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A-4F BLUE ANGEL FLIGHT USAGE DATA - 1976

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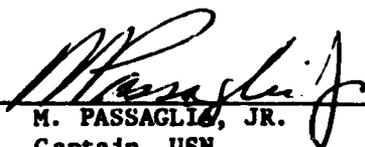
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents flight usage data which is used for monitoring individual Blue Angel aircraft structural fatigue life. Data identify operational trends that are beneficial/detrimental to prolonging aircraft fatigue life. A total of 2700.4 hours of counting accelerometer data and 363.2 hours of oscillograph data were processed and are presented. This data provides the basis for flight spectra development of Blue Angel mission utilizations as well as information concerning "point in the sky" assumptions required for fatigue analyses.		

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S U M M A R Y

The mission of the Blue Angel Flight Demonstration Squadron is to demonstrate precision techniques of Naval aviation. The flight demonstration consists of six aircraft, four "diamond" and two "solo," which perform a prescribed sequence of precise aerobatic and close formation maneuvers at low altitudes. The maneuvers performed represent tactical techniques developed in practice and actual combat. During such maneuvers, pilots and aircraft are repeatedly subjected to high magnitude positive and negative loads or "g's." This type of flight loading significantly affects aircraft fatigue life expectancy.

The Blue Angel Structural Fatigue Life Monitoring Program, AIRTASK A53530/202/78012-74-84, sponsored by the Naval Air Systems Command (AIR-530), combines flight usage data with cumulative fatigue damage theory and test results to determine the structural fatigue life expended for each aircraft. The objective of this program is to maximize operational availability of squadron aircraft without compromising structural reliability and safety of flight.

Reported herein are Blue Angel flight usage data representing 2700.4 hours of counting accelerometer reports and 363.2 hours of VGH oscillograph records collected during 1976. This data is used to generate cumulative exceedance spectra for various Blue Angel mission utilizations which have application in fatigue life calculations and the identification of extreme or excessive exceedance trends beneficial/detrimental to prolonging fatigue life. Normal acceleration, airspeed, altitude, and gross weight data presented furnish information regarding changes in "point in the sky" assumptions required for fatigue analyses.

Data presented in this report indicate:

1. Solo show is the most severe among 1976 mission utilizations (i.e., frequency of "g" counts exceeds all other type flights).
2. The diamond slot (# 4) and solo (#'s 5 and 6) aircraft show an increase (compared to 1974/5 usage) in the rate per hour of high positive "g" loads and a decrease in frequency (counts per hour) of extreme negative "g" loads.
3. The average aircraft gross weight at which maneuvers are performed decreased in 1976 (based on aircraft # 4, # 5, # 6 data) from 1974/1975.

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BACKGROUND

Since 1974, A-4F Blue Angel aircraft have been equipped with counting accelerometers and oscillograph recorders for the purpose of monitoring structural fatigue integrity (i.e., fatigue life expended) on a continuous basis. This report presents flight usage data accumulated during the 1976 calendar year and is a continuation of 1974-75 data presented in NAVAIRDEVGEN Report No. 76276-30 of 30 June 1976. Blue Angel flight maneuver data reported herein is used for individual aircraft fatigue life expended calculations and the identification of trends beneficial/detrimental to prolonging aircraft fatigue life. Included in this report are:

- a. Counting accelerometer cumulative exceedance data for each Blue Angel aircraft by serial number.
- b. Positive and negative cumulative exceedance rates for each Blue Angel mission utilization.
- c. Airspeed, altitude, and gross weight data for "point in the sky" fatigue analyses assumptions and trend monitoring.

For the purpose of this report, Blue Angel service usage is classified into eight mission utilization categories as follows:

- solo show
- solo practice
- diamond show
- diamond practice
- cross country
- checkout
- unknown
- other

The above categories completely define the Blue Angel flight syllabus. The latter two utilizations account for flights for which little or no information is available and are used primarily for classification of counting accelerometer data (i.e., "unknown" refers to unidentified flights/data from any of the other categories, while "other" refers to flights/data which do not fit any of the above categories).

INSTRUMENTATION

Appendix A contains detailed descriptions of both the counting accelerometer and oscillograph recorders. Counting accelerometer units (transducer and indicator) are installed in all A-4F Blue Angel aircraft while oscillograph systems are installed only in the two solo (#5 and #6) and diamond slot (#4) position aircraft. Table I contains the 1976 Blue Angel aircraft position history and also includes a listing of pilots. It is noted that oscillograph data was not obtained from the #5 solo position aircraft after March 1976 due to fire damage and economical considerations.

DATA PROCESSING

Counting accelerometer data are submitted monthly for each Blue Angel aircraft using the forms of Figure 1. These forms contain daily flight by flight information including flight date, duration, mission utilization, and counting accelerometer readings. Upon receipt at NAVAIRDEVCECEN, individual aircraft data are quality controlled and classified by mission utilization.

Oscillograph data are forwarded to NAVAIRDEVCECEN weekly on paper tape records and processed as described in reference (a). Computer listings of oscillograph data, compiled for each instrumented aircraft, contain sequential values of normal acceleration peak values along with simultaneous values of airspeed, altitude, and gross weight.

With each oscillograph record, the squadron forwards pilot flight reports (Figure 2) to aid in the clarification and verification of oscillograph data. These reports are completed following each flight and contain counting accelerometer readings along with other pertinent flight information. Pilot flight reports provide the link required to relate oscillograph to counting accelerometer data by individual flight and mission utilization.

DATA METHODS AND RESULTS

As indicated in Table II, 2700.4 hours of acceptable counting accelerometer data were collected in 1976. Appendix B contains the counting accelerometer cumulative exceedance history for each 1976 A-4F Blue Angel aircraft. The total 1976 counting accelerometer exceedances and flight hours for each mission utilization (all aircraft) is indicated in Table III. It is noted that "check-out," "unknown," and "other" utilizations are excluded because they are not normally scheduled missions and contain little data compared to the other utilizations. The ratio of Table III data to a 1000 hour base yields the 1976 cumulative exceedance rate per 1000 hours for each mission utilization (as shown on the last line of Table III).

Counting accelerometer data only reflects maneuver activity at the positive 5g through 8g levels. To obtain exceedance data at both positive and negative "g" load levels, 451.8 hours of oscillograph data were collected during 1976. For each oscillograph instrumented aircraft, utilization cumulative exceedances are determined by employing the following criteria:

- a. Selecting only those oscillograph flights which, via matching pilot flight reports, correspond to flights from counting accelerometer reports (thereby identifying the mission utilization of the oscillograph flight data).

b. Oscillograph flights identified from counting accelerometer reports as "checkout," "unknown," or "other" utilizations are not considered because of insignificant amounts of data in these categories.

c. Exceedance ranges of one g (i.e., 5.00 to 5.99, -1.00 to -1.99, etc.) are employed from +2.00g and above and from -1.00g and below. At zero g, an interval from -0.99g to +0.25g was used to correspond with reference (b).

Based on the above criteria, 363.2 hours of oscillograph data were selected for analysis. For each oscillograph instrumented aircraft, Table IV indicates exceedances (5g to 8g) for the selected data and the corresponding counting accelerometer exceedances. Table V contains the 1976 cumulative (positive and negative) exceedance summary and associated flight hours for each oscillograph instrumented aircraft according to mission utilization. Summation of respective utilization exceedances over all aircraft yields the total utilization exceedance summary of Table VI. The ratio of Table VI data to a 1000 hour base results in the 1976 cumulative utilization exceedance rates per 1000 hours indicated in Table VII.

Table VIII shows the utilization cumulative exceedance rates per 1000 hours for 1974 and 1975 (from reference (a)) as well as the combined 1974/1975 and 1974/1975/1976 rates.

Cumulative utilization exceedance rates per 1000 hours obtained from both counting accelerometer and oscillograph data are plotted in Figures 3 through 14. For graphical purposes, all exceedance ranges are plotted at the low range endpoint for positive exceedance ranges, at the high range endpoint for negative exceedances (i.e., plotted at 5.00 for the 5.00 to 5.99 range, plotted at -1.00 for the -1.00 to -1.99 range), and at 0.00 for the -0.99 to +0.25 range. Where plotted points do not fall on a smooth line, curves are faired. Exact points may be obtained from appropriate tables.

Figures 3 and 4 present 1976 counting accelerometer practice versus show rates for solo and diamond usage, respectively. Figures 5 through 9 present 1976 versus 1974 and 1975 counting accelerometer exceedance rates per 1000 hours for solo show, solo practice, diamond show, diamond practice, and cross country utilizations, respectively. Figures 10 through 14 present 1976 versus combined 1974/75 oscillograph exceedance rates (with counting accelerometer 5 to 8g exceedance rates also indicated) for the same above utilizations, respectively.

In addition to recording maneuver load (normal acceleration) histories, oscillograph units provide a continuous time history of aircraft airspeed and altitude. These parameters can affect the critical flight condition or "point in the sky" (airspeed and altitude at which all maneuvers are assumed to occur) assumed for full scale fatigue tests and fatigue analyses by influencing such factors as wing center of pressure, wing loading distributions, tail loads, etc. Based on the 363.2 hours of selected oscillograph data, Appendix C presents airspeed and altitude versus "g" discrete

exceedance data for the solo (BUNO'S 154984, 154986) and diamond (BUNO 154179) positions without regard to utilization (i.e., solo practice, solo show, cross country, are all included in the solo category). Altitude bands selected range from sea level to 9143.7 metres (30,000 ft.) for airspeed values ranging from 51.4 to 333.9 m/s (100 to 649 knots) in increments of 25.7 m/s (50 knots). Exceedance ranges are those which were previously used for oscillograph data. Also indicated is the average aircraft gross weight during recorded maneuvers for the altitude band indicated. Table IX presents the percentage of total discrete exceedances occurring within altitude and airspeed intervals for 1976. Table X presents similar data for the combined 1974/75 seasons from reference (a). Table XI shows a comparison of 1976 (Appendix C) versus combined 1974/1975 (reference (a)) average aircraft flight gross weight for various altitude bands.

OBSERVATIONS

Solo Show

As in 1974 and 1975, this is the most severe among all utilizations with respect to exceedance frequency. Counting accelerometer and oscillograph 1976 exceedance rates per 1000 hours between 5g and 8g are higher than those of previous years while severe negative "g" activity sharply declined (both frequency and magnitude) in 1976 from the previous year (Figures 5 and 10). The latter may have been influenced by the lack of show data from the #5 solo position aircraft after March, 1976 due to the fire mentioned previously.

Solo Practice

In 1976, this was the second most severe of all utilizations with exceedance rates between 5g and 8g higher than those of previous years (Figure 6). As with the solo show utilization, severe negative "g" activity sharply declined in 1976 from the previous year (Figure 11). Lack of solo practice (oscillograph) data after March, 1976 from the #5 solo aircraft may be responsible for the differences in solo practice counting accelerometer and oscillograph exceedance rates at the high g levels as shown in Figure 11.

Diamond Show

It is noted that oscillograph diamond rates reflect only #4 diamond slot position aircraft activity, while counting accelerometer rates represent data from all diamond aircraft. The relative severity of exceedance frequency for the diamond slot aircraft at high positive "g" levels is reflected by differences in oscillograph and counting accelerometer rates indicated in Figure 12. Oscillograph rates indicate a significant increase in 7g and 8g activity in 1976 from the previous year with a slight decrease in activity at the -1g level. Counting accelerometer rates in 1976 are consistent with those of previous years except at the 8g level, where a noticeable decrease in activity occurred (Figure 7). This decrease appears to be consistent with a progressive trend at this g level since 1974.

Diamond Practice:

Rates for this utilization in 1976 show a significant increase from previous years in 7g and 8g activity and a decrease in both magnitude and frequency of negative g exceedances, (Figures 8 and 13). Here, as previously, differences in counting accelerometer and oscillograph rates are due to differences in the number of aircraft represented by the data.

Cross Country:

Counting accelerometer rates based on data from all aircraft for this utilization in 1976 are generally consistent with those of previous years (Figure 9). Oscillograph rates in 1976 (Figure 14) show a marked decrease in negative g magnitude and frequency and a slight decrease in positive g frequency from the previous year (perhaps due to the lack of #5 solo oscillograph data after March, 1976). Differences between counting accelerometer and oscillograph rates in Figure 14 are due primarily to the large relative percentage of solo aircraft data reflected in the oscillograph rates, and the fact that solo aircraft are prone to a higher frequency of exceedances than diamond aircraft.

Counting accelerometer versus Oscillograph:

Table IV indicates both oscillograph and counting accelerometer 5g to 8g level cumulative utilization exceedances. It is noted that exceedances are grouped into pre-selected ranges at each g level (i.e., 5.00-5.99, 6.00-6.99, etc.); however, counting accelerometer g level ranges are, in reality, dependent on individual transducer calibration values. Calibration specifications require the counting accelerometer to operate within $\pm 0.1g$ at the 5.0 and 6.0g levels and within $\pm 0.15g$ at the 7.0 and 8.0g levels. Differences in the number of exceedances recorded by both oscillograph and counting accelerometer may therefore be due to differences in g level ranges (e.g., at the 5g level the oscillograph range is 5.00-5.99g, while the counting accelerometer lower range limit value may be between 4.9-5.1 with upper range limit value between 5.9-6.1). Differences between oscillograph and counting accelerometer exceedances indicated in Table IV data are considered to be consistent with the above differences in g level range thresholds.

