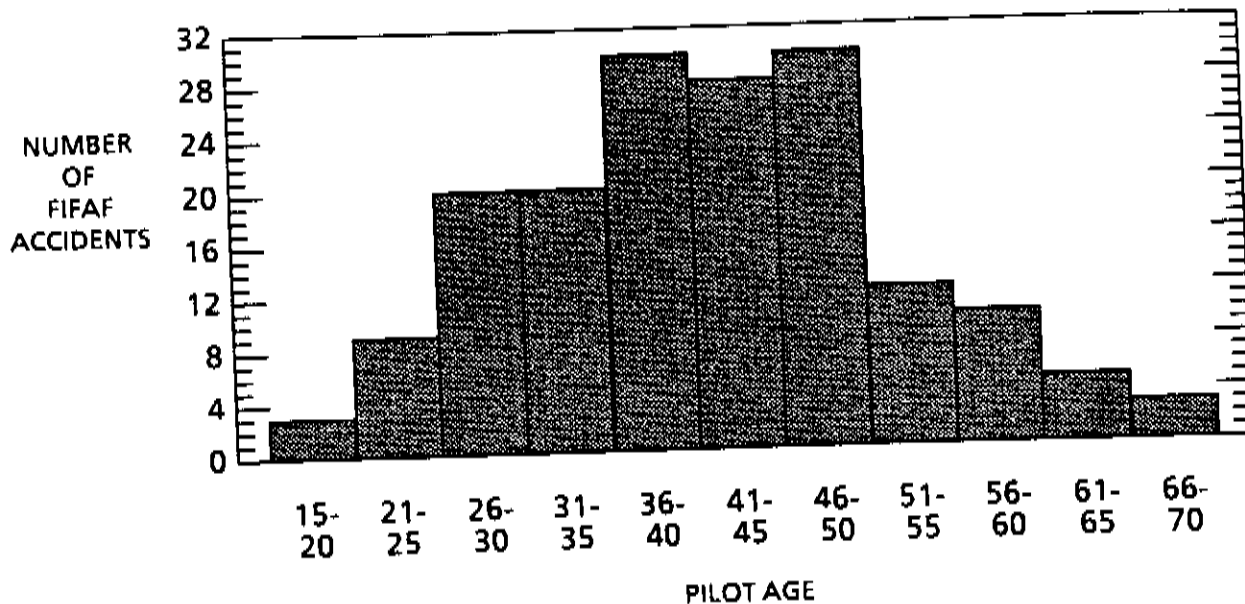


FIGURE 6-11. FIFAF ACCIDENT DISTRIBUTION BY PILOT AGE

TABLE 6-14. SUMMARY OF FLIGHT EXPERIENCE

HOURS OF EXPERIENCE	PERCENTAGE OF FIFAF ACCIDENTS	
	TOTAL FLIGHT EXPERIENCE	IN-TYPE FLIGHT EXPERIENCE
>250		
<50		35.4
51-100		16.6
101-150		12.5
151-200		6.4
201-250		4.4
TOTAL	17.2	75.3
251-500		
251-300		4.8
301-350		1.4
351-400		1.4
401-450		2.0
451-500		0.7
TOTAL	28.5	10.3
501-10000		
501-750	13.3	4.2
751-1000	8.1	2.7
1001-2000	8.1	6.1
2001-3000	11.1	1.4
3001-4000	3.6	0
4001-5000	3.0	0
5001-10000	4.6	0
TOTAL	52.8	14.4
>10000	2.5	0

7.0 RISK FACTORS FOR IN-FLIGHT AIRFRAME FAILURES

This study has focused on one airplane with 38 years of flying history. In particular, the study was directed toward one type of accident: those that involved in-flight airframe failure. Using previous studies that considered a larger group of aircraft, the task force pointed out that the V-tail Bonanza is one of several high performance single-engine airplanes that has a higher rate of in-flight structural failure than other categories of aircraft. However, the fact that there are exceptions to this higher rate (Mooney M20 and Beech 33 and 36) suggest that the rate could be reduced.

To put the issue of FIFAF accidents in perspective, it should be noted that of ten categories of fatal accidents for general aviation, it was the least likely to occur according to an NTSB study. For the V-tail however, it accounts for 25 percent of the fatal accidents. So even though the V-tail has an overall safety record that is quite good, its FIFAF accident record has resulted in some adverse publicity.

This study investigated the structural characteristics as well as the accident records for the various models of the V-tail and found a strong correlation. The original 35, which was manufactured in 1947 and 1948 has a FIFAF accident rate that is clearly higher than all of the subsequent models. It is also the only model that was certified Normal Category, and it therefore was not designed to the same structural criteria as subsequent models. If the original 35 airplane were not flown any more conservatively than its newer counterpart, the original Model 35 would be expected to have the highest FIFAF accident rate of all Model 35 Bonanzas.

The wing, designed for 3.8 g's limit or 5.7 g's ultimate, has been a frequent cause for FIFAF accidents of the original 35. The wing structural changes for certification under the Utility Category for Model A35 resulted in a significant reduction in the probability of wing failure.

The extension of the tail chord for Model C35 resulted in a nominal increase in aerodynamic loads. At the same time, torsional rigidity at higher loads became more important because of the aerodynamic center shifting forward of the front spar. The tail structure satisfied the certification requirements, but the probability of overstressing the tail is higher for the C35 than for previous models.

For subsequent changes in the tail structure (Models F, H, and S, in particular) the expectation of overstressing is reduced. The accident record reflects this expectation.

