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LOGISTICS IMPACT OF LONGER C-5 MISSIONS.(U)

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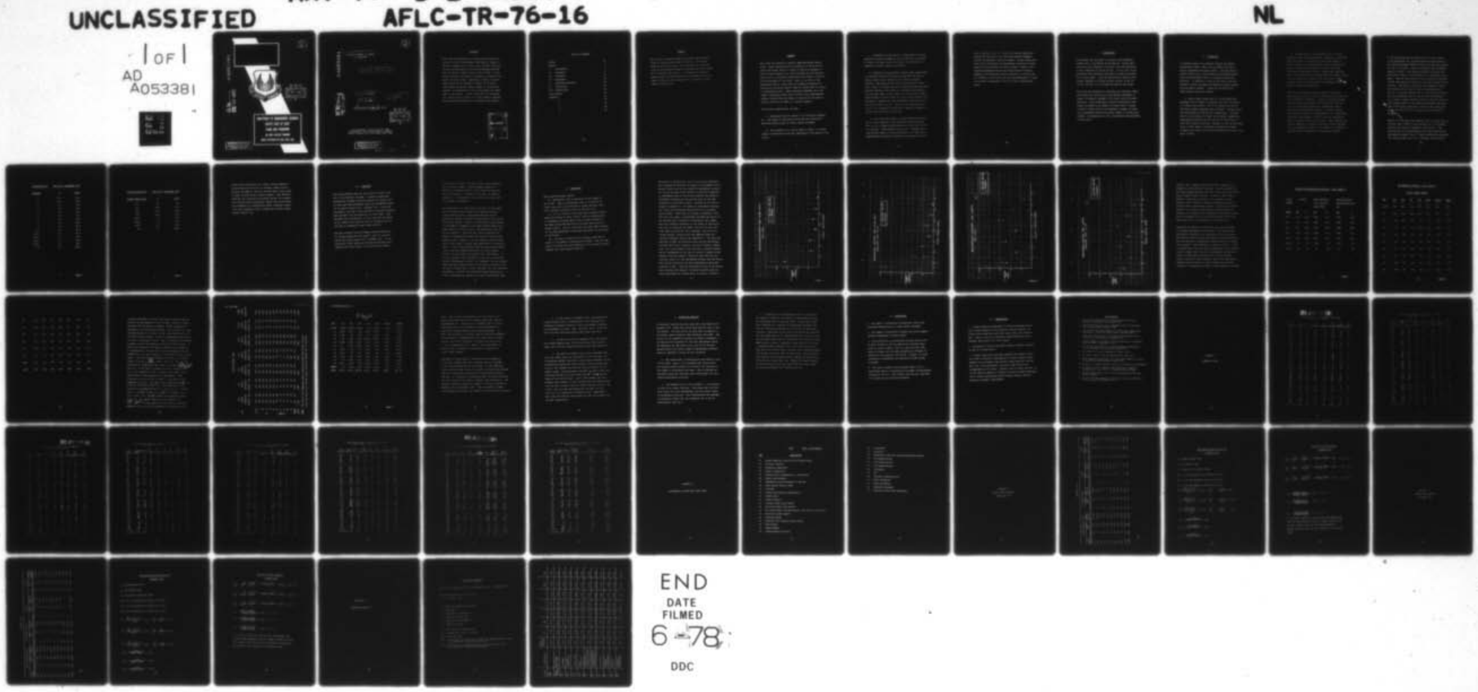

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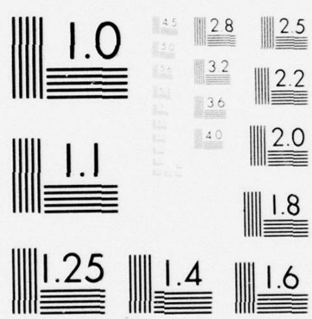

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PLANS AND PROGRAMS

AIR FORCE LOGISTICS COMMAND

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

(2)

LOGISTICS IMPACT OF LONGER C-5 MISSIONS

AFLC-TR-76-16

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May 1977

AFLC Technical Report No. 76-16

The Management Sciences Office (XRS)
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ABSTRACT

This study was undertaken to determine the impact and savings to accrue from maximum commitment to longer C-5 missions (perhaps 15-17 hours) using inflight refueling. This was accomplished by reviewing maintenance writeup data for shorter flights versus longer flights. Traditional logistics forecasting techniques are based on the number of flying hours. Therefore, a change in sortie length would not be expected to impact on logistics requirements unless the overall number of flying hours changed. An examination of this relationship was undertaken in this study. It was found that the occurrence of a sortie tends to result in a given number of maintenance writeups regardless of the length of the sortie.

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PREFACE

This is one of several studies to evaluate the logistics impact of changing the length of sorties. This study, based on the C-5 aircraft, is an extension of a previous study on the logistics impact of changing the sortie length on F-4 aircraft (see Ref. 9). It attempts to identify those systems for which maintenance is impacted on by the number of sorties flown instead of/or in addition to the number of hours flown.

SUMMARY

This study has resulted in several observations and conclusions. Those observations and conclusions of this C-5A aircraft study which relate to length of sortie as opposed to type of sortie appear to be valid uniformly for all aircraft. This position is generally supported by the reports listed in the bibliography of this study. Most, if not all of the referenced reports, infer that the traditional approach of forecasting logistics support based on flying hours is subject to considerable error. While unanimous agreement as to the "ideal" forecasting model does not exist, most knowledgeable authors conclude that the number of sorties and the type of sorties flown has an impact on logistics support.

The following observations are made:

a. Maintenance does not appear to be flying hour dependent. The number of maintenance write-ups per flying hour decreases monotonically as flight length increases.

b. The occurrence of a sortie tends to result in a given number of maintenance write-ups regardless of the length of the sortie.

c. Although the distribution of maintenance write-ups among the aircraft systems is not the same for all lengths of flight, no trend (either increasing or decreasing) is apparent as sortie length is increased.

d. Although previous similar studies (see bibliography) on a variety of aircraft types conclude that the type of mission flown has an impact on the logistics support required, this study was not able to confirm that conclusion. Most C-5 flights are cargo hauling missions and hence multiple "mission codes" were not available for analysis. With the data used in this study, the sorties with "blank" mission code or mission code other than "cargo hauling" were concluded to exhibit the same maintenance write-up rate as the cargo hauling sorties. This is to be expected since the C-5 is a transport aircraft and a variety of maneuvers is not flown from sortie to sortie.

e. This study was unable to relate maintenance write-ups to actual demands on the wholesale logistics system. This is not a unique problem peculiar to this study or the C-5 aircraft. Maintenance write-ups are a standard data item and may result in three conditions: (1) labor being expended with no supplies expenditure (adjusting, calibrating, cleaning, etc.), (2) labor and supplies expenditure against the base stocks (3) labor and supplies requests against the wholesale logistics system. No data system was found which would track the maintenance write-ups to actual demands on the wholesale logistics system. However, even though maintenance writeups were used instead of actual demands on the wholesale logistics system, it is felt that all findings of this study are valid and meaningful at least on an order of magnitude if not on a finite quantitative basis.

I. INTRODUCTION

This project was initiated by a letter from HQ USAF/LG, 8 March 1976, to HQ MAC/LG and HQ AFLC/LO. Within AFLC, the project was assigned to LOAC who, with the assistance of LOR, completed an initial review. In July 1976 it was determined that sufficient data was not readily available for a quick answer. Since HQ AFLC/XR had a similar study already underway to evaluate shorter sorties on the F-4 for TAC (See Ref. 9), XR became the OPR for this study.