It is noted that the maximum and minimum "g" values for each of the oscillograph instrumented aircraft (based on 363.2 hours of oscillograph data) and the utilization during which these values were recorded are as follows:

<u>BUNO</u>	<u>MAX</u>	<u>MIN</u>	<u>UTILIZATION</u>
154179	9.32	-1.84	Diamond show
154984	8.93	-3.13	Solo Practice
154986	8.84	-3.07	Solo Practice

VGH Data

Based on Appendix C oscillograph data, Tables IX, X, and XI indicate the following:

a. An increase in 1976 from previous years in both solo and diamond exceedances experienced at the high altitude range 4571.7 - 9143.7 metres (15,000 - 30,000 feet).

b. An increase in 1976 from previous years in the percent of exceedances (solo and diamond) experienced at lower airspeeds.
For example,

diamond 1974/75:	76%	<	205.6 m/s (400 knots)
diamond 1976:	93%	<	205.6 m/s (400 knots)
solo 1974/75:	71.4%	<	205.6 m/s (400 knots)
solo 1976:	77.4%	<	205.6 m/s (400 knots)

c. A decrease in 1976 from previous years of both solo and diamond average aircraft gross weights during maneuver exceedance.

CONCLUSIONS

The following are general conclusions/trends based on data contained in this report.

a. Solo show is the most severe among 1976 mission utilizations with respect to exceedance frequency.

b. In 1976, the diamond slot (#4) and both solo (#5 and #6) position aircraft are experiencing high positive g's more frequently and severe negative g's less frequently than in 1974/75.

c. Blue Angel #4, #5, and #6 position aircraft are experiencing exceedances at lower average gross weights in 1976 than in previous years.

NADC-77287-60

PILOT FLIGHT REPORT

NASC AIR TASK 10400301/NJ201 "Blue Angels" A-4F Aircraft Structure Integrity

TO THE PILOT: This aircraft is equipped with flight recorders which automatically produce a record of airspeed, altitude, and flight accelerations. This information will contribute to improvement of structural design requirements and fatigue life determination. The following information is required for proper evaluation of the recorded data. Your assistance is greatly appreciated.

DATE _____ "BLUE ANGELS"
TAKE OFF TIME _____ MODEL _____ A-4F
FLIGHT DURATION _____ A/C SER NO. _____
LOCATION _____
GROSS WEIGHT: (TAKE OFF) _____ (LANDING) _____
FUEL WEIGHT: (TAKE OFF) _____ (LANDING) _____
HIGH "G" LOAD _____
REMARKS (TYPE OF SHOW, UNUSUAL MANEUVERS, WEATHER, ETC.) _____

COUNTING ACCELEROMETER READINGS

	1	2	3	4
TAKE OFF				
LANDING				

OSCILLOGRAPH MAG. SER. NO. _____

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WARMINSTER, PA 18974

PLEASE RETURN THIS REPORT WITH OSCILLOGRAPH MAGAZINE TO NAVAIRDEVCCN (CODE 3031)