Concurrent with the Model M35 in 1960, the production of the Model 33 was initiated. The fact that it has an exceptional FIFAF record is noteworthy, since the major difference is the tail. The tail of the Model 33 is subjected to less severe conditions than the V-tail because of the following factors:

- The torsional load is less severe on the Model 33 tail which has a shorter chord.
- The Model 33 tail has slightly lower loads because of its smaller area.

- The Model 33 tail has lower loads because it does not perform the double function of vertical and horizontal controls with the same surface (the V-tail does).

These factors apparently provide enough extra margin for the Model 33 tail structure so that the probability of overstressing the tail becomes very remote.

While the difference in FIFAF accident rates for the Model 35 and Model 33 is greater than would be expected, some difference is not surprising. Investigation of other types of accidents was not within the scope of this study, but the differences in rates for other categories of fatal accidents (other than FIFAF accidents) and all accidents were surprisingly high.

In the FIFAF accident category the Model 36 is remarkably safe and comparable to the Model 33. Intuition is further confounded with the Model 36 accident record when compared to that of the Model 35 for all accidents and other fatal accidents. In these categories the Model 36 and Model 35 are not significantly different.

Because of the limited information available from FIFAF accidents leading up to and during structural breakup, it is impossible to define the dominant scenario. Whenever an airframe suffers an in-flight structural failure, it is known that the flight loads exceeded the strength of the airframe. The overload condition leading to failure is commonly attributed to pilot error. In the judgment of the task force, the correlation between structural margin and FIFAF accident rate in the Model 35 series reflects overload type failures, but pilot error is only one of several possible sources.

The following discussion summarizes the task force's understanding of the risk factors involved, in the light of the Bonanza assessment. Most of the factors apply to other airplanes besides the Bonanza and have the same potential to cause or contribute to a FIFAF accident as long as a structural margin is low.

Among the contributing factors, the task force considers spiral divergence to be the most prevalent. In these cases, pilot error is a contributing factor. The majority of the V-tail Bonanza FIFAF accidents involved either VFR pilots flying into IFR weather or thunderstorm encounters.

The divergent spiral situation usually begins with loss of ground reference. This loss is particularly critical to VFR pilots, who generally depend on the real horizon for attitude feedback and are not proficient with instruments. The loss also indirectly increases workload, as the pilot must begin to worry about his course of action, look for holes in the clouds, etc. Under such conditions it is natural that the first subtle indications of a spiral may escape the pilot's attention. Even instrument-rated pilots are not immune unless they are highly proficient. Once into the spiral, the airplane will accelerate, steepen its flight path angle, and increase its angle of bank while maintaining trim attitude. If the pilot is not sufficiently proficient, chances are that he or she may incorrectly assess the situation as a dive and attempt to pull up without first leveling the wings. By the time the pilot recognizes the spiral, the airplane may have accelerated close to or even beyond its design dive speed.

At this point different outcomes are possible, depending upon the specifics of the situation. If the airplane happens to have large structural margins, it can survive

a severe pullup but may still crash if the available altitude and pilot effort are not sufficient to effect the pullup. Conversely, low margins can lead to FIFAF accidents in the following ways:

- Limitation of pullup capability by low wing strength (e.g., original Model 35).
- Panic pullup attempts, imposing maneuver loads exceeding the tail strength.

A second contributing factor, also involving pilot error, is violation of the airplane's aft c.g. limit. If the airplane then happens to encounter turbulence, the disturbance and/or pilot over-correction in the situation of low longitudinal stability can place the airplane at higher positive or negative angles of attack. It is then possible to literally fly the wings (or tail) off the airplane by developing maximum aerodynamic load above maneuvering speed.

A third contributing factor is found among the airplane's flying and handling qualities. A lightly damped Dutch roll characteristic can mask the sign of spiral divergence in turbulent IFR weather. Even in VFR weather, some pilots may attempt to damp the motion out with the controls and may over-correct. In the case of the Bonanza, the Dutch roll has a flat ("tail-wagging") characteristic. Over-correction on the Bonanza may involve counter-sideslip rudder and/or combination of tail balancing load with an unchecked rudder maneuver load. Both conditions have been identified as potential FIFAF causes. The task force considers this type of situation not attributable to pilot error because it can occur within the permissible envelope on the airplanes V-n diagram, especially for airplanes with the wide chord tail.

Fourth, the execution of combined full-rudder and elevator at maneuvering speed can cause a FIFAF accident by overloading one surface of the V-tail Bonanza (all models from C35 through V35B, except H35). Ordinarily this should not be a problem because production airplanes are limited to 2/3 rudder and 2/3 elevator by pilot effort (as specified in CAM-03). However, airplanes retrofitted with dual controls maybe subject to this type of failure.

Fifth, the task force considers gust-encounters to be a contributing factor. In this case, two situations are possible when the airplane is within the permissible V-n envelope; encountering a gust during maneuvering or encountering a severe gust without warning while flying at speeds above cruise speed. Both situations come under the category of random occurrences that may or may not cause a FIFAF accident, depending on the structural strength of the tail.

The issue of reviewing certification requirements and estimating aerodynamic loads for V-tail configurations is currently being addressed by the Small Airplane Empennage FAA/Industry Loads Working Group which is chaired by Terry Barnes, FAA National Resource Specialist for Aerodynamic Loads. The working group is considering the problem reviewing certification requirements and of estimating loads on T-tail and canard configurations as well as the V-tail.