This study was undertaken to determine the logistics impact and savings that would accrue from maximum commitment to longer C-5 missions (perhaps 15-17 hours) using in-flight refueling. Since traditional logistics forecasting techniques are based on the number of flying hours, a change of sortie length would not be expected to impact on logistics requirements unless the overall number of flying hours changed. An examination of this relationship was undertaken in this study.

II. DISCUSSION

A literature search was conducted through the Defense Documentation Center (DDC) and the Defense Logistics Studies Information Exchange (DLSIE). Although several studies hinted that a relationship exists between sortie length and maintenance rate, no substantive data was presented. In addition to the DDC and DLSIE literature searches, contact was made with Douglas Aircraft Company and with Boeing Company. Information received from those sources was quite valuable.

a. Boeing report #D162-10015-1, "B-52D Operations - Southeast Asia vs CONUS," concluded that after four hours of a twelve hour mission, 50% of the failure and 47% of the abort causing conditions have occurred. At eight hours the percentages are 80% and 93%, respectively. The data used in this current C-5 study did not permit identifying maintenance write-ups with the portion of the flight at which the condition occurred. However, as will be discussed later in this report, this study concludes that longer flights do not result in any more maintenance write-ups than short flights.

b. Douglas Aircraft Company #MDA 75-055, "Initial Maintenance Cost Prediction Method," contains a table which shows the change in maintenance cost as the length of flights changes. The Douglas report did not contain supportive information and efforts to obtain additional information from Douglas Aircraft Company were unproductive. The contact point at Douglas Aircraft Company stated that the company had invested over three years on an in-house study and was reluctant to disseminate the information to outside organizations.

Although the Boeing and Douglas reports do not apply specifically to the C-5 aircraft, they are felt to be valuable background information. Review of the bibliography will show that many reports have been written over the past 10 or more years relative to forecasting and/or evaluating the maintenance aspects of various aircraft. Those reports resulted in recommendations for several data collection improvements to permit relating maintenance data to specific sorties and missions. They observed that a major obstacle to routinely analyzing aircraft malfunction and maintenance data was the absence of a method for relating sortie information to maintenance records.

In reviewing possible data bases for use in this study, it was determined that the Maintenance Analysis Detection and Reporting System (MADARS) would be the best data source for the C-5 aircraft. Data was requested from the MADARS system at OC-ALC. This system provided flying hour and maintenance data for each aircraft on an individual sortie basis. The data was grouped by sortie length and the maintenance rates were calculated for each major system of the aircraft. Maintenance rates were then compared to determine whether sortie length affected maintenance rate. That is, is the maintenance rate for five two hour flights and the maintenance rate for one ten hour flight equal or is there an effect caused by the fact that the five two hour flights result in four additional takeoffs and landings (high stress conditions) as well as four additional cycles "on" and "off" of all electrical and electronic equipment?

Review of flying hour data revealed that on a given day, an aircraft might fly 0-20 hours and make up to 43 landings and still be classified as flying "one sortie." The distributions of landings/sortie and flying hours/sortie are shown in Tables 1 and 2. Those distributions represent 9001 sorties flown July 1975 - September 1976 inclusive.

Landings/Sortie July 1975 - September 1976

Landings	%	Cum %
1	58.5	58.5
2	12.5	71.0
3	2.5	73.5
4	1.4	74.9
5	1.2	76.1
6	1.2	77.3
7	1.3	78.6
8	1.5	80.1
9	1.8	81.9
10	2.4	84.3
11-15	11.1	95.4
16-20	2.1	97.5
21-25	1.5	99.0
26-30	0.7	99.7
31+	0.3	100.0

TABLE 1

Flying Hours/Sortie	July 1975 - September 1976	
Flight Length (Hrs)	%	Cum %
0-2	8.9	8.9
2-4	18.3	27.2
6-8	31.6	58.8
8-10	19.4	78.2
10-12	3.6	97.8
12-14	1.3	99.1
14-16	0.6	99.7
16+	0.3	100.0

TABLE 2

Since sorties consisting of a single landing comprise a significant portion of all C-5 sorties, namely 58.5% a decision was made to restrict the data used in this study to those sorties having a single landing. That decision permitted the evaluation of sorties (cycles) as a predictive variable while eliminating "noise" that could result from attempting to differentiate among "landings" versus "full stop landings" versus "landing gear cycles" versus "engine cycles," etc.

III. PROCEDURE

This study examined data for the entire C-5 fleet since only 77 aircraft are involved. A special program was developed by Oklahoma City ALC personnel to extract flying hour data and maintenance data from the MADARS system for the period August 1976 - December 1976. As stated previously, "sorties" which consisted of multiple landings were excluded from consideration for this study. Also excluded from consideration in this study was any impact on the tankers that might be used for refueling the C-5 aircraft to accomplish longer length sorties.

The data extracted from the MADARS system consisted of all single landing sorties flown by each C-5 aircraft during the period August 1976 - December 1976. It contained the flight length and maintenance writeups that resulted from each flight, by aircraft serial number.

The data was arrayed in two hour flight length segments for 0-14 hour flights. Flight lengths exceeding 14 hours were excluded since too little data was available for valid analysis. A summary of the data is shown in appendix 1. An explanation of the work unit codes (WUC) is contained in Appendix 2.

As stated above, the maintenance data used in this study were the maintenance writeups that resulted from each single landing sortie. Maintenance writeups do not necessarily result in demands (requisitions) on the wholesale supply system. Ideally, the maintenance data desired is the number of demands on the supply system which result from sorties of various length. Unfortunately, this link was not possible. Certainly data exists regarding the number of demands made against any specific federal stock numbered item. However, it is not possible, with the data used in this study, to track that demand back to a specific sortie. Such a link probably cannot be made without developing a new data system specifically for that purpose. Efforts are being made to determine that relationship. It is felt; however, that regardless of the exact correlation between "maintenance writeups" and "demands", the conclusions drawn from this study relative to the effect of sorties, flying hours, mission type, critical systems, etc. are valid and meaningful. At worst, the conclusions would show only an order of magnitude as opposed to a finite quantitative value.

IV. HYPOTHESES

Three hypotheses were tested:

H_1 - Maintenance rate is dependent on the length of the flight. That is, maintenance rate is a function of flying hours and is not affected by engine startup, takeoffs, landings, equipment cycles on and off, etc.

H_2 - if H_1 is false in the sense that a greater maintenance rate occurs on short flights, then the distribution of maintenance writeups which occur on short flights is the same as the distribution for writeups which occur on longer flights. That is, each work unit code (WUC) accounts for the same percentage of writeups regardless of the length of the flight.

H_3 - The type of mission flown (mission code) has an effect on the number of maintenance writeups. That is, some types of missions are more demanding on the various aircraft systems than other mission types are.

Hypothesis #1 (maintenance rate is flying hour dependent) was evaluated by analyzing the number of maintenance write-ups per flying hour and the number of maintenance writeups per sortie for each flight length (in two hour groupings). If maintenance rate is flying hour related, the number of maintenance writeups per flying hour would be the same regardless of the sortie length. As shown by the last six columns of Appendix 1, the number of maintenance writeups per flying hour decreases monotonically with increased sortie length. Those same six columns of Appendix 1 also show that the number of maintenance writeups per sortie is not monotonically increasing or decreasing, but remains basically constant regardless of the length of the sortie. That data is presented in summary form for all work unit codes (WUC) and with WUC 01-09 excluded. WUC 01-09 are "ground support" actions while the remaining WUCs are "aircraft systems" related (see Appendix 2). The data was analyzed in those two groupings since certain maintenance writeups (WUC 01-09, refueling, aircraft cleaning, inspection, etc.) are related to the fact that a sortie occurred and are independent of the type or length of mission flown. Review of the two groups of data will show that the conclusions relative to the maintenance writeup rate per flying hour and per sortie are the same regardless of which WUC grouping is used. Only the quantitative value of the maintenance writeup rate changes, the overall pattern does not. This relationship is further shown in figures 1 through 4.