FIGURE 2. PILOT FLIGHT REPORT

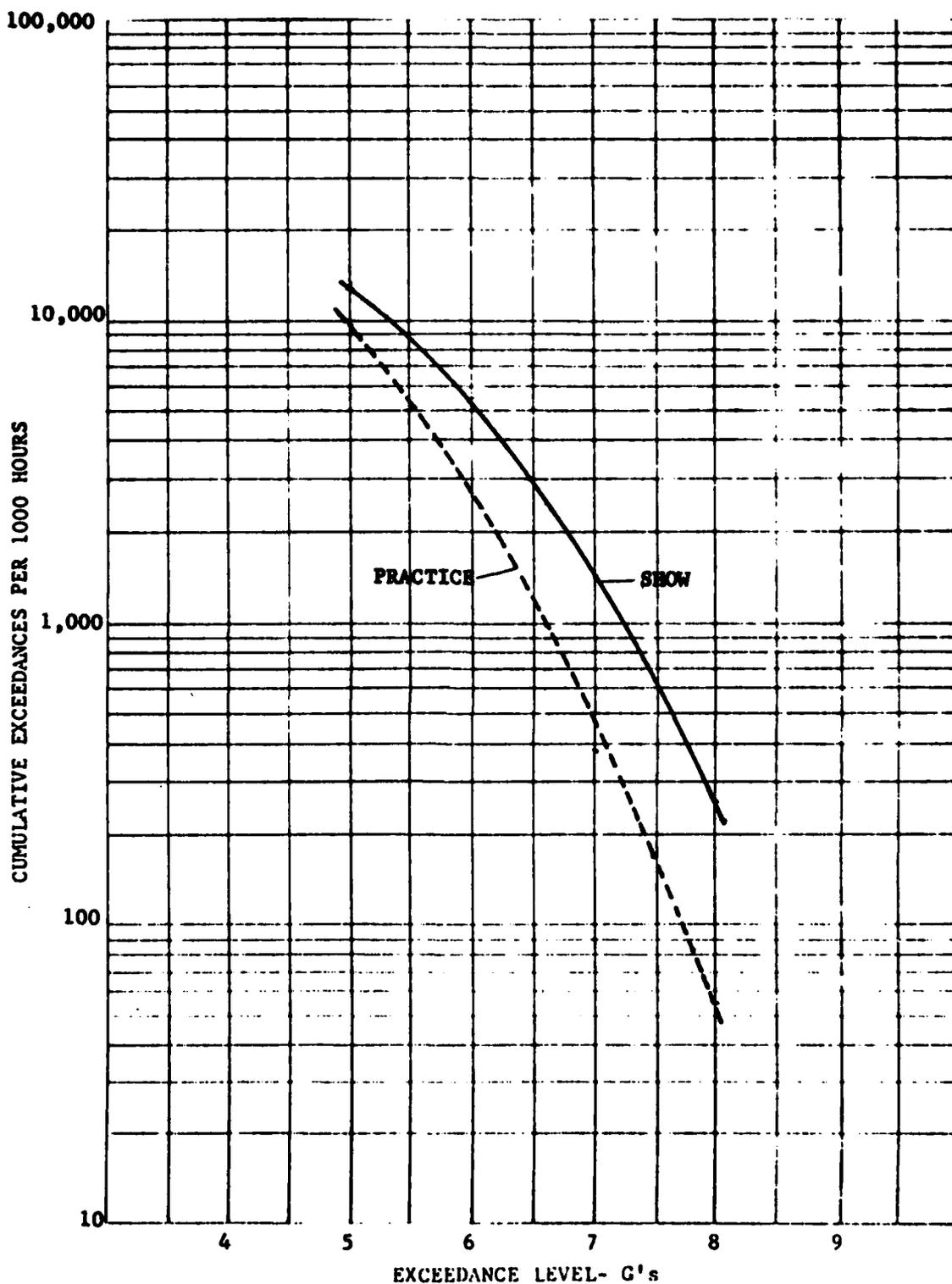


FIGURE 3. COUNTING ACCELEROMETER 1976 RATES PER 1000 HOURS - SOLO AIRCRAFT

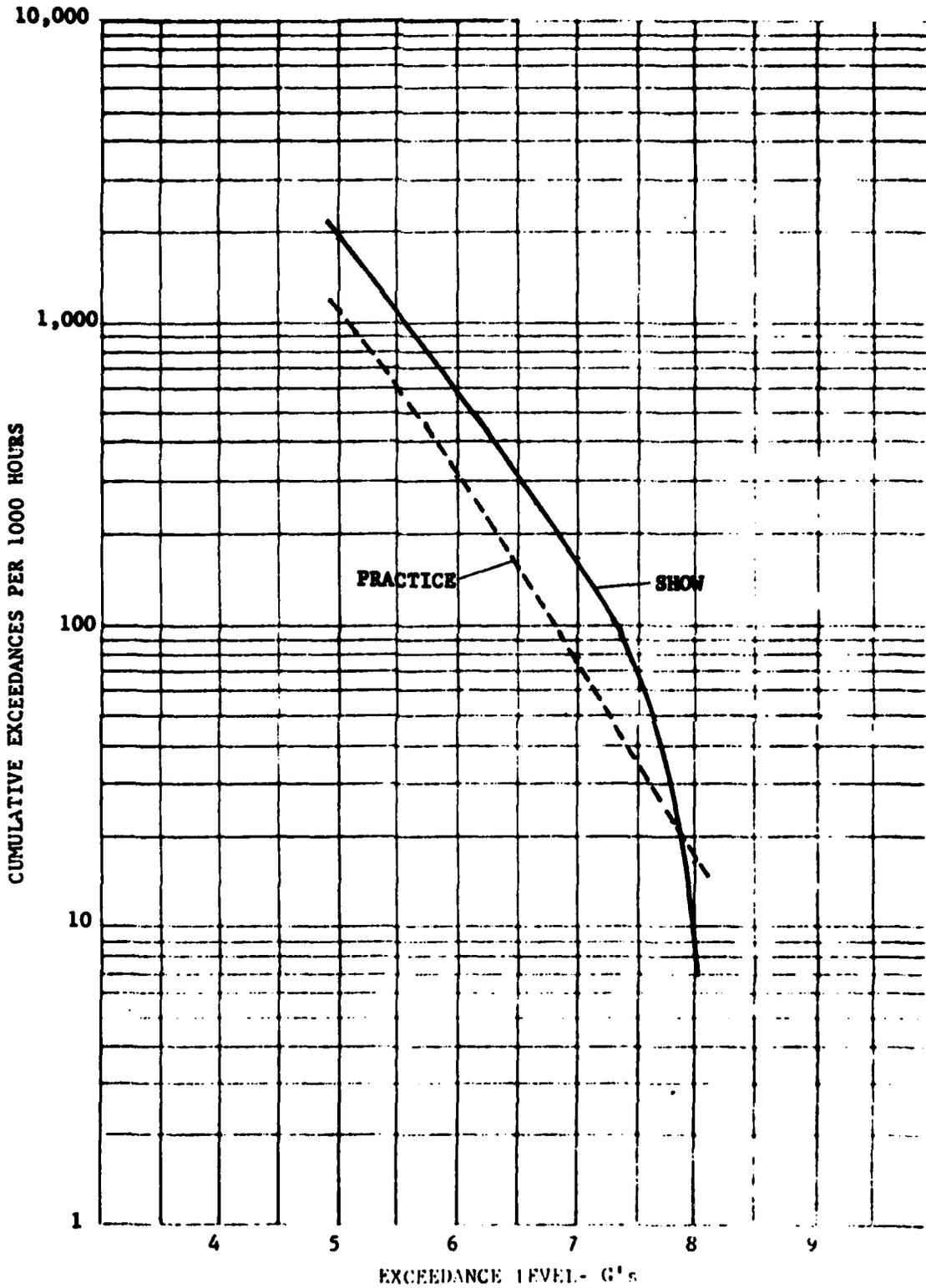


FIGURE 4. COUNTING ACCELEROMETER 1976 RATES PER 1000 HOURS - DIAMOND AIRCRAFT

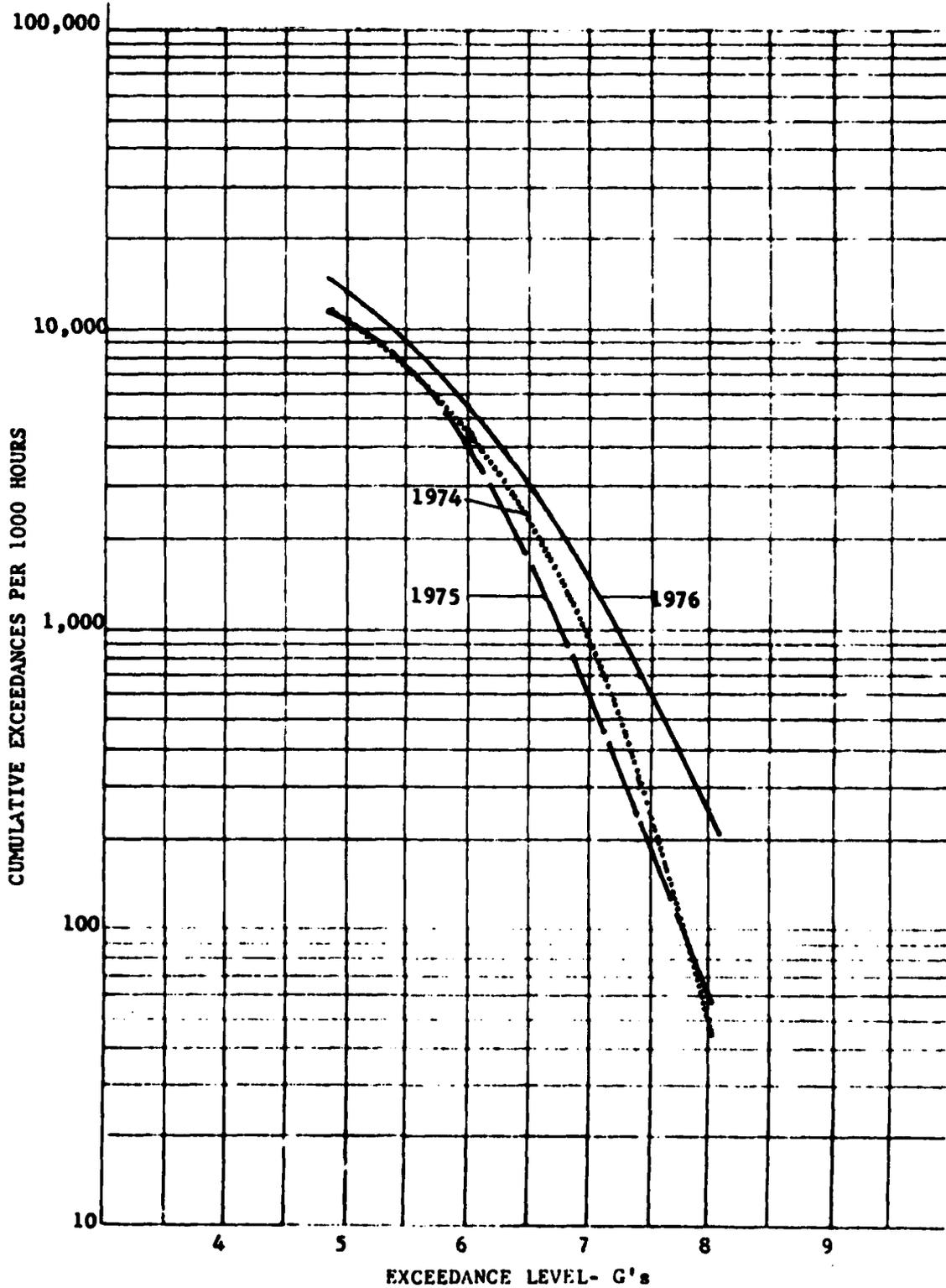


FIGURE 5. COUNTING ACCELEROMETER 1974/1975/1976 RATES PER 1000 HOURS - SOLO SHOW

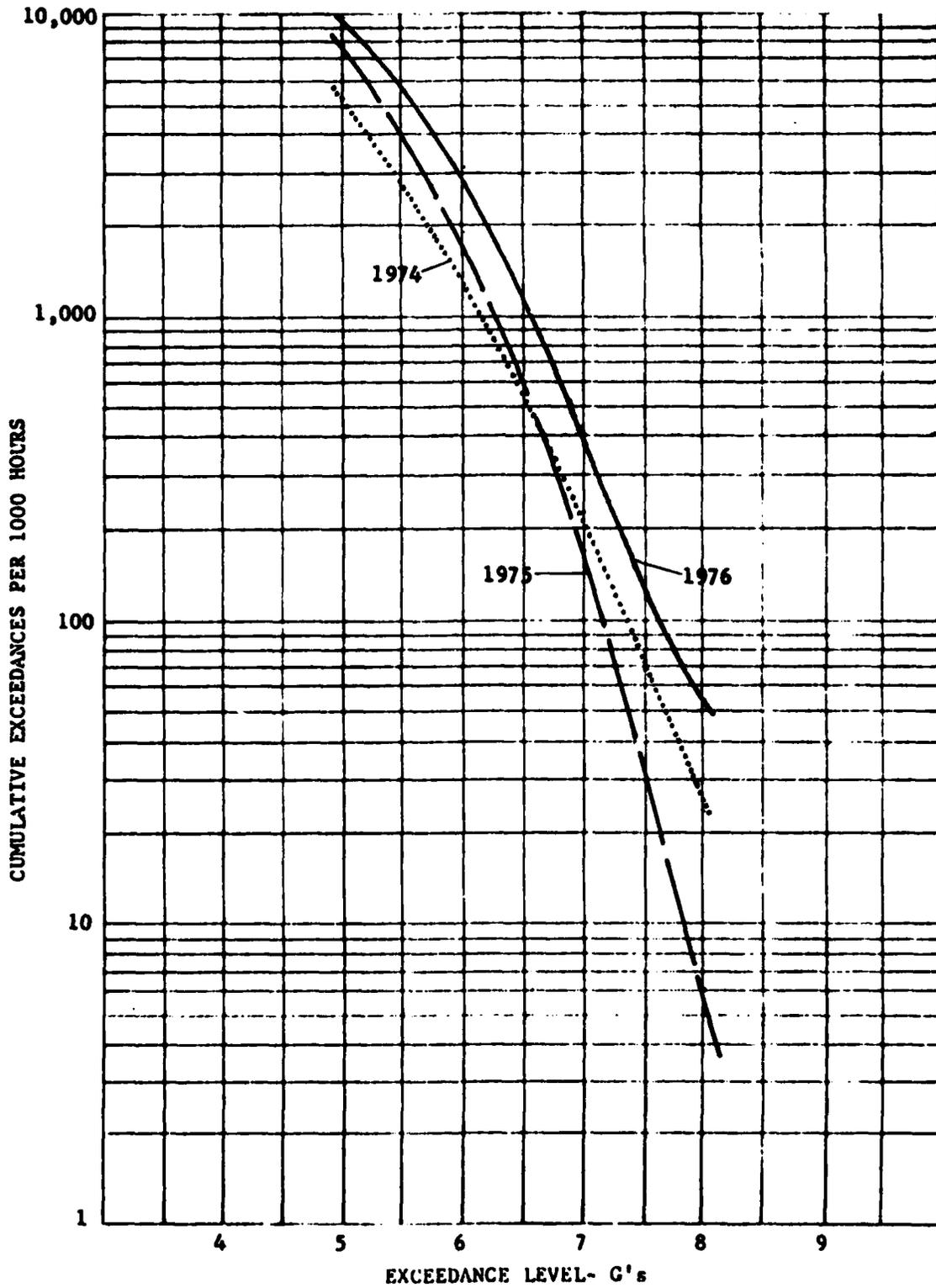


FIGURE 6. COUNTING ACCELEROMETER 1974/1975/1976 RATES PER 1000 HOURS - SOLO PRACTICE

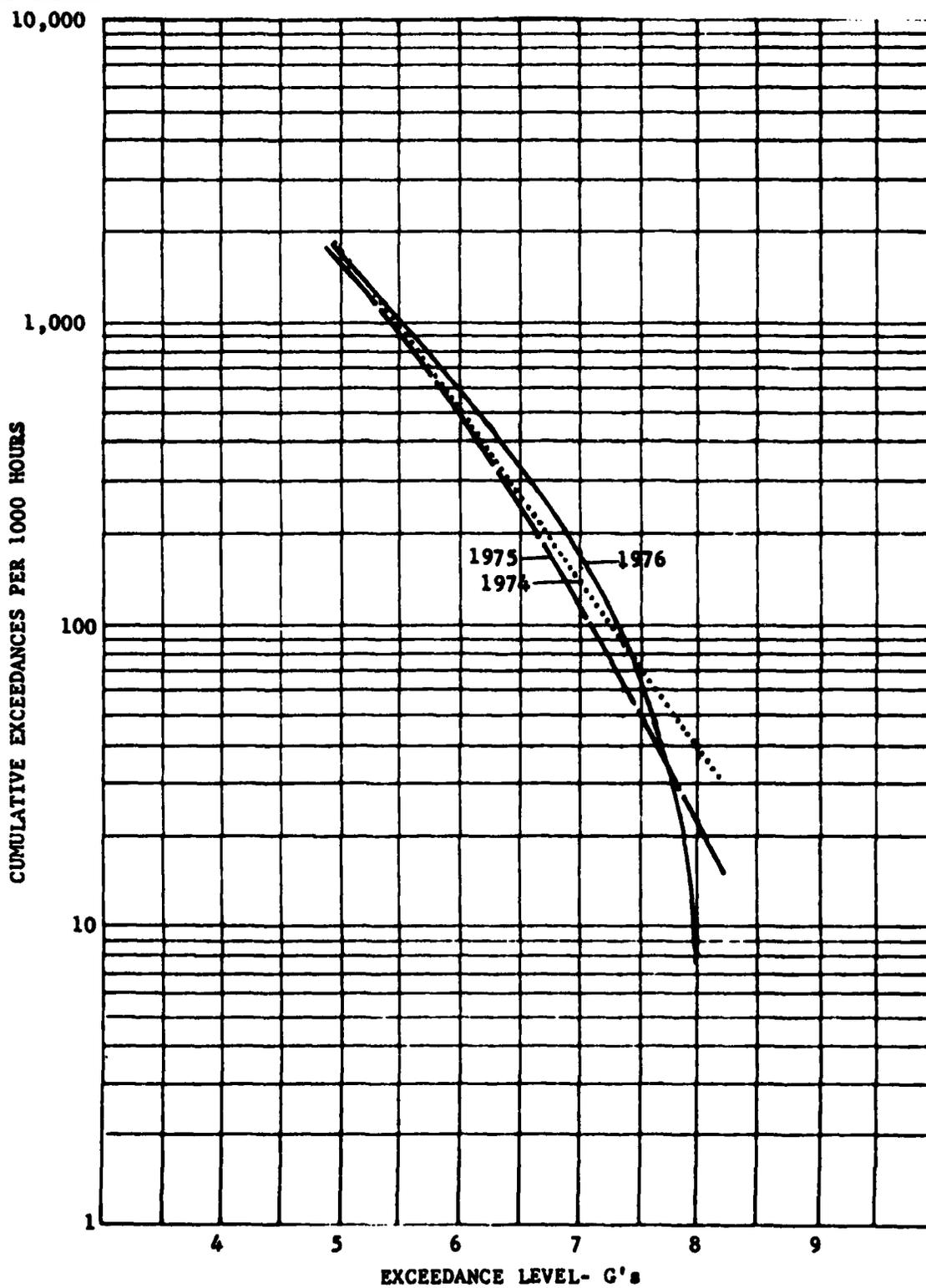


FIGURE 7. COUNTING ACCELEROMETER 1974/1975/1976 RATES PER 1000 HOURS - DIAMOND SHOW

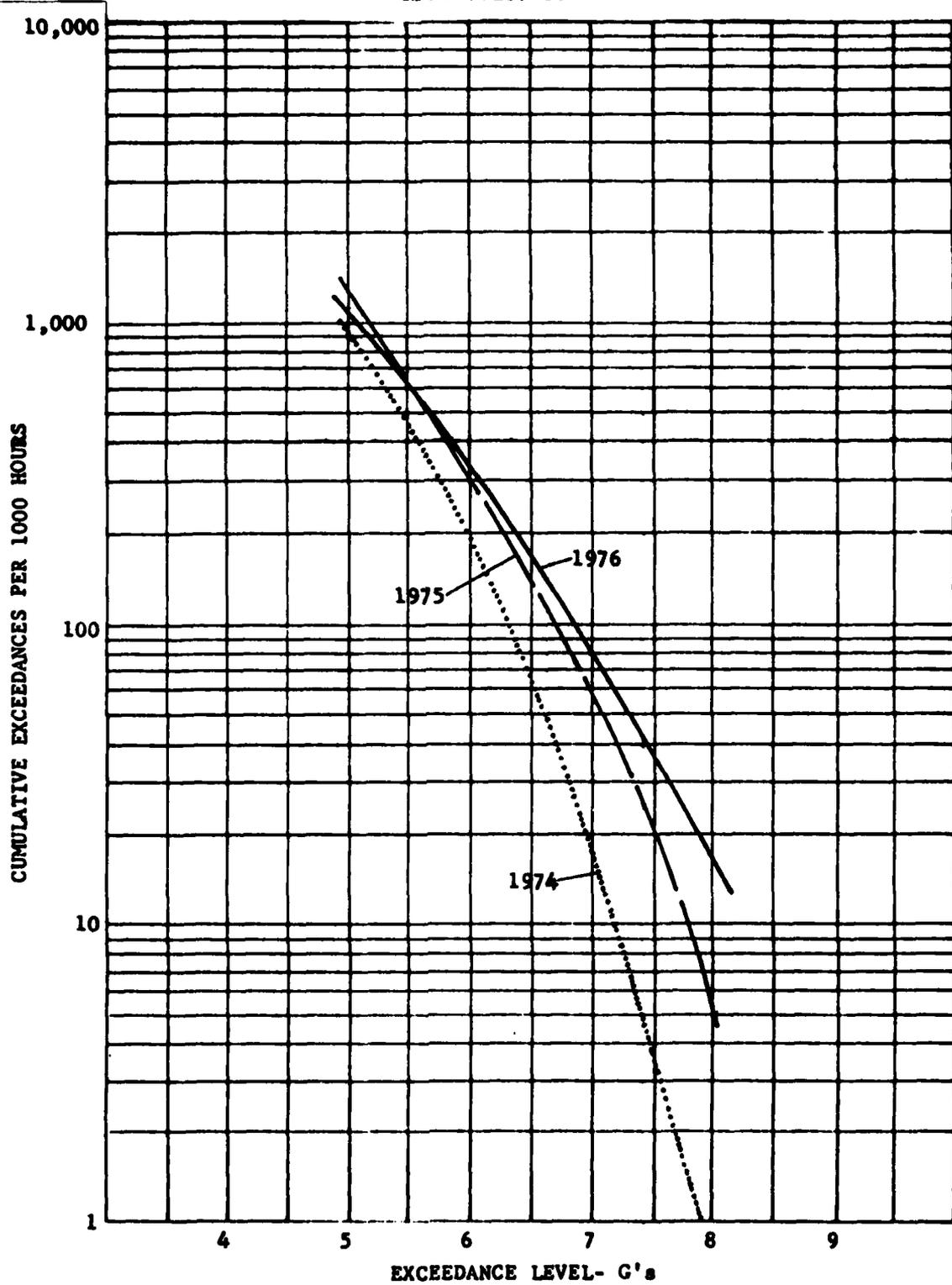


FIGURE 8. COUNTING ACCELEROMETER 1974/1975/1976 RATES PER 1000 HOURS - DIAMOND PRACTICE

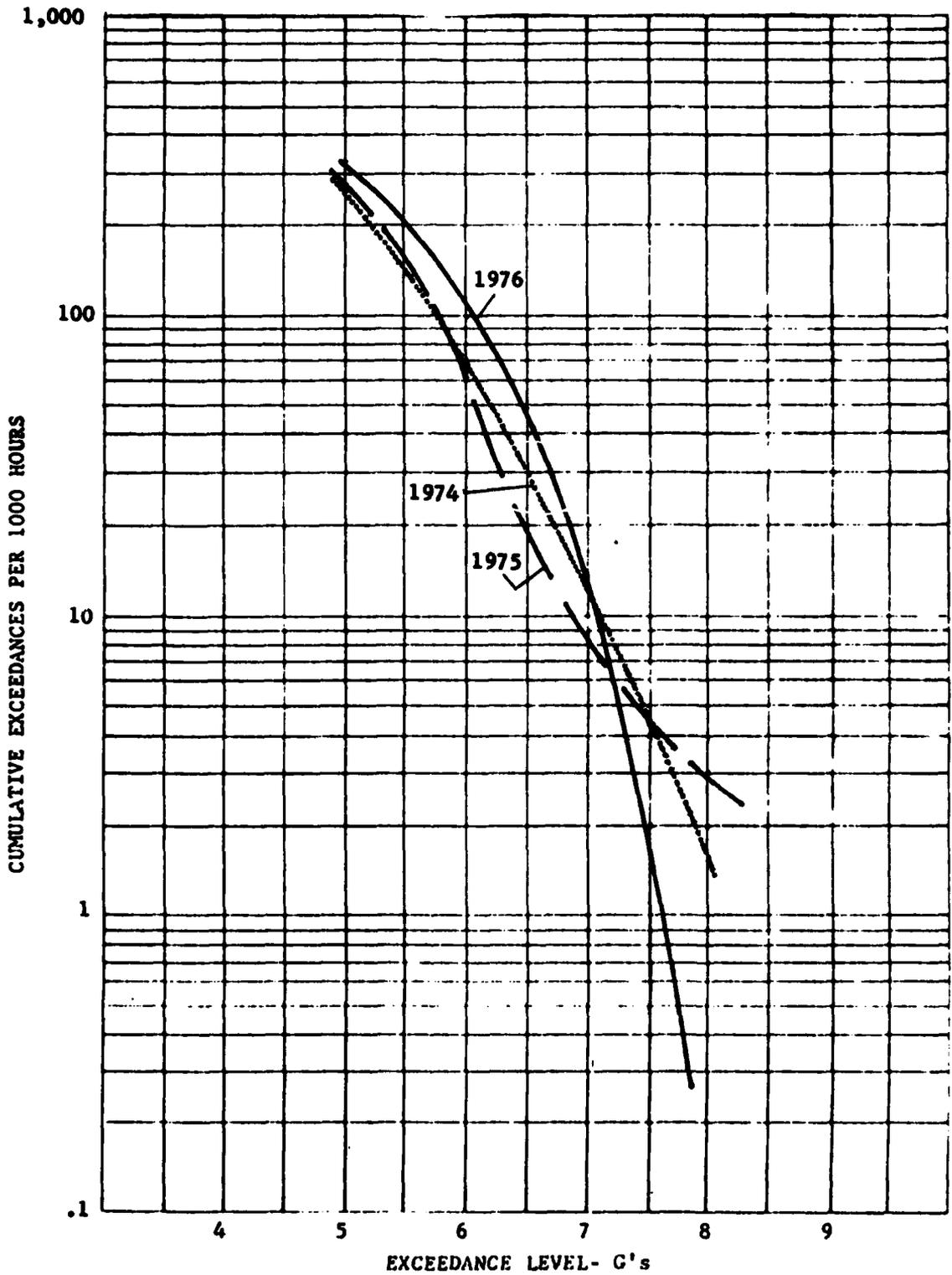


FIGURE 9. COUNTING ACCELEROMETER 1974/1975/1976 RATES PER 1000 HOURS - CROSS COUNTRY

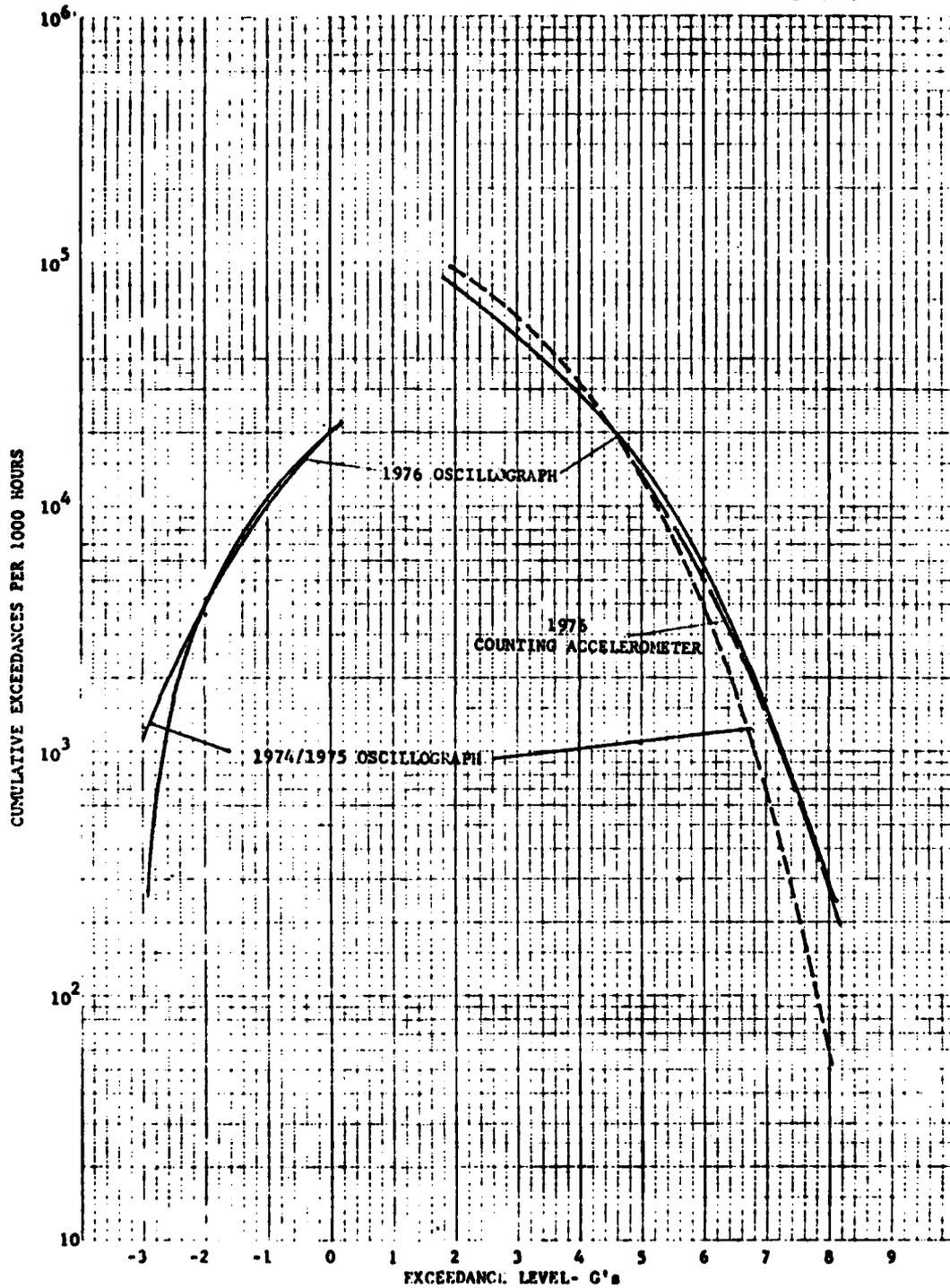


FIGURE 10. BLUE ANGEL ACCELERATION EXCEEDANCE RATES 1974/1975 vs. 1976 - OSCILLOGRAPH DATA - SOLO SHOW

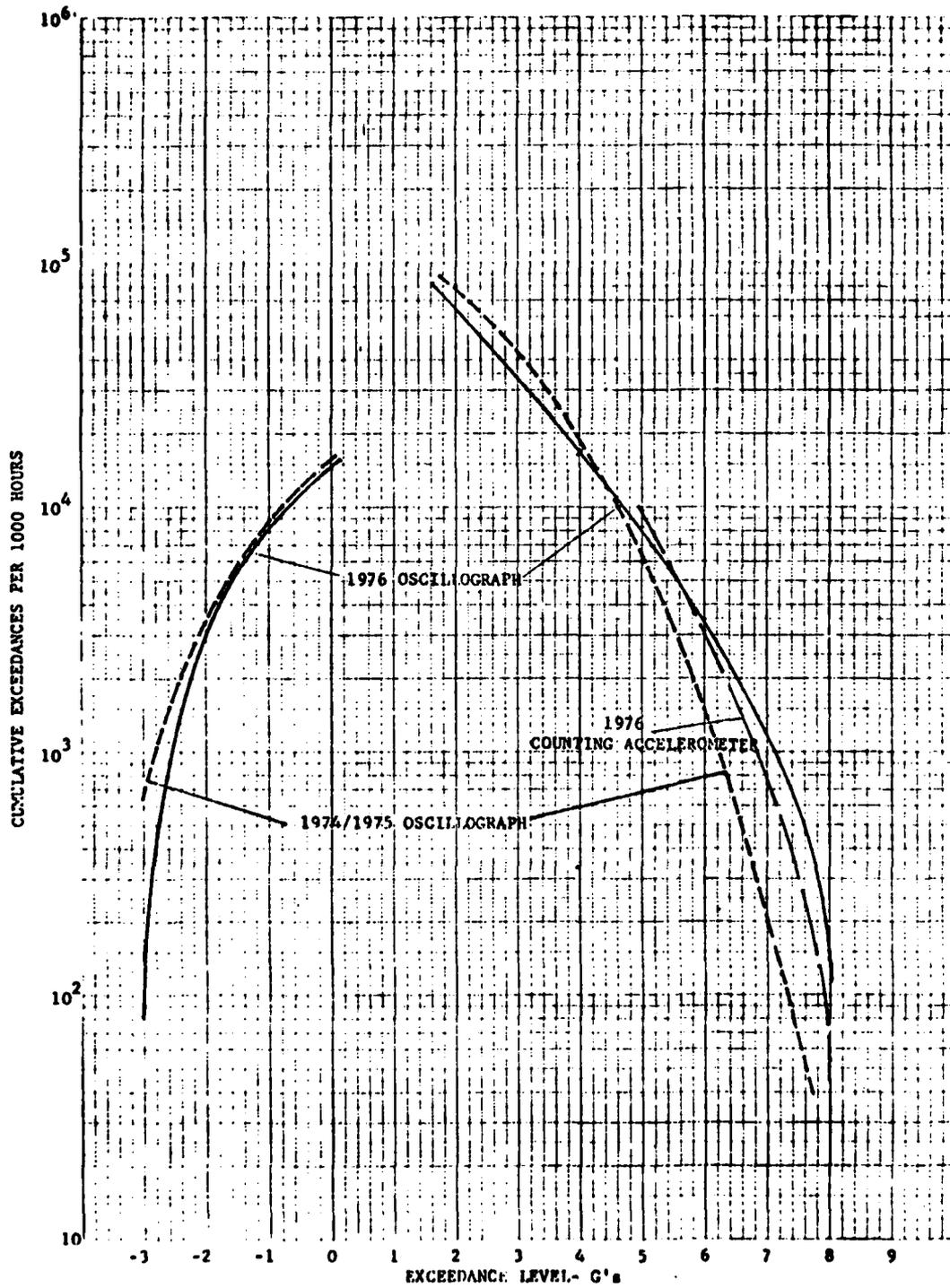


FIGURE 11. BLUE ANGEL ACCELERATION EXCEEDANCE RATES 1974/1975 vs. 1976 - OSCILLOGRAPH DATA - SOLO PRACTICE

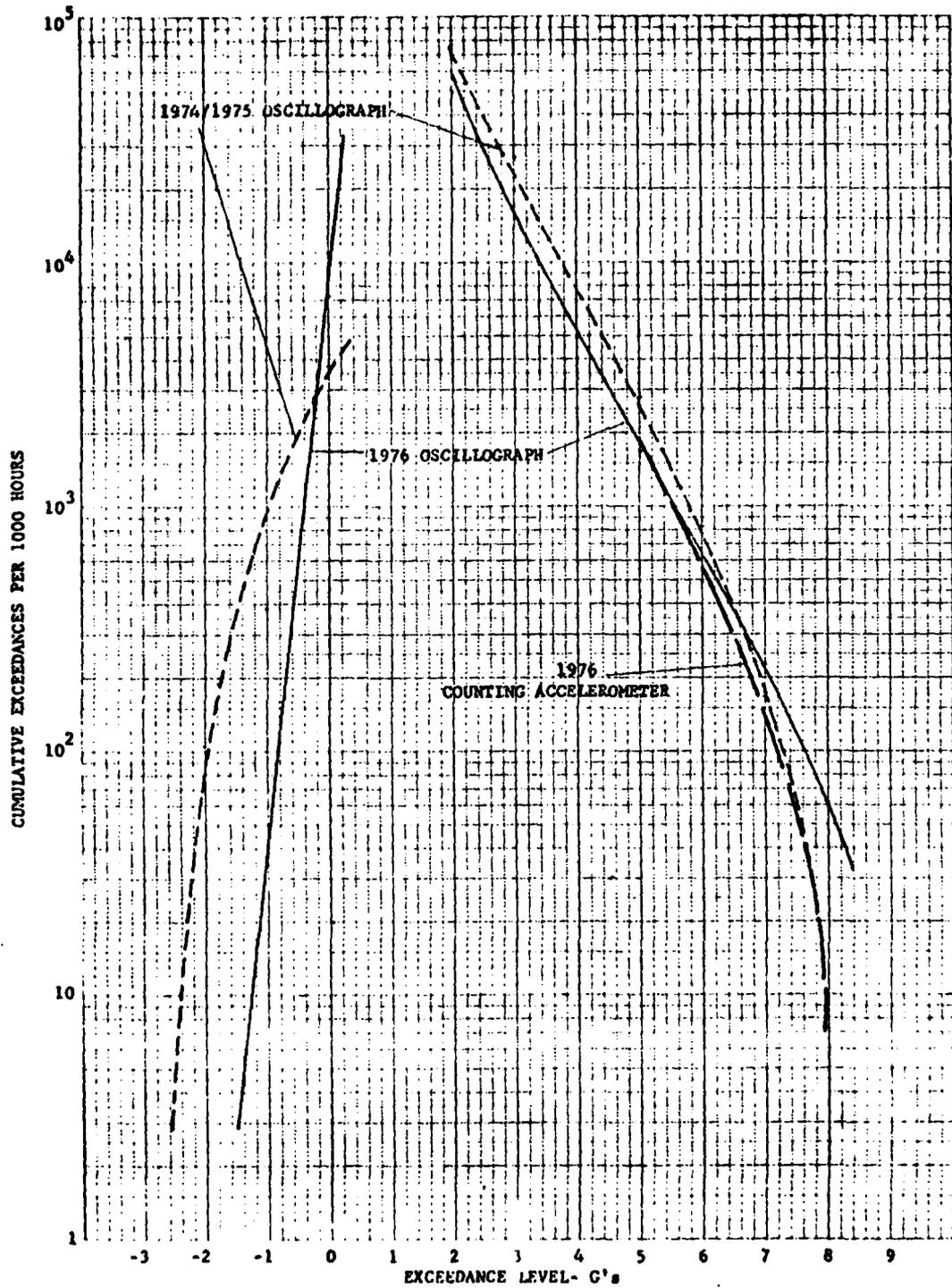


FIGURE 12. BLUE ANGEL ACCELERATION EXCEEDANCE RATES 1974/1975 vs. 1976 - OSCILLOGRAPH DATA - DIAMOND SHOW

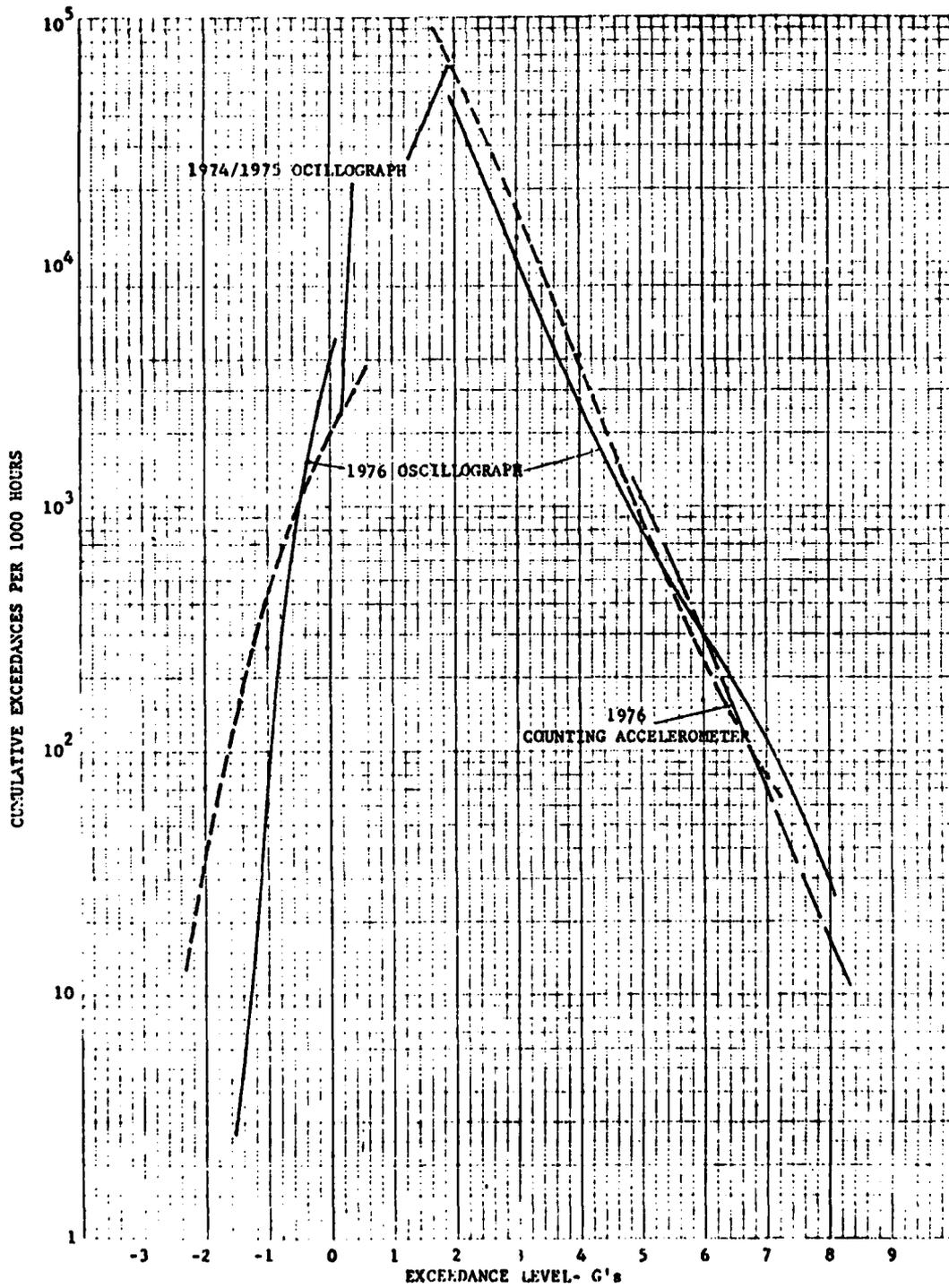


FIGURE 13. BLUE ANGEL ACCELERATION EXCEEDANCE RATES 1974/1975 vs. 1976 - OSCILLOGRAPH DATA - DIAMOND PRACTICE

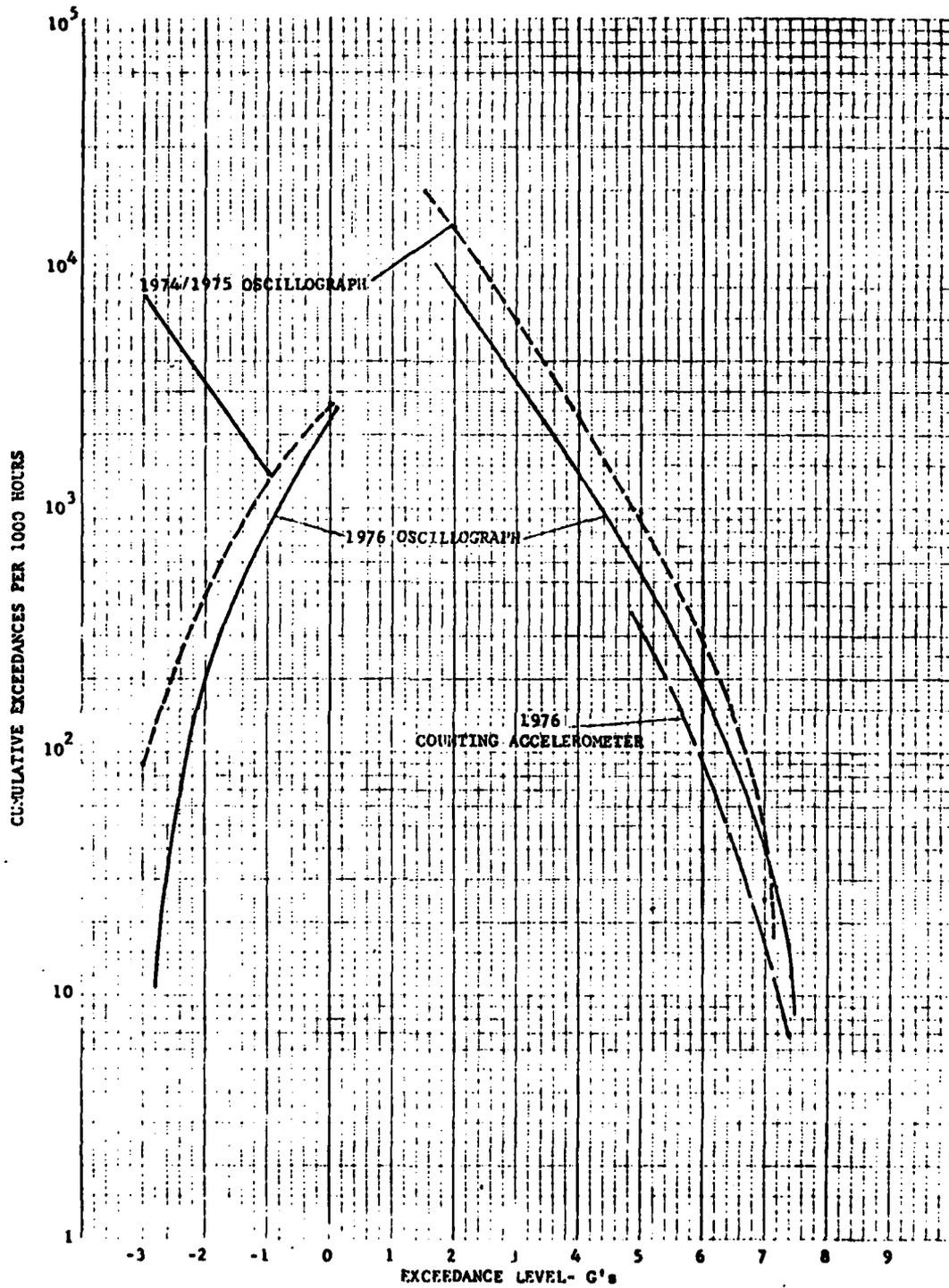


FIGURE 14. BLUE ANGEL ACCELERATION EXCEEDANCE RATES 1974/1975 vs. 1976 - OSCILLOGRAPH DATA - CROSS COUNTRY

TABLE I

BLUE ANGEL 1976 PILOTS AND AIRCRAFT POSITION HISTORY

AIRCRAFT POSITION	PILOT
1	CMDR. K. JONES
2	CAPT. W. HOLVERSTOTT
3	LT. A. CISNEROS
4	LT. J. PATTON
5	LT. D. SAPP
6	LT. J. MILLER
7 (NARRATOR)	LT. N. KRAFT

<u>AIRCRAFT SERIAL NO.</u>	J	F	M	A	M	J	J	A	S	O	N	D
154984	5	5	5	*	*	*	*	*	*	*	*	*
154983	1	1	1	1	1	1	1	1	1	1	1	-
154975	PAR	PAR	PAR	PAR	PAR	5	5	5	5	5	5	-
154986	6	6	6	6	6	6	6	6	6	6	6	-
155029	3	3	3	3	3	3	3	3	3	3	3	-
154179	4	4	4	4	4	4	4	4	4	4	4	-
154176	7	7	7	5	5	7	7	7	7	7	7	-
154177	2	2	2	2	2	2	2	2	2	2	2	-

NOTE: BUNO 154984 - FIRE 3/30/76

TABLE II
BLUE ANGEL 1976 COUNTING ACCELEROMETER DATA SUMMARY

SERIAL NUMBER	TOTAL 1976 HOURS	ACCEPTABLE 1976 COUNTING ACCELEROMETER HOURS	EXCEEDANCES			