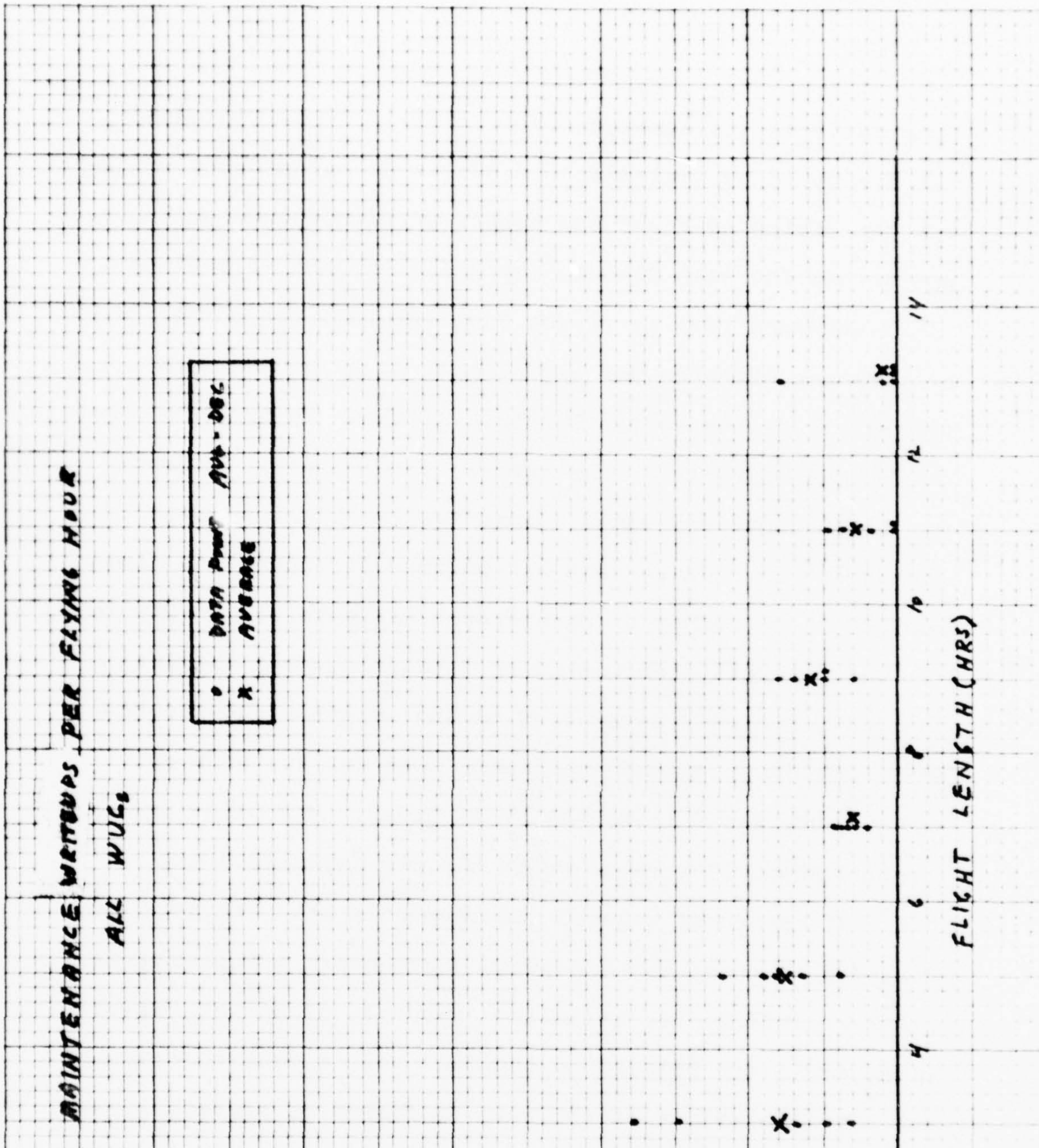
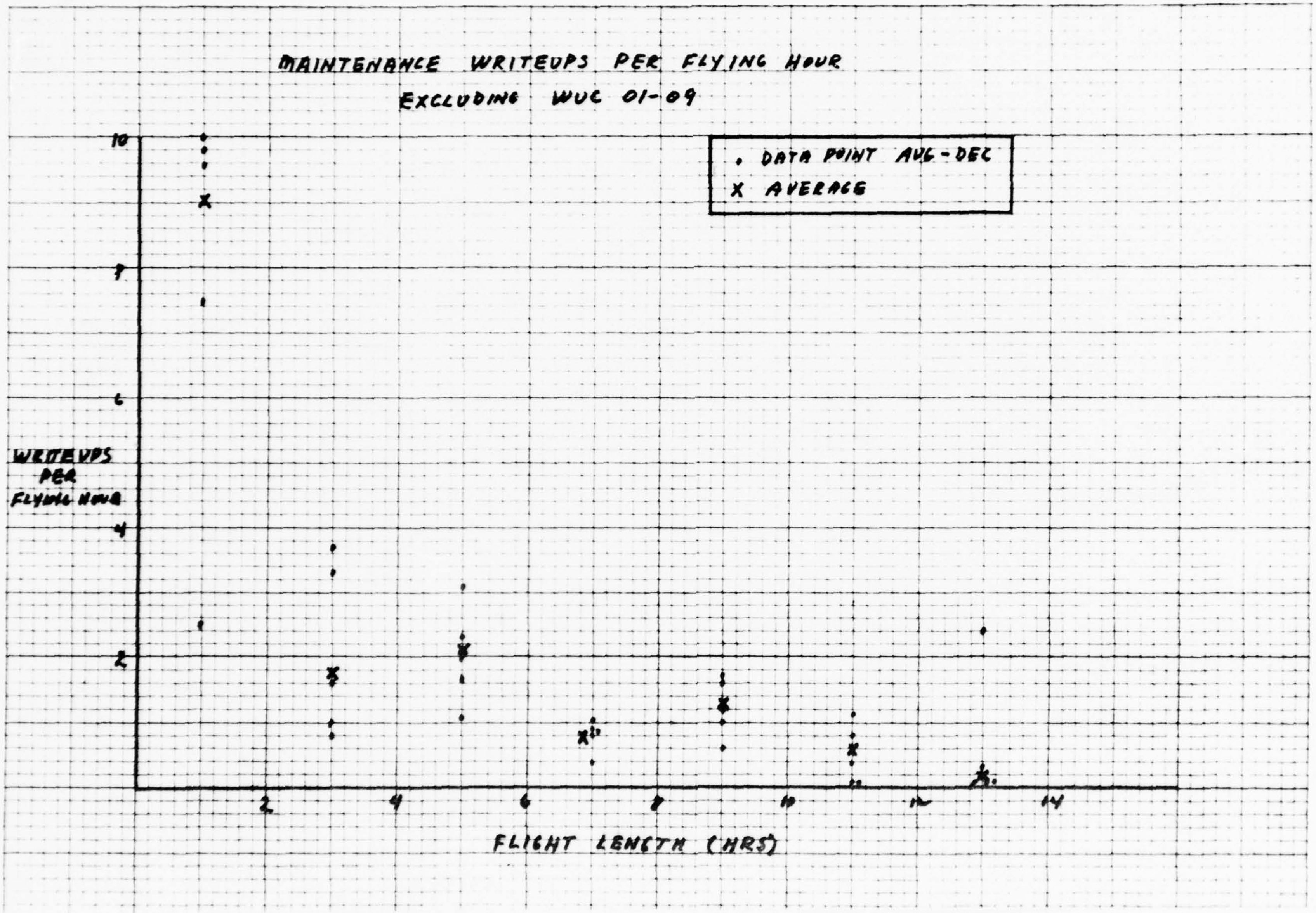