			5	6	7	8
154984	112.5	112.5	1108	340	32	4
154983	428.7	426.4	172	8	0	0
154975	213.8	201.7	690	226	73	17
154986	412.7	412.1	3077	1136	207	29
155029	432.1	432.1	407	101	17	0
154179	450.5	448.6	440	139	32	4
154176	229.6	229.6	863	282	44	8
154177	<u>438.2</u>	<u>437.4</u>	469	177	54	7
	2718.1	2700.4				

TABLE III
COUNTING ACCELEROMETER UTILIZATION SUMMARY - 1976

SERIAL NUMBER	SOLO SHOW				SOLO PRACTICE				CROSS COUNTRY						
	ACCEPTABLE HOURS	5	6	CUMULATIVE EXCEEDANCES 7 8	ACCEPTABLE HOURS	5	6	CUMULATIVE EXCEEDANCES 7 8	ACCEPTABLE HOURS	5	6	CUMULATIVE EXCEEDANCES 7 8			
154176	13.9	177	88	13	3	530	152	15	0	60.2	41	12	2	0	
154177	0.0	0	0	0	0	4.9	15	2	0	166.7	16	7	4	0	
154179	0.0	0	0	0	0	14.8	103	38	2	164.4	18	8	2	0	
154975	42.8	395	145	48	11	42.6	232	68	23	109.5	57	12	2	0	
154983	0.0	0	0	0	0	1.2	2	0	0	168.1	8	0	0	0	
154984	4.0	52	28	6	0	92.1	1015	304	26	8.1	7	2	0	0	
154986	62.3	993	418	119	18	177.2	1931	665	82	164.8	148	52	6	0	
155029	0.0	0	0	0	0	0.0	0	0	0	162.6	31	6	0	0	
TOTALS	123.0	1617	679	186	32	390.4	3828	1229	148	21	1004.4	326	99	16	0
RATES PER 1000 HOURS		13146	5520	1512	260		9805	3148	379	54		325	99	16	0