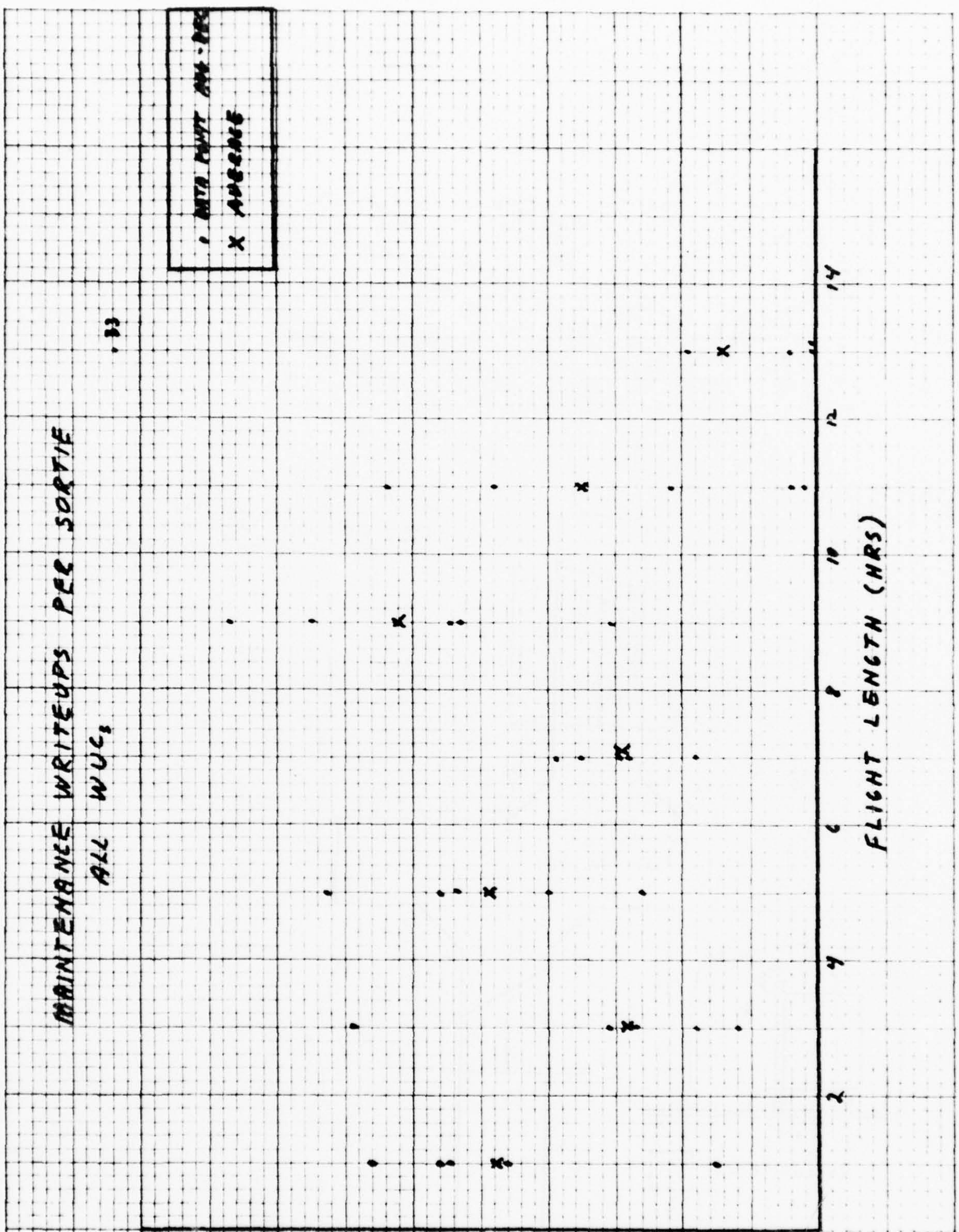