TABLE III
COUNTING ACCELEROMETER UTILIZATION SUMMARY - 1976

SERIAL NUMBER	DIAMOND SHOW								DIAMOND PRACTICE							
	ACCEPTABLE HOURS				CUMULATIVE EXCEEDANCES				ACCEPTABLE HOURS				CUMULATIVE EXCEEDANCES			
	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
154176	0.8	0	0	0	0	0	0	0	83.8	97	25	13	5			
154177	62.4	141	53	22	1			177.1	290	111	26	6				
154179	62.3	119	41	13	1			173.8	198	51	15	3				
154975	0.0	0	0	0	0	0	0	2.5	0	0	0	0				
154983	61.7	54	3	0	0			173.3	92	5	0	0				
154984	0.0	0	0	0	0	0	0	6.3	25	5	0	0				
154986	0.0	0	0	0	0	0	0	3.6	4	1	0	0				
155029	59.9	143	44	8	0			182.4	221	49	9	0				
TOTALS	247.1	457	141	43	2			802.8	927	247	63	14				
RATES PER 1000 HOURS		1849	571	174	8				1155	308	78	17				

TABLE IV
COUNTING ACCELEROMETER VERSUS OSCILLOGRAPH EXCEEDANCE SUMMARY - 1976

	154984 (28.0 HOURS)				154986 (163.1 HOURS)				155179 (172.1 HOURS)			
	5	6	7	8	5	6	7	8	5	6	7	8
OSCILLOGRAPH												
SOLO PRACTICE	164	66	20	5	544	229	43	6	-	-	-	-
SOLO SHOW	10	5	2	0	577	263	68	13	-	-	-	-
CROSS COUNTRY	4	0	0	0	52	18	4	0	13	2	1	0
DIAMOND PRACTICE	-	-	-	-	-	-	-	-	53	19	8	2
DIAMOND SHOW	-	-	-	-	-	-	-	-	81	27	11	3
COUNTING ACCELEROMETER												
TOTAL	178	71	22	5	1173	510	115	19	147	48	20	5
SOLO PRACTICE	165	50	11	3	559	214	36	6	-	-	-	-
SOLO SHOW	11	5	2	0	641	260	75	10	-	-	-	-
CROSS COUNTRY	4	0	0	0	41	13	2	0	10	4	1	0
DIAMOND PRACTICE	-	-	-	-	-	-	-	-	57	19	9	2
DIAMOND SHOW	-	-	-	-	-	-	-	-	85	33	10	1
TOTAL	180	55	13	3	1241	487	113	16	152	56	20	3

TABLE V
OSCILLOGRAPH DATA CUMULATIVE EXCEEDANCE SUMMARY - 1976

EXCEEDANCES (g)	BUNO 154984			BUNO 154986			BUNO 154179		
	SOLO PRACTICE	SOLO SHOW	CROSS COUNTRY	SOLO PRACTICE	SOLO SHOW	CROSS COUNTRY	DIAMOND PRACTICE	DIAMOND SHOW	CROSS COUNTRY
g ≤ -3.00	6	0	0	2	0	0	0	0	0
-2.99 ≤ g ≤ -2.00	130	4	2	170	182	26	0	0	0
-1.99 ≤ g ≤ -1.00	196	6	5	491	448	78	4	2	8
-0.99 ≤ g ≤ 0.25	325	14	8	953	884	195	250	350	81
2.00 ≤ g ≤ 2.99	1567	45	40	3990	3320	558	2510	2420	364
3.00 ≤ g ≤ 3.99	873	31	22	2315	2112	262	828	933	139
4.00 ≤ g ≤ 4.99	319	16	6	1084	1070	113	177	236	37
5.00 ≤ g ≤ 5.99	164	10	4	544	577	52	53	81	13
6.00 ≤ g ≤ 6.99	66	5	0	229	263	18	19	27	2
7.00 ≤ g ≤ 7.99	20	2	0	43	68	4	8	11	1
8.00 ≤ g	5	0	0	6	13	0	2	3	0
HOURS	25.4	.8	1.8	60.8	42.7	59.6	65.5	48.4	58.2

TABLE VI
OSCILLOGRAPH DATA UTILIZATION CUMULATIVE EXCEEDANCE SUMMARY - 1976

EXCEEDANCES (g)	DIAMOND		SOLO		CROSS COUNTRY
	PRACTICE	SHOW	PRACTICE	SHOW	
8 < -3.00	0	0	8	0	0
-2.99 < 8 < -2.00	0	0	300	186	30
-1.99 < 8 < -1.00	4	2	687	454	91
-0.99 < 8 < 0.25	250	350	1278	898	284
2.00 < 8 < 2.99	2510	2420	5557	3365	962
3.00 < 8 < 3.99	828	933	3188	2143	423
4.00 < 8 < 4.99	177	236	1403	1086	156
5.00 < 8 < 5.99	53	81	708	587	69
6.00 < 8 < 6.99	19	27	295	268	20
7.00 < 8 < 7.99	8	11	63	70	5
8.00 < 8	2	3	11	13	0
	HOURS 65.5	48.4	86.2	43.5	119.6

TABLE VII
OSCILLOGRAPH DATA UTILIZATION CUMULATIVE EXCEEDANCE RATES PER 1000 HOURS - 1976

EXCEEDANCES (S)	DIAMOND		SCLO		CROSS COUNTRY
	PRACTICE	SHOW	PRACTICE	SHOW	
8 < -3.00	0	0	92.8	0	0
-2.99 < 8 < -2.00	0	0	3480.3	4275.9	250.8
-1.99 < 8 < -1.00	61.1	41.3	7969.8	10,436.8	760.9
-0.99 < 8 < 0.25	3816.8	7231.4	14,826.0	20,643.7	2374.6
2.00 < 8 < 2.99	38,320.6	50,000.0	64,466.4	77,356.3	8043.5
3.00 < 8 < 3.99	12,641.2	19,276.9	36,983.8	49,264.4	3536.8
4.00 < 8 < 4.99	2702.3	4876.0	16,276.1	24,965.5	1304.3
5.00 < 8 < 5.99	809.2	1673.6	8213.5	13,494.3	576.9
6.00 < 8 < 6.99	290.1	557.9	3422.3	6160.9	167.2
7.00 < 8 < 7.99	122.1	227.3	730.9	1609.2	41.8
8.00 < 8	30.5	62.0	127.6	298.9	0
HOURS	65.5	48.4	86.2	43.5	119.6

TABLE VIII
OSCILLOGRAPH DATA
UTILIZATION CUMULATIVE EXCEEDANCE RATES PER 1000 HOURS
1974/1975/1976

EXCEEDANCE (G)	1974/1975				1974/1975/1976				
	D I A M O N D PRACTICE	S H O W	S O L PRACTICE	CROSS COUNTRY	D I A M O N D PRACTICE	S H O W	S O L PRACTICE	CROSS COUNTRY	
≤ G ≤ -3.00	0	0	656	1238	0	0	354	805	36
-2.99 ≤ G ≤ -2.00	72	105	2838	3676	33	52	3182	3886	325
-1.99 ≤ G ≤ -1.00	258	360	6801	8589	157	209	7427	9236	903
-.99 ≤ G ≤ .25	2039	3734	15622	20285	2998	5501	15196	20410	2510
2.00 ≤ G ≤ 2.99	70411	76181	83320	105970	53097	62954	73219	95961	10492
3.00 ≤ G ≤ 3.99	16261	26730	40174	53577	14308	22965	38465	52068	4463
4.00 ≤ G ≤ 4.99	4186	7975	17028	21597	3386	6409	16625	22776	1760
5.00 ≤ G ≤ 5.99	1091	2743	6064	10037	939	2203	7216	11247	735
6.00 ≤ G ≤ 6.99	161	823	1392	3985	231	689	2480	4747	223
7.00 ≤ G ≤ 7.99	18	169	201	718	74	198	485	1030	36
8.00 ≤ G	0	0	0	50	17	31	68	137	0
HOURS OF DATA	55.9	47.4	74.7	80.8	121.4	95.8	160.9	124.3	197.2

TABLE VIII
OSCILLOGRAPH DATA
UTILIZATION CUMULATIVE EXCEEDANCE RATES PER 1000 HOURS
1974/1975/1976

EXCEEDANCE (G)	1974				1975				CROSS COUNTRY
	0 PRACTICE	1 A M O N D SHOW	S O L PRACTICE	0 L O SHOW	0 PRACTICE	1 A M O N D SHOW	S O L PRACTICE	0 L O SHOW	
≤ G ≤ -3.00	0	0	0	0	0	0	1142	2193	234
-2.99 ≤ G ≤ -2.00	97	255	597	1193	83	40	4499	5592	1003
-1.99 ≤ G ≤ -1.00	390	816	4623	5994	670	120	8615	10592	1839
-.99 ≤ G ≤ .25	1039	3367	13145	18778	2012	3267	17459	21447	3846
2.00 ≤ G ≤ 2.99	81364	84592	87264	112699	11698	56972	80396	100789	18361
3.00 ≤ G ≤ 3.99	16136	33214	38302	54744	4004	16414	41562	52675	8896
4.00 ≤ G ≤ 4.99	3409	10051	14528	22273	1761	5139	18881	21075	3578
5.00 ≤ G ≤ 5.99	779	3878	5346	10739	859	1474	6597	9496	1170
6.00 ≤ G ≤ 6.99	65	1020	1447	5000	356	279	1352	3202	234
7.00 ≤ G ≤ 7.99	0	306	252	1278	20	40	163	285	33
8.00 ≤ G	0	0	0	57	0	0	0	44	0
HOURS OF DATA	30.8	19.6	31.8	35.2	47.7	25.1	42.9	45.6	29.9

TABLE IX
DIAMOND AND SOLO SURVEY
PERCENT EXCEEDANCES IN ALTITUDE AND AIRSPEED RANGES - 1976

DIAMOND - 1976

PERCENT OF TOTAL EXCEEDANCES (TOTAL = 5,917)	ALTITUDE RANGE METRES (FT)	PERCENT OF TOTAL EXCEEDANCES IN ALTITUDE RANGE			
		V <	300 KTS	400 KTS	500 KTS
		300 KTS	≤ V <	≤ V <	≤ V <
		300 KTS	400 KTS	500 KTS	600 KTS
50.8	A < 609.3(2,000)	11.2	34.7	4.5	.4
40.8	609.3(2,000) ≤ A < 1523.7(5,000)	12.8	26.7	1.3	0
7.1	1523.7(5,000) ≤ A < 3047.7(10,000)	4.8	2.2	.1	0
.2	3047.7(10,000) ≤ A < 4571.7(15,000)	.2	0	0	0
1.1	4571.7(15,000) ≤ A < 9143.7(30,000)	.1	1.0	0	0

SOLO - 1976

PERCENT OF TOTAL EXCEEDANCES (TOTAL = 11,903)	ALTITUDE RANGE METRES (FT)	PERCENT OF TOTAL EXCEEDANCES IN ALTITUDE RANGE			
		V <	300 KTS	400 KTS	500 KTS
		300 KTS	≤ V <	≤ V <	≤ V <
		300 KTS	400 KTS	500 KTS	600 KTS
62.2	A < 609.3(2,000)	4.8	38.6	16.3	2.5
23.2	609.3(2,000) ≤ A < 1523.7(5,000)	5.0	14.8	3.1	.3
12.8	1523.7(5,000) ≤ A < 3047.7(10,000)	8.3	4.0	.4	0
.6	3047.7(10,000) ≤ A < 4571.7(15,000)	.5	.1	0	0
1.2	4571.7(15,000) ≤ A < 9143.7(30,000)	.1	1.2	0	0

TABLE X
DIAMOND AND SOLO SURVEY
PERCENT EXCEEDANCES IN ALTITUDE AND AIRSPEED RANGES - 1974/1975

PERCENT OF TOTAL EXCEEDANCES (TOTAL = 10,495)	ALTITUDE RANGE METRES (FT)	PERCENT OF TOTAL EXCEEDANCES IN ALTITUDE RANGE			
		V <	300 KTS ≤ V <	400 KTS ≤ V <	500 KTS ≤ V <
		300 KTS	400 KTS	500 KTS	600 KTS
50.5	A < 609.3(2,000)	5.7	28.5	15.8	.5
42.1	609.3(2,000) ≤ A < 1523.7(5,000)	8.1	27.2	6.7	.1
6.8	1523.7(5,000) ≤ A < 3047.7(10,000)	3.1	2.9	.8	0
.5	3047.7(10,000) ≤ A < 4571.7(15,000)	.1	.3	.1	0
.1	4571.7(15,000) ≤ A < 9143.7(30,000)	0	.1	0	0

PERCENT OF TOTAL EXCEEDANCES (TOTAL = 27,452)	ALTITUDE RANGE METRES (FT)	PERCENT OF TOTAL EXCEEDANCES IN ALTITUDE RANGE			
		V <	300 KTS ≤ V <	400 KTS ≤ V <	500 KTS ≤ V <
		300 KTS	400 KTS	500 KTS	600 KTS
58.9	A < 609.3(2,000)	3.3	30.8	24.0	.8
28.3	609.3(2,000) ≤ A < 1523.7(5,000)	7.6	17.1	3.5	.1
11.9	1523.7(5,000) ≤ A < 3047.7(10,000)	7.7	3.9	.3	0
.6	3047.7(10,000) ≤ A < 4571.7(15,000)	.3	.3	0	0
.3	4571.7(15,000) ≤ A < 9143.7(30,000)	.1	.2	0	0