MAINTENANCE WRITEUPS PER FLYING HOUR
ALL WUCs
• DATA POINT AUG - DEC
x AVERAGE
FLIGHT LENGTH (HRS)
2
4
6
8
10
12
14
WRITEUPS PER FLYING HOUR
3
6
9
12

FIGURE 1

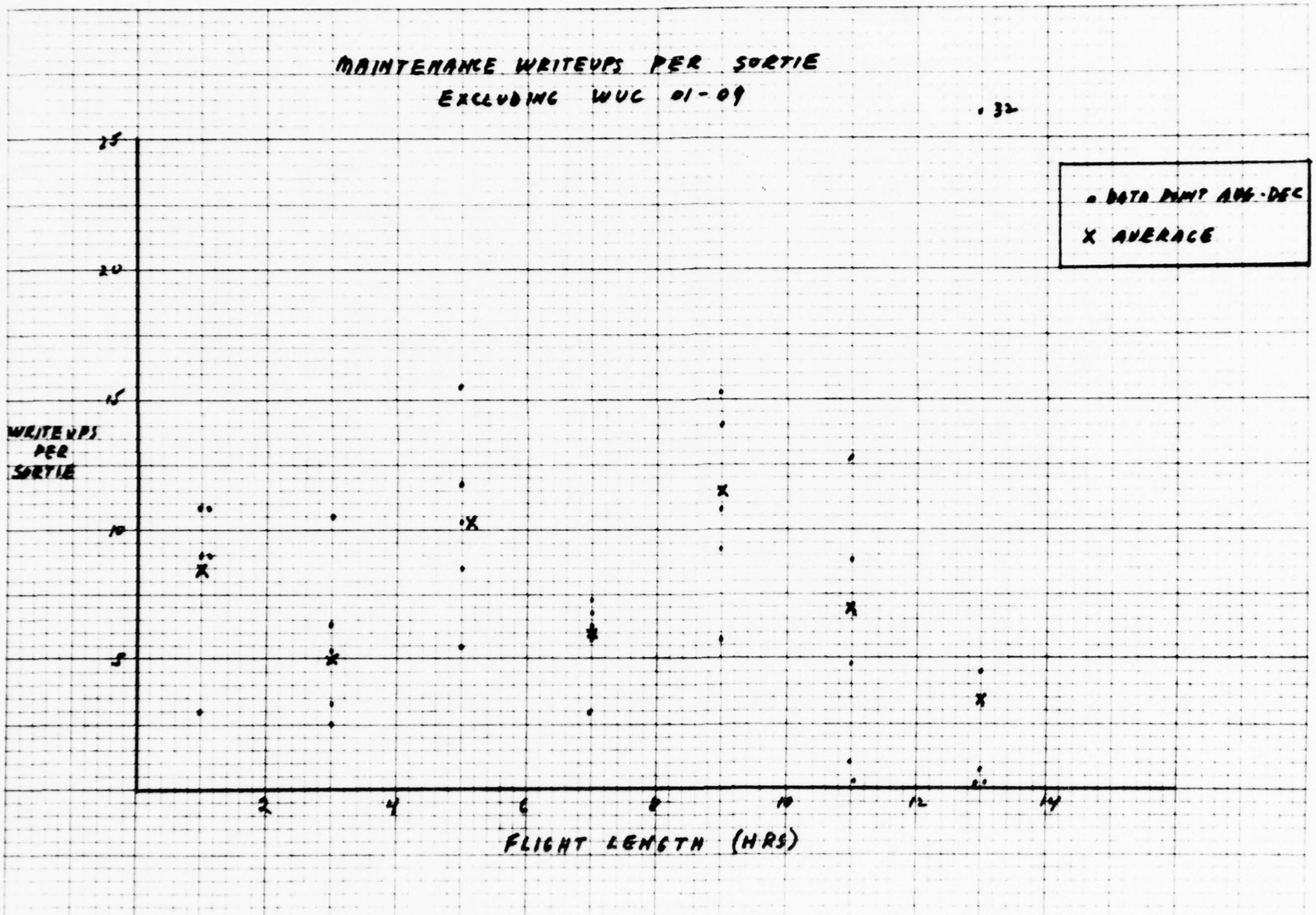


MAINTENANCE WRITEUPS PER FLYING HOUR
EXCLUDING WUC 01-09
• DATA POINT AUG-DEC
X AVERAGE
WRITEUPS PER FLYING HOUR
10
8
6
4
2
4
6
8
10
12
14
FLIGHT LENGTH (HRS)



MAINTENANCE WRITEUPS PER SORTIE
ALL WUCs
· DATA POINT AUG-DE
X AVERAGE
.33
FLIGHT LENGTH (HRS)
2
4
6
8
10
12
14
WRITEUPS PER SORTIE
5
10
15
20
25

FIGURE 3


MAINTENANCE WRITEUPS PER SORTIE
EXCLUDING WUC 01-09
• 32
• DATA POINT AUG-DEC
X AVERAGE
WRITEUPS PER SORTIE
25
20
15
10
5
2
4
6
8
10
12
14
FLIGHT LENGTH (HRS)

Figures 1 and 3 present data for all WUC; figures 2 and 4 present data with WUC 01-09 excluded. Data is plotted for each month August-December 1976 and for each two hour flight length grouping from 0-14 hours. Figures 1 and 2 show a definite curve with relatively little scatter of data. Figures 3 and 4, however, display considerable scatter in the data with no discernable pattern. Even with the severe scatter, it is obvious that neither a monotonically increasing nor a monotonically decreasing relationship exists. Using the average value for each flight length group, the best curve fit is a straightline of constant value.

Hypothesis #2 (each WUC accounts for the same percentage of writeups regardless of the length of the flight) was evaluated by tabulating the percentage of sorties within each flight length grouping and comparing those percentages with the percent of maintenance writeups which fell within each grouping. That tabulation is shown in table 3. This is another way of showing what was presented in the previous section, namely that the rate of maintenance writeups per sortie is relatively uniform over all sortie lengths. Table 4 lists the "ground support" (WUC 01-09) maintenance writeups and the fifteen aircraft systems with the most writeups. A tabulation was made of what percent of writeups

SORTIES AND MAINTENANCE WRITE-UPS AUG 76-DEC 76

FLIGHT LENGTH	SORTIES		MAINT WRITE-UPS (All Work Unit Codes "WUC")		MAINT WRITE-UPS (Excluding WUC-01-09)	
(Hrs)	No.	%	No.	%	No.	%
0-2	230	11.8	2691	12.7	1947	11.9
2-4	370	19.0	2585	12.2	1859	11.4
4-6	457	23.4	5613	26.4	4704	28.8
6-8	348	17.8	2603	12.3	2063	12.7
8-10	447	22.9	6975	32.9	5122	31.4
10-12	77	3.9	680	3.2	537	3.3
12-14	22	1.1	79	0.4	75	0.5

TABLE 3

MAINTENANCE WRITE-UPS AUG 76-DEC 76

FLIGHT LENGTH (HOURS)

WUC	0-2	2-4	4-6	6-8	8-10	10-12	Total
	%	%	%	%	%	%	%
01-09	27.5	28.2	16.2	20.8	26.6	21.1	23.3
11	13.2	13.9	14.8	13.8	15.7	17.5	14.7
23	8.4	8.3	8.2	7.3	7.3	7.6	7.8
13	7.8	6.4	7.9	10.8	6.0	3.8	7.3
72	4.6	5.8	7.5	5.6	6.3	7.9	6.3
55	6.0	5.1	7.9	5.0	5.2	7.1	6.0
41	3.3	4.1	4.1	3.1	4.1	5.1	3.9
51	2.7	3.2	4.2	2.7	3.7	3.2	3.5
12	2.8	3.2	3.6	2.7	3.2	3.1	3.2
44	2.9	2.4	3.4	3.9	3.0	4.0	3.2

TABLE 4

45	3.6	2.6	3.2	4.2	2.7	3.4	3.1
52	2.7	3.2	3.9	2.0	3.1	2.8	3.1
46	2.0	1.6	2.5	2.1	2.4	2.8	2.3
42	2.1	1.9	2.3	2.7	1.6	1.5	2.0
14	2.8	1.5	1.9	1.7	1.0	1.2	1.6
24	1.0	1.3	1.5	1.9	0.9	1.2	1.3
Misc	6.6	7.3	6.8	9.7	7.2	6.7	7.4
Total	100	100	100	100	100	100	100

each WUC accounted for within each flight length as well as overall for the composite of all flights. Review of table 4 indicates that no trend is apparent, either increasing or decreasing, as flight length changes. The question is: Does the distribution of writeups, by WUC, vary significantly for different length flights? A test of independence was carried out using a contingency table. Table 5 classifies maintenance writeups (actual and expected) by WUC and flight length. To obtain the theoretical frequencies (based on the assumption of independence), we apply the marginal percentages for the composite of all flight lengths to the totals for each flight length. Thus the expected frequency for WUC 11 for flight length 0-2 hours is $\frac{3121}{21126}$ X 2691 = 396, etc. To test the hypothesis of independence for table 5, we compute $\sum \frac{(F_{ij} - f_{ij})^2}{f_{ij}}$ where Fij is the actual frequency of row i, column j and fij is the frequency of row i, column j that would be expected based on the hypothesis of independence. That calculation is carried out in table 6. The value of the summation is 481.70. We compare this result with the $\chi^2 0.05$ point for the proper value of n. This sets the risk of rejecting the hypothesis when it is true at 0.05. In this test, n = (number of rows - 1) (number of columns - 1); or (12-1) (6-1) = 55. Most χ^2 tables do not contain values for n 30. For larger values of n the formula: 8 = $\sqrt{2x^2} - \sqrt{2n - 1}$ is used where 8 is the value of a variable measured from its mean and expressed in standard deviation

TABLE 5

FLIGHT LENGTH (HRS)