TABLE XI

AVERAGE AIRCRAFT GROSS WEIGHT 1974/1975 vs. 1976

ALTITUDE RANGE METRES (FEET)	SOLO GROSS WEIGHT (POUNDS)		DIAMOND GROSS WEIGHT (POUNDS)	
	1976	1974/75	1976	1974/75
0 < A < 609.3 (0 < A < 2,000)	14262	14776	14523	14669
609.3 < A < 1523.7 (2,000 < A < 5,000)	14207	15126	14303	14634
1523.7 < A < 3047.7 (5,000 < A < 10,000)	14288	15286	14103	14456
3047.7 < A < 4571.7 (10,000 < A < 15,000)	14284	15429	13880	15298
4571.7 < A < 9143.7 (15,000 < A < 30,000)	15139	15127	14840	15667

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- (d) Barber, Clyde, "Naval Flight Loads Research Program," Digest of United States Naval Aviation Electronics/TPD Booklet 7-65, September, 1965
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APPENDIX A
INSTRUMENTATION DESCRIPTION

Instrumentation Description

The Century model 409 oscillograph system (Figure A-1), consisting of the oscillograph, bridge balance unit, pressure and acceleration transducers, and associated components, was designed for applications where space and weight requirements are critical, as well as for adverse shock, vibration, and temperature conditions. Weighing approximately 9.072 kilograms (20 pounds), this system is capable of continuously monitoring eight flight parameters, each simultaneously recorded on a photosensitive film or paper. (Figure A-2 shows the recording galvanometers used in this unit.) In principle, the oscillograph records deviations of current flow in a galvanometer coil from those current values associated with level flight. Each flight parameter is associated with its own transducer and galvanometer. As the transducer changes the current flow in the galvanometer coil, motor action deflects the mirror in a direction and amount determined by the transducer output. As the mirror is deflected, the trace of the light beam is recorded on the moving film or paper via the optical system shown in Figure A-3. Using a series of collimating mirrors, the light beam is narrowed until the projection of light from each galvanometer on the film (or paper) is a very small spot. When several flight parameters (galvanometers) are being recorded, necessary trace identification is made by momentarily interrupting each light path in sequence. Since the sequence of interruption is independent of the trace position on the film (or paper), it is always possible to determine which galvanometer is responsible for a particular trace. The rate of interruption varies with film/(paper) speed, so regardless of that speed, a trace is interrupted the same number of times in a given length of record. Magazines of the light sensitive film, called records, are 45.72 metres (150 feet) long and are capable of recording approximately five hours of flight time (the oscillograph is activated only in the wheels up configuration) at a rate of 0.1524 metres (6 inches) per minute. Oscillograph units for the A-4F Blue Angel flight usage data study provide a continuous time history of aircraft airspeed, altitude, and normal acceleration. The recording portion of the oscillograph in all instrumented aircraft is located at fuselage station 20 in the nose compartment. Airspeed and altitude transducers are located approximately at fuselage station 30.0. The normal acceleration transducer, mounted on rigid structure close to the aircraft center of gravity to eliminate angular accelerations, is located at fuselage station 236.0 port side frame.

Systron-Donner counting accelerometer units (Figure A-4) weighing approximately 2.268 kilograms (5 pounds), provide an automatic, in-flight (wheels-up) permanent record of normal acceleration at four pre-set load or "g" levels. The transducer is a solid state, force-balance device whose output voltage is indicative of the induced magnetic field voltage required to return a mass to its neutral (level flight) position. Output voltage is registered by the indicator via window counters, with each window corresponding to a different load/g level. By taking periodic readings and comparing with previous readings, the cumulative number of exceedances at each level can be determined for the time interval between readings.

Counting accelerometer units installed in Blue Angel aircraft for this study measure normal accelerations at the 5.0, 6.0, 7.0, and 8.0g levels. These units are referred to as "dash seven" type. MIL SPEC A-22145BAS (February 28, 1970) requires the counting accelerometer to operate within $\pm 0.1g$ at the 5.0 and 6.0g levels, and within $\pm 0.15g$ at the 7.0 and 8.0g levels. The transducers are located at fuselage station 236.0 port side frame, beside the oscillograph transducer. Indicators are located in the portside landing gear wheel well.

RECORDER
APPROX. 30.5cm. X 15.7cm. X 15.7 cm.
(12" X 6 " X 6")



Figure A-1. Oscillograph System

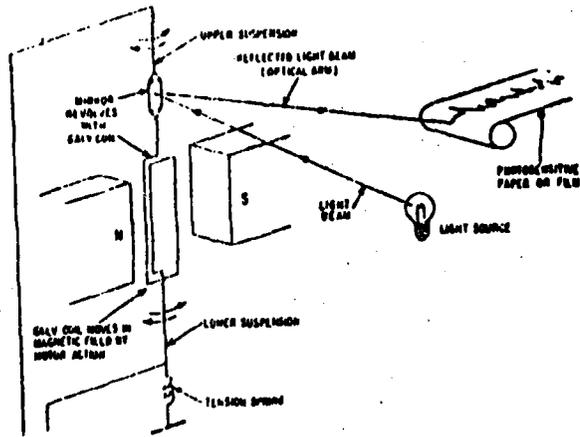


FIGURE A-2: GALVANOMETER UNIT

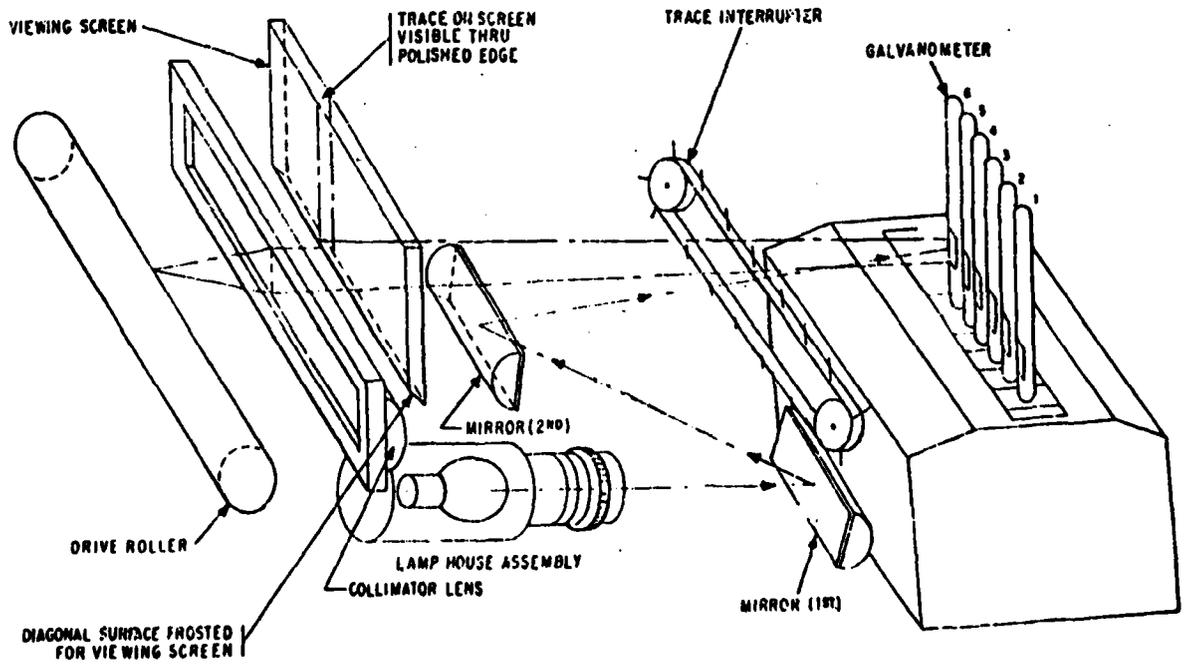


FIGURE A-3: OSCILLOGRAPH OPTICAL SYSTEM

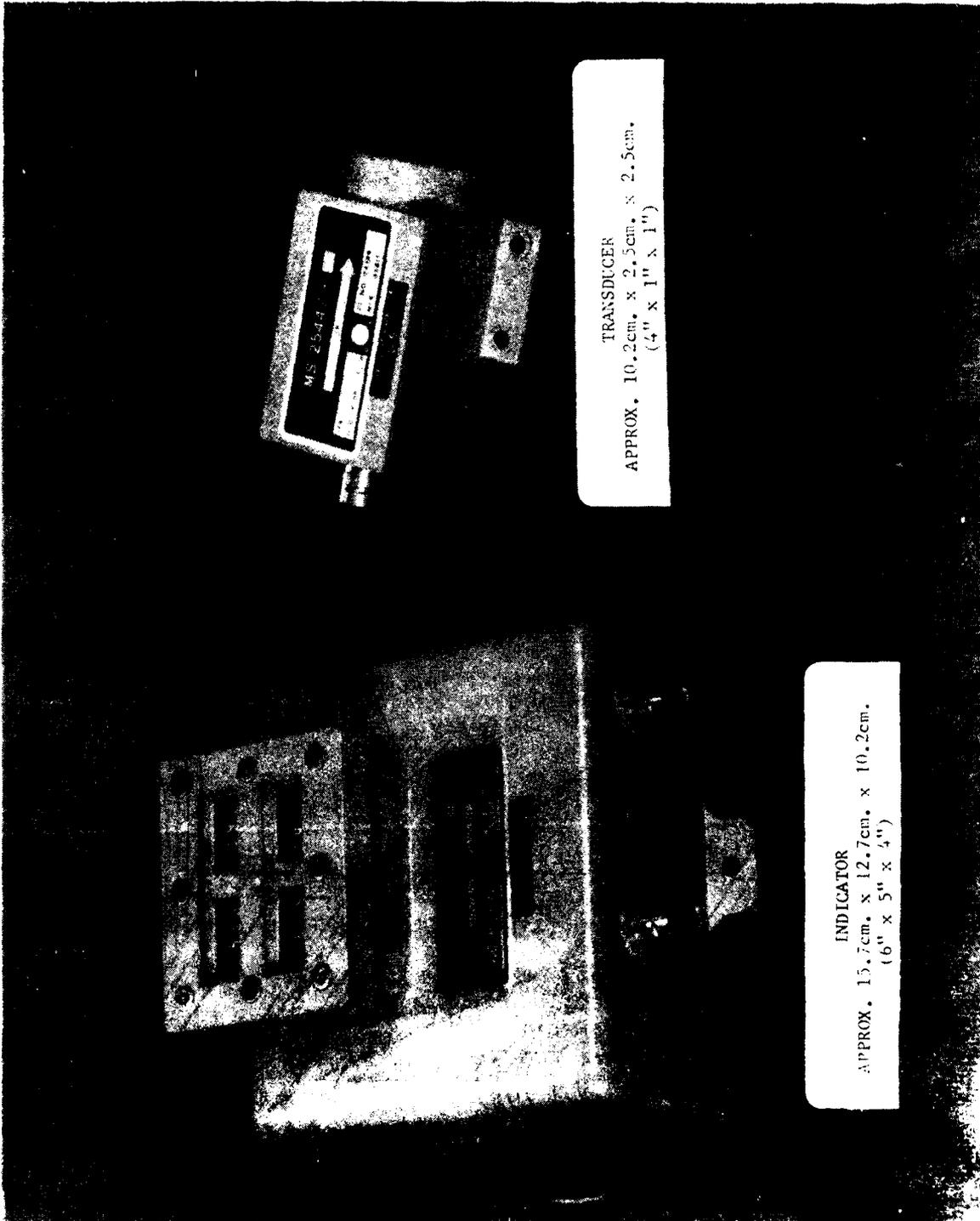


Figure A-4. Counting Accelerometer System

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APPENDIX B
BLUE ANGEL AIRCRAFT COUNTING ACCELEROMETER
DATA BY UTILIZATION FOR 1976

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154984

NAIX: 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
PRACTICE DIAMOND	6.3	6.3	25	5	0	0
PRACTICE SOLO	92.1	92.1	1015	304	26	4
SHOW DIAMOND	0.0	0.0	0	0	0	0
SHOW SOLO	4.0	4.0	52	28	6	0
CROSS COUNTRY	8.1	8.1	7	2	0	0
CHECK OUT	2.0	2.0	9	1	0	0
OTHER	0.0	0.0	0	0	0	0
UNKNOWN	0.0	0.0	0	0	0	0
TOTALS	112.5	112.5	1108	340	32	4

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154983

NADC 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>EXCEEDANCES</u>	<u>8</u>
PRACTICE DIAMOND	174.0	173.3	5	0
PRACTICE SOLO	1.2	1.2	0	0
SHOW DIAMOND	62.5	61.7	3	0
SHOW SOLO	0.0	0.0	-	-
CROSS COUNTRY	168.9	168.1	0	0
CHECK OUT	2.3	2.3	0	0
OTHER	19.8	19.8	0	0
UNKNOWN	0.0	0.0	0	0
TOTALS	428.7	426.4	172	8

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154975

NADC 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
PRACTICE DIAMOND	2.5	2.5	0	0	0	0
PRACTICE SOLO	44.2	42.6	232	68	23	6
SHOW DIAMOND	0.0	0.0	0	0	0	0
SHOW SOLO	44.4	42.8	395	145	48	11
CROSS COUNTRY	115.6	109.5	57	12	2	0
CHECK OUT	1.3	1.3	6	1	0	0
OTHER	0.0	0.0	0	0	0	0
UNKNOWN	5.8	3.0	0	0	0	0
TOTALS	213.8	201.7	690	226	73	17