WUC	0-2 MAINT WRITE-UPS ACTUAL	0-2 EXP	2-4 MAINT WRITE-UPS ACTUAL	2-4 EXP	4-6 MAINT WRITE-UPS ACTUAL	4-6 EXP	6-8 MAINT WRITE-UPS ACTUAL	6-8 EXP	8-10 MAINT WRITE-UPS ACTUAL	8-10 EXP	10-14 MAINT WRITE-UPS ACTUAL	10-14 EXP	TOTAL MAINT WRITE-UPS
01-09	744	624	726	599	909	1301	540	603	1853	1616	147	176	4919
11	354	396	360	380	831	825	359	383	1097	1025	120	112	3121
23	226	210	214	202	459	439	191	203	507	545	62	59	1659
13	211	197	165	189	444	410	280	190	420	510	32	55	1552
72	123	170	150	163	420	354	147	164	437	439	60	48	1337
55	162	162	132	155	441	337	130	156	360	419	51	46	1276
41	90	106	107	102	230	221	81	102	284	274	43	30	835
51	72	94	83	91	236	197	71	91	258	245	25	27	745
12	76	87	84	83	203	181	71	84	220	224	29	24	683
44	79	86	63	82	196	179	102	83	207	222	29	24	676
45	97	85	66	81	182	176	109	82	188	219	25	23	667
OTHER	457	476	435	457	1062	993	522	461	1144	1234	136	134	3756
TOTAL	2691		2585		5613		2103		6975		759		21226

NOTE: The sum of the "expected value" rows and columns may differ slightly from the sum of the "actual value" rows and columns due to rounding.

$$\sum \frac{(F_{ij} - fi_j)^2}{fij}$$

WUC	0-2	2-4	4-6	6-8	8-10	10-14	TOTAL
01-09	23.08	26.93	118.11	6.58	34.76	4.78	214.24
11	4.45	1.05	.04	1.50	4.91	.57	12.52
23	1.22	.71	.91	.71	2.65	.15	6.35
13	.99	3.05	2.82	42.63	15.88	9.62	74.99
72	12.99	1.04	12.31	1.76	.01	3.00	31.11
55	0	3.41	32.09	4.33	8.31	2.63	50.77
41	2.42	.25	.37	4.32	.36	5.63	13.35
51	5.15	.70	7.72	4.40	.69	.15	18.81
12	1.39	.01	2.67	2.01	.07	1.04	7.19
44	.57	4.40	1.61	4.35	1.01	1.04	12.98
45	1.69	2.78	.20	8.89	4.39	.17	18.12
OTHER	.76	1.06	4.79	8.07	6.56	.03	21.27
TOTAL	54.71	45.39	183.64	89.55	79.60	28.81	481.70

TABLE 6

units. The β value corresponding to a 0.05 risk is 1.65. Substituting this value in the formula gives a χ^2 value of approximately 73. Since 481.70 is greater than 73 we conclude that there is a difference in the distribution of maintenance writeups among flight length groupings. Indeed, the difference is so great that we would have rejected the hypothesis of independence at the 0.001 level of significance, since the 0.001 point of the χ^2 distribution for n = 55 is approximately 90. However, as stated above, no trend (either increasing or decreasing) is apparent as flight length changes.

Hypothesis #3 (some types of missions are more demanding on aircraft systems than other missions) was not included in the initial definition of this study. It was added only after a similar study on the F-4 aircraft concluded that mission code was a significant determinant of maintenance writeups. (See Ref. 9) Therefore, the August-October 1976 data extracted for this study did not contain a mission code designation. The addition of mission code was included in the data extracted in November 1976 and December 1976. Those two months of data were analyzed for mission code impact with the following results:

a. Of 401 sorties in November 1976; 270 sorties had a blank mission code, 92 sorties had an "MI" mission code (scheduled transport missions in which the primary objective is the movement of cargo. Ref: AFR 60-1, atch 2, 2 Jan 75), and 39 sorties contained mission codes other than "MI".

b. Of the 363 sorties in December 1976; 199 sorties had a blank mission code, 140 sorties had an "MI" mission code, and 24 sorties contained mission codes other than "MI".

c. The data for November 1976 and for December 1976 were each tested using the Aspin-Welch t test (See Ref. 10) to determine whether there was a significant difference in the maintenance writeups per sortie between "blank" mission code sorties, "MI" mission code sorties and the universe of all mission codes. The Aspin-Welch procedure is used to test the difference between two simple means when σ_1' and σ_2' are unknown and may not be equal. In all cases tested, for both November and December, it was concluded that the samples came from the same universe; that is, "blank" mission code and "MI" mission code have the same maintenance writeup rate per sortie as the universe of all mission codes. Appendices 3 and 4 show the data and the statistical test for November and December respectively.

V. REGRESSION ANALYSIS

A regression analysis was made using data from August 1976 - December 1976. Seven data points were used for each of the five months. The data points for each month correspond to the flight length groupings used throughout the study. The results of the regression analysis are shown in Appendix 5. An analysis was conducted for the total maintenance write-ups observed, all WUC except 01-09, and the 10 aircraft systems having the largest number of maintenance writeups. Review of Appendix 5 brings out the following:

a. The coefficiency of determination was always in the 50-70% range. Hence, it is estimated that flying hours and sorties jointly account for 50-70% of the variance in the number of maintenance write-ups. This is neither an extremely strong nor extremely weak relationship for forecasting maintenance write-ups.

b. The standard error of the estimate ( ) is relatively high in all cases tabulated. This means that the forecast values will vary considerably from the actual values of maintenance write-ups. This substantiates the statement in paragraph a above that the regression fit is not an exceptionally good one.

c. In addition to the regression runs of flying hours and sorties jointly as a predictor of maintenance writeups, two additional sets of runs were made. Flying hours alone were evaluated as a predictor of maintenance writeups and sorties alone were evaluated as a predictor of maintenance writeups. Comparison of the joint runs and the two individual runs shows that in all twelve cases the R^2 for the joint run is higher than either of the R^2s for the individual runs. Additionally, review of appendix 5 shows that for 10 of the 12 groups of WUCs evaluated, the R^2 for sortie was larger than the R^2 for flying hours, although the difference between the two was relatively small in some cases. This indicates that sorties are a slightly better predictor of maintenance writeups than flying hours are. Adding the second variable in the regression run of the joint effect of flying hours and sortie increases the R^2 value about 10%.

VI. CONCLUSIONS

1. The number of maintenance writeups per flying hour decreases monotonically as flight length increases.

2. The number of maintenance writeups per sortie remains constant regardless of flight length.

3. The distribution of maintenance writeups which occur on short flights is not the same as for writeups which occur on longer flights. That is, each work unit code does not account for the same percentage of writeups regardless of the length of the flight. However, no trend increasing or decreasing was observed as flight length increased.

4. The type of mission flown (mission code) is not a significant factor in determining the number of maintenance writeups on the C-5. This results from the fact that most C-5 flights are cargo hauling missions.

VII. OBSERVATIONS

1. A study should be undertaken to relate maintenance write-ups to actual demands on the wholesale logistic system. No current data system was found that could track this relationship. Hence, a new data collection system would have to be designed specifically for this purpose.

2. Forecasts of future requirements should consider "sorties" as well as "flying hours".

3. Further study should be made regarding the impact of mission code on logistics requirements for other aircraft types. Because of the singular type mission (cargo hauling) flown by the C-5A, a true evaluation of mission type could not be accomplished in this study. However, the F-4 study (See Ref. 9) of the logistics impact of changing the sortie length indicated that a strong relationship exists between mission type and maintenance support requirements.

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9. AFLC Technical Report No. 76-7 "Logistics Impact of Sortie Oriented Air Crew Training" (April 1977)

10. Acheson J. Duncan "Quality Control and Industrial Statistics"

11. AU Report 1375-71 "Enroute Base Refueling vs Aerial Refueling for the C-5A in a Strategic Airlift Role"

12. Douglas Report MDA 75-055 "Initial Maintenance Cost Prediction Method"

13. RM 1790 "Factors Affecting Malfunction Rates of F86-F and F86-D Aircraft" (September 1956)

APPENDIX 1

SUMMARY OF DATA

BEST AVAILABLE COPY

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 01 GRND HAND	WUC 02 CLEANING	WUC 03 SCH INSP	WUC 04 SPEC INSP	WUC 05 PRESERV
0-2							
AUG	55	45	25	--	3	6	--
SEP	46	37	87	4	35	73	--
OCT	34	69	111	7	29	13	--
NOV	38	35	77	3	14	7	--
DEC	53	44	139	14	41	18	--
TOTAL	276	230	439	28	122	117	0
2-4							
AUG	314	106	54	1	1	5	--
SEP	165	52	129	4	88	111	4
OCT	124	73	59	2	18	23	--
NOV	224	69	63	6	25	16	--
DEC	232	70	53	4	25	6	--
TOTAL	1059	370	358	17	157	161	4
4-6							
AUG	564	113	75	9	1	9	--
SEP	476	95	160	17	5	22	2
OCT	582	116	179	2	64	20	--
NOV	383	76	67	2	24	9	--
DEC	295	57	121	8	30	7	--
TOTAL	2300	457	602	38	124	67	2
6-8							
AUG	405	56	34	1	13	19	3
SEP	282	39	66	5	2	19	4
OCT	641	91	76	12	1	13	2
NOV	671	93	89	10	14	16	--
DEC	494	69	81	13	1	10	--
TOTAL	2493	348	346	41	31	77	9
8-10							
AUG	761	86	72	4	42	27	1
SEP	583	65	150	5	63	19	--
OCT	770	35	146	4	42	13	2
NOV	982	108	464	29	170	35	--
DEC	927	103	351	19	70	40	1
TOTAL	4023	447	1193	61	387	134	4
10-12							
AUG	65	6	--	--	--	--	--
SEP	106	10	2	--	--	2	--
OCT	230	21	9	--	1	3	--
NOV	219	20	43	--	17	3	--
DEC	215	20	41	--	15	7	--
TOTAL	835	77	95	--	33	15	--
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	1	--	--	--	--
OCT	13	1	--	--	--	--	--
NOV	103	8	1	--	--	--	--
DEC	104	9	2	--	--	--	--
TOTAL	285	22	4	--	--	--	--
GRAND TOTAL	11271	1951	3027	185	854	571	19

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 07 RECORDS	WUC 09 SHOP SUPP	WUC 11 AIRFRAME	WUC 12 COCKPIT COMPART	WUC 13 LND GEAR
0-2							
AUG	55	45	4	2	34	9	12
SEP	46	37	15	--	38	9	23
OCT	84	69	17	--	108	30	65
NOV	38	35	--	--	63	7	54
DEC	53	44	--	--	61	21	57
TOTAL	276	230	36	2	354	[illegible]	211
2-4							
AUG	314	106	2	--	42	10	13
SEP	165	52	19	--	[illegible]	21	30
OCT	124	73	4	--	[illegible]	23	67
NOV	224	69	--	2	65	20	[illegible]
DEC	232	70	--	2	46	10	24
TOTAL	1059	370	25	4	360	34	165
4-6							
AUG	564	113	15	--	[illegible]	[illegible]	46
SEP	476	95	46	2	301	[illegible]	132
OCT	582	116	9	--	223	62	127
NOV	383	76	2	1	100	26	56
DEC	295	57	--	1	39	33	66
TOTAL	2300	457	72	4	831	203	441
6-8							
AUG	405	56	8	--	49	8	9
SEP	282	39	18	--	79	3	15
OCT	641	91	8	--	107	14	74
NOV	671	93	--	2	70	30	59
DEC	494	69	--	--	54	16	123
TOTAL	2493	348	34	2	359	71	280
8-10							
AUG	761	86	15	1	106	16	30
SEP	583	65	26	--	173	23	34
OCT	770	85	36	--	190	40	80
NOV	982	108	1	3	353	60	157
DEC	927	103	1	1	275	31	119
TOTAL	4023	447	79	5	1097	220	420
10-12							
AUG	65	6	--	--	6	--	--
SEP	106	10	--	--	--	--	--
OCT	230	21	--	--	25	4	8
NOV	219	20	--	--	36	8	16
DEC	215	20	--	--	52	9	2
TOTAL	835	77	--	--	119	21	26
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	--	--	1	--	2
OCT	13	1	--	--	--	--	--
NOV	103	8	--	--	--	1	--
DEC	104	8	--	--	--	7	4
TOTAL	285	22	--	--	1	8	6
GRAND TOTAL	11271	1951	246	17	3121	683	1552

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 14 CONTROLS	WUC 23 ENGINE	WUC 24 AUX ENG	WUC 41 AIR COND	WUC 42 POWER SUP
0-2							
AUG	55	45	8	13	--	3	9
SEP	46	37	3	50	8	23	8
OCT	74	69	21	67	7	37	12
NOV	39	35	11	54	4	16	14
DEC	53	44	28	42	7	11	13
TOTAL	276	230	76	226	26	90	56
2-4							
AUG	314	196	2	39	4	18	3
SEP	165	52	16	65	7	43	18
OCT	124	73	6	47	7	29	12
NOV	224	69	3	44	8	13	11
DEC	232	70	13	19	7	13	5
TOTAL	1059	370	40	214	33	107	49
4-6							
AUG	551	113	7	45	9	32	13
SEP	476	95	31	137	26	72	56
OCT	532	116	27	171	24	72	36
NOV	393	76	26	55	14	32	12
DEC	295	57	17	51	9	22	14
TOTAL	2300	457	108	459	82	230	131
6-8							
AUG	405	56	2	22	3	11	8
SEP	292	39	2	19	5	12	9
OCT	641	91	15	62	13	22	13
NOV	671	93	14	46	13	19	24
DEC	491	69	11	46	10	17	15
TOTAL	2493	348	44	191	49	81	69
8-10							
AUG	761	86	2	59	3	23	10
SEP	583	65	5	68	5	45	10
OCT	770	85	11	96	17	52	21
NOV	932	103	29	146	31	69	50
DEC	927	103	25	138	10	95	21
TOTAL	3923	442	72	507	66	284	112
10-12							
AUG	65	6	--	--	--	--	--
SEP	106	10	--	--	--	--	--
OCT	230	21	--	8	2	4	4
NOV	219	20	2	35	3	17	5
DEC	215	20	6	9	3	14	1
TOTAL	835	77	8	52	8	35	10
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	1	5	1	7	4
OCT	13	1	--	--	--	--	--
NOV	193	8	--	1	--	--	--
DEC	104	8	--	4	2	1	2
TOTAL	375	22	1	10	3	8	7
GRAND TOTAL	11271	1951	349	1659	267	835	434