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154986

<u>UTILIZATION</u>	<u>HOURS FLOKN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>EXCEEDANCES</u>	
PRACTICE DIAMOND	3.6	3.6	6	8
PRACTICE SOLO	177.2	177.2	1	0
SHOW DIAMOND	0.0	0.0	0	0
SHOW SOLO	62.3	62.3	0	0
CROSS COUNTRY	164.8	164.8	418	18
CHECK OUT	4.2	4.2	52	0
OTHER	0.0	0.0	0	0
UNKNOWN	0.6	0.0	0	0
TOTALS	412.7	412.1	1136	29

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 155029

NADC 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
PRACTICE DIAMOND	182.4	182.4	221	49	9	0
PRACTICE SOLO	0.0	0.0	0	0	0	0
SHOW DIAMOND	59.9	59.9	143	44	8	0
SHOW SOLO	0.0	0.0	0	0	0	0
CROSS COUNTRY	162.6	162.6	31	6	0	0
CHECK OUT	4.7	4.7	6	1	0	0
OTHER	22.5	22.5	6	1	0	0
UNKNOWN	0.0	0.0	0	0	0	0
TOTALS	432.1	432.1	407	101	17	0

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: **154172**

NAIAC 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>EXCEEDANCES</u>	
PRACTICE DIAMOND	173.8	173.8	51	3
PRACTICE SOLO	14.8	14.8	38	0
SHOW DIAMOND	62.3	62.3	41	1
SHOW SOLO	0.0	0.0	0	0
CROSS COUNTRY	164.4	164.4	8	0
CHECK OUT	1.5	1.5	0	0
OTHER	24.2	24.2	1	0
UNKNOWN	9.5	7.6	0	0
TOTALS	450.5	448.6	139	4

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154176

NADC 77287-60

<u>UTILIZATION</u>	<u>HOURS FLOXX</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>EXCEEDANCES</u>	<u>8</u>
		<u>5</u>	<u>6</u>	<u>7</u>
PRACTICE DIAMOND	83.8	97	25	13
PRACTICE SOLO	57.6	530	152	15
SHOW DIAMOND	0.8	0	0	0
SHOW SOLO	13.9	177	88	13
CROSS COUNTRY	60.2	41	12	2
CHECK OUT	3.0	12	3	0
OTHER	6.1	6	2	1
UNKNOWN	4.2	0	0	0
TOTALS	229.6	863	282	44

8

1976

BLUE ANGEL COUNTING ACCELEROMETER DATA

SERIAL NUMBER: 154177

NADC 77287-60

<u>CATEGORIZATION</u>	<u>HOURS FLOWN</u>	<u>ACCEPTABLE COUNTING ACCELEROMETER</u>	<u>EXCEEDANCES</u>	<u>8</u>
		<u>5</u>	<u>6</u>	<u>7</u>
PRACTICE DIAMOND	177.1	290	111	6
PRACTICE SOLO	4.9	15	2	0
SHOW DIAMOND	62.4	141	53	1
SHOW SOLO	0.0	0	0	0
CROSS COUNTRY	166.7	16	7	0
CHECK OUT	3.6	6	4	0
OTHER	14.7	1	0	0
UNKNOWN	8.8	0	0	0
TOTALS	438.2	469	177	7

NADC-77287-60

APPENDIX C
SURVEY OF AIRSPEED, ALTITUDE, AND EXCEEDANCE
FOR 1976 DIAMOND AND SOLO

A4F BLUE ANGELS 1976 DIAMOND

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 0 TO 1999 FEET
(.00 TO 609.30 METRES)

AVERAGE GROSS WEIGHT 14523 POUNDS
(6587.49 KILOGRAMS)

EQUIVALENT AIRSPEED, KNOTS

LOAD FACTOR	100		150		200		250		300		350		400		450		500		550		600		TOTAL
	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3
-.99 TO .25	0	2	3	31	93	62	10	13	7	0	0	0	0	0	0	0	0	0	0	0	0	0	221
2.00 TO 2.99	1	4	99	463	818	389	62	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1843
3.00 TO 3.99	0	0	2	39	178	385	88	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	703
4.00 TO 4.99	0	0	1	15	18	62	29	10	6	1	0	0	0	0	0	0	0	0	0	0	0	0	142
5.00 TO 5.99	0	0	0	4	14	12	14	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	52
6.00 TO 6.99	0	0	0	0	2	11	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
7.00 TO 7.99	0	0	0	0	0	6	1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
TOTAL EXCEEDANCES	1	6	105	553	1123	929	214	54	23	2	0	0	0	0	0	0	0	0	0	0	0	0	3010

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 2000 TO 4999 FEET
(607.60 TO 1523.70 METRES)

AVERAGE GROSS WEIGHT 14303 POUNDS
(6487.65 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS												649 TOTAL
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL	
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	0	0	0	2	1	0	0	0	0	0	3
-.99 TO .25	5	1	19	57	73	34	13	1	0	0	0	0	203
2.00 TO 2.99	0	5	66	458	617	185	24	3	0	0	0	0	1358
3.00 TO 3.99	0	0	11	97	298	249	18	4	0	0	0	0	677
4.00 TO 4.99	0	0	0	33	41	48	8	1	0	0	0	0	131
5.00 TO 5.99	0	0	0	7	15	15	2	0	0	0	0	0	39
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	1	0	0	0	0	0	0	1
8.00 AND UP	0	0	0	0	0	0	0	1	0	0	0	0	1
TOTAL EXCEEDANCES	5	6	96	652	1044	534	66	10	0	0	0	0	2413

A4F BLUE ANGELS 1976 DIAMOND

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 5000 TO 9999 FEET
(1524.00 TO 3047.70 METRES)

AVERAGE GROSS WEIGHT 14103 POUNDS
(6396.85 KILOGRAMS)

EQUIVALENT AIRSPEED, KNOTS

LOAD FACTOR	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	0	0	0	1	0	0	0	0	0	1
-.99 TO .25	48	12	21	35	26	2	0	0	0	0	0	144
2.00 TO 2.99	0	3	32	89	35	10	1	0	0	0	0	170
3.00 TO 3.99	0	1	11	20	29	3	1	0	0	0	0	65
4.00 TO 4.99	0	0	0	10	11	7	1	0	0	0	0	29
5.00 TO 5.99	0	0	0	1	3	3	1	0	0	0	0	8
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXCEEDANCES	48	16	64	155	104	26	4	0	0	0	0	417

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 10000 TO 14999 FEET
(3048.00 TO 4571.70 METRES)

AVERAGE GROSS WEIGHT 13880 POUNDS
(6295.86 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS											TOTAL			
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649				
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-.99 TO .25	1	1	1	0	0	0	0	0	0	0	0	0	0	0	4
2.00 TO 2.99	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2
3.00 TO 3.99	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
4.00 TO 4.99	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
5.00 TO 5.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXCEEDANCES	1	2	2	4	1	0	0	0	0	0	0	0	0	0	10

A4F BLUE ANGELS 1976 DIAMOND

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 15000 TO 29999 FEET
(4572.00 TO 9143.70 METRES)

AVERAGE GROSS WEIGHT 14840 POUNDS
(6731.45 KILOGRAMS)

EQUIVALENT AIRSPEED, KNOTS

LOAD FACTOR	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	0	0	6	1	0	0	0	0	0	7
-.99 TO .25	0	0	1	2	33	2	0	0	0	0	0	38
2.00 TO 2.99	0	0	1	0	16	1	2	0	0	0	0	20
3.00 TO 3.99	0	0	1	0	1	0	0	0	0	0	0	2
4.00 TO 4.99	0	0	0	0	0	0	0	0	0	0	0	0
5.00 TO 5.99	0	0	0	0	0	0	0	0	0	0	0	0
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXCEEDANCES	0	0	3	2	56	4	2	0	0	0	0	67

A4F BLUE ANGELS 1976 SOLO

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE (0 TO 1999 FEET
 .00 TO 609.30 METRES)

AVERAGE GROSS WEIGHT 14262 POUNDS
 (6469.13 KILOGRAMS)

EQUIVALENT AIRSPEED, KNOTS

LOAD FACTOR	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL
LESS THAN -3.00	0	0	0	0	1	7	0	0	0	0	0	8
-2.99 TO -2.00	0	0	4	0	34	275	93	0	0	0	0	406
-1.99 TO -1.00	0	3	14	0	19	322	124	2	0	0	0	484
-.99 TO .25	0	10	43	21	65	185	82	9	12	7	0	434
2.00 TO 2.99	0	9	95	242	671	772	398	55	20	5	1	2268
3.00 TO 3.99	0	0	5	112	340	784	382	85	45	30	1	1764
4.00 TO 4.99	0	0	0	9	100	442	241	45	15	8	0	860
5.00 TO 5.99	0	0	0	0	42	343	158	55	35	11	0	644
6.00 TO 6.99	0	0	0	0	1	170	108	46	52	17	1	395
7.00 TO 7.99	0	0	0	0	0	25	21	18	30	9	0	103
8.00 AND UP	0	0	0	0	0	0	3	11	4	2	0	20
TOTAL CALLEDANCES	0	22	161	384	1273	3325	1610	326	213	89	3	7406

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 2000 TO 4999 FEET
(609.60 TO 1523.70 METRES)

AVERAGE GROSS WEIGHT 14207 POUNDS
(6444.06 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS											
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	1	14	43	8	0	0	0	0	66
-1.99 TO -1.00	0	1	2	8	16	47	15	0	0	0	0	89
-0.99 TO .25	0	8	33	47	110	81	39	10	0	0	0	328
2.00 TO 2.99	0	1	69	279	301	198	77	6	5	0	0	936
3.00 TO 3.99	0	0	5	129	340	292	76	17	8	3	0	870
4.00 TO 4.99	0	0	0	11	88	151	44	15	4	1	0	314
5.00 TO 5.99	0	0	0	0	17	51	19	13	2	1	0	103
6.00 TO 6.99	0	0	0	0	2	9	18	5	2	1	0	37
7.00 TO 7.99	0	0	0	0	0	2	2	4	2	0	0	10
8.00 AND UP	0	0	0	0	0	0	0	0	4	0	0	4
TOTAL RECORDED	0	10	109	475	888	874	298	70	27	6	0	2157

A-1F BLUE ANGELS 1976 SOLO

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 5000 TO 9999 FEET
(1524.00 TO 3047.70 METRES)

AVERAGE GROSS WEIGHT 14288 POUNDS
(6481.05 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS										600 TO 649 TOTAL	
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599		
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	6	3	1	18	2	0	0	0	0	30
-1.99 TO -1.00	6	7	51	43	4	3	0	0	0	0	0	108
-.99 TO .25	17	27	85	112	49	14	3	1	0	0	0	308
2.00 TO 2.99	0	7	206	251	110	36	7	2	0	0	0	619
3.00 TO 3.99	0	0	31	132	121	37	12	4	1	0	0	338
4.00 TO 4.99	0	0	0	9	34	29	8	0	0	0	0	80
5.00 TO 5.99	0	0	0	0	4	16	0	3	0	0	0	23
6.00 TO 6.99	0	0	0	0	2	2	5	3	0	0	0	12
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ENCOUNTERS	17	41	379	550	325	155	37	13	1	0	0	1518

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 10000 TO 14999 FEET
(3048.00 TO 4571.70 METRES)

AVERAGE GROSS WEIGHT 14284 POUNDS
(6479.21 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS												600 TO	
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL		
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	2	2	0	1	0	0	0	0	0	0	0	5
-.99 TO .25	3	2	2	3	3	0	0	0	0	0	0	0	0	13
2.00 TO 2.99	0	1	18	19	4	1	0	0	0	0	0	0	0	43
3.00 TO 3.99	0	0	2	4	5	1	0	0	0	0	0	0	0	12
4.00 TO 4.99	0	0	0	1	2	0	0	0	0	0	0	0	0	3
5.00 TO 5.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXCEEDANCES	3	3	24	29	14	3	0	0	0	0	0	0	0	76

A4F BLUE ANGELS 1970 SOLO

OBSERVED NORMAL LOAD FACTOR VS. EQUIVALENT AIRSPEED TABULATION

ALTITUDE 15000 TO 29999 FEET
(4572.00 TO 9143.70 METRES)

AVERAGE GROSS WEIGHT 15139 POUNDS
(6866.90 KILOGRAMS)

LOAD FACTOR	EQUIVALENT AIRSPEED, KNOTS												600 TO 649 TOTAL	
	100 TO 149	150 TO 199	200 TO 249	250 TO 299	300 TO 349	350 TO 399	400 TO 449	450 TO 499	500 TO 549	550 TO 599	600 TO 649	TOTAL		
LESS THAN -3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-2.99 TO -2.00	0	0	0	0	5	1	0	0	0	0	0	0	0	0
-1.99 TO -1.00	0	0	2	1	17	2	0	0	0	0	0	0	0	22
-.99 TO -.25	0	0	0	6	59	3	0	0	0	0	0	0	0	68
2.00 TO 2.99	0	0	0	3	43	3	0	0	0	0	0	0	0	49
3.00 TO 3.99	0	0	0	0	4	0	0	0	0	0	0	0	0	4
4.00 TO 4.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.00 TO 5.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.00 TO 6.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.00 TO 7.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.00 AND UP	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL CATEGORIES	0	0	2	10	128	9	0	0	0	0	0	0	0	149

D I S T R I B U T I O N L I S T

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