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 44 LIGHT	WUC 45 HYDRAULIC	WUC 46 FUEL	WUC 47 OXYGEN	WUC 49 MISC UTIL	WUC 51 INST
0-2								
AUG	55	45	4	6	2	2	3	--
SEP	46	37	10	17	7	1	5	27
OCT	84	69	41	21	21	10	15	18
NOV	38	35	12	27	16	1	6	10
DEC	53	44	12	26	8	4	--	17
TOTAL	276	230	79	97	54	13	29	72
2-4								
AUG	314	106	5	16	4	3	5	14
SEP	165	52	16	16	6	2	6	23
OCT	124	73	19	8	16	2	8	17
NOV	224	69	14	16	7	1	5	24
DEC	232	70	9	10	9	1	1	5
TOTAL	1059	370	63	66	42	9	25	33
4-6								
AUG	564	113	36	16	14	4	3	29
SEP	476	95	44	40	34	9	19	33
OCT	582	116	61	73	47	12	15	60
NOV	383	76	23	23	17	3	5	30
DEC	295	57	32	25	18	2	14	34
TOTAL	2300	457	196	182	140	35	61	236
6-8								
AUG	405	56	9	7	3	2	4	12
SEP	282	39	19	12	5	5	1	7
OCT	641	91	36	18	12	3	13	15
NOV	671	93	24	33	19	6	10	18
DEC	494	69	14	34	15	4	5	21
TOTAL	2493	348	102	109	54	20	33	71
8-10								
AUG	761	86	17	10	14	4	5	24
SEP	583	65	18	24	12	2	6	32
OCT	770	85	40	38	34	2	17	29
NOV	982	108	71	59	53	10	25	91
DEC	927	103	61	57	51	11	6	82
TOTAL	4023	447	207	188	170	29	59	258
10-12								
AUG	65	6	--	--	--	--	--	--
SEP	106	10	--	--	--	--	--	--
OCT	230	21	1	4	3	1	3	2
NOV	219	20	15	13	10	--	2	13
DEC	215	20	11	6	6	2	1	7
TOTAL	835	77	27	23	19	3	6	22
12-14								
AUG	52	4	--	--	--	--	--	--
SEP	13	1	--	--	2	--	1	2
OCT	13	1	--	--	--	--	--	--
NOV	103	8	1	2	--	1	--	--
DEC	104	8	1	--	1	1	--	1
TOTAL	285	22	2	2	3	2	1	3
GRAND TOTAL	11271	1951	676	667	482	116	214	745

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 52 AUTO PILOT	WUC 55 MADAR	WUC 61 HF COM	WUC 62 VHF COM	WUC 63 UHF COM
0-2							
AUG	55	45	5	18	1	--	1
SEP	46	37	15	43	3	--	3
OCT	84	69	27	44	5	--	6
NOV	38	35	10	27	3	3	3
DEC	53	44	15	30	8	1	2
TOTAL	276	230	72	162	20	4	15
2-4							
AUG	314	106	13	22	2	1	1
SEP	165	52	22	33	5	--	4
OCT	124	73	19	39	5	--	5
NOV	224	69	15	22	5	1	3
DEC	232	70	15	16	5	1	--
TOTAL	1059	370	84	132	22	3	13
4-6							
AUG	564	113	39	83	9	--	1
SEP	476	95	76	147	15	6	7
OCT	582	116	46	110	12	1	13
NOV	383	76	30	70	11	2	3
DEC	295	57	29	31	12	1	--
TOTAL	2300	457	220	441	59	10	24
6-8							
AUG	405	56	9	4	1	1	--
SEP	282	39	5	18	8	--	1
OCT	641	91	20	30	11	--	6
NOV	671	93	5	47	17	4	5
DEC	494	69	13	31	16	1	2
TOTAL	2493	348	52	130	53	6	14
8-10							
AUG	761	86	32	30	16	2	1
SEP	583	65	18	49	5	3	2
OCT	770	85	37	59	18	--	7
NOV	982	108	70	102	20	2	9
DEC	927	103	56	120	38	14	16
TOTAL	4023	447	213	360	97	21	35
10-12							
AUG	65	6	--	--	--	--	--
SEP	106	10	--	--	--	--	--
OCT	230	21	4	10	3	1	--
NOV	219	20	9	25	2	2	1
DEC	215	20	6	13	2	1	1
TOTAL	835	77	19	48	7	4	2
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	--	1	--	--	--
OCT	13	1	--	--	--	--	--
NOV	103	3	--	1	--	--	--
DEC	104	3	1	1	3	--	--
TOTAL	285	22	1	3	3	--	--
GRAND TOTAL	11271	1951	661	1276	261	48	103

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 64 INTERPHONE	WUC 65 IFF	WUC 66 EMER COM	WUC 71 RADIO NAV	WUC 72 RADAR NAV
0-2							
AUG	55	45	1	--	2	--	2
SEP	46	37	6	--	--	6	41
OCT	84	69	8	2	4	9	37
NOV	38	35	2	--	1	7	24
DEC	53	44	6	--	2	9	19
TOTAL	276	230	23	2	9	31	123
2-4							
AUG	314	106	--	2	--	5	22
SEP	165	52	8	--	--	8	48
OCT	124	73	12	2	3	5	37
NOV	224	69	7	--	4	5	29
DEC	232	70	3	1	3	3	14
TOTAL	1059	370	30	5	10	26	150
4-6							
AUG	564	113	10	--	1	6	47
SEP	476	95	9	3	9	23	123
OCT	582	116	21	3	7	22	113
NOV	383	76	5	1	3	8	63
DEC	295	57	5	2	3	10	69
TOTAL	2300	457	50	9	23	69	420
6-8							
AUG	405	56	1	--	1	3	11
SEP	282	39	3	--	6	2	23
OCT	641	91	10	2	9	14	41
NOV	671	93	4	1	5	8	37
DEC	494	69	6	--	6	7	35
TOTAL	2493	348	24	3	27	34	147
8-10							
AUG	761	86	8	--	4	13	43
SEP	583	65	9	--	1	10	48
OCT	770	85	24	1	3	21	74
NOV	982	108	16	11	15	20	152
DEC	927	103	16	3	12	29	120
TOTAL	4023	447	73	15	35	93	437
10-12							
AUG	65	6	--	--	--	--	--
SEP	106	10	--	--	--	--	--
OCT	230	21	--	--	--	1	11
NOV	219	20	3	1	2	9	26
DEC	215	20	2	--	1	1	17
TOTAL	835	77	5	1	3	11	54
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	2	--	--	1	2
OCT	13	1	--	--	--	--	--
NOV	103	8	--	--	--	--	--
DEC	104	9	1	1	--	--	4
TOTAL	285	22	3	1	--	1	6
GRAND TOTAL	11271	1951	208	36	107	265	1337

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	WUC 91 EMER EQPT	WUC 97 [redacted] FIRE EXT	TOTAL	MAINT. ACTIONS PER FLY HR	MAINT. ACTIONS PER SORT
0-2							
AUG	55	45	--	--	175	3.18	3.89
SEP	46	37	2	--	617	13.41	16.68
OCT	84	69	5	8	805	9.58	11.67
NOV	38	35	4	1	481	12.66	13.74
DEC	53	44	2	--	613	11.56	13.93
TOTAL	276	230	13	9	2691	9.75	11.70
2-4							
AUG	314	106	4	2	320	1.02	3.02
SEP	165	52	2	14	897	5.44	17.25
OCT	124	73	4	2	569	4.59	7.79
NOV	224	69	--	12	472	2.11	6.84
DEC	232	70	3	1	327	1.40	4.67
TOTAL	1059	370	13	31	2585	2.44	6.98
4-6							
AUG	564	113	6	--	726	1.29	6.42
SEP	476	95	11	1	1729	3.63	18.20
OCT	582	116	8	2	1642	2.82	14.16
NOV	383	76	4	5	757	1.98	9.96
DEC	295	57	3	1	759	2.57	13.31
TOTAL	2300	457	32	9	5613	2.44	12.28
6-8							
AUG	405	56	--	--	256	.63	4.57
SEP	282	39	6	--	379	1.34	9.72
OCT	641	91	4	2	678	1.06	7.45
NOV	671	93	6	11	676	1.01	7.27
DEC	494	69	11	--	614	1.24	8.89
TOTAL	2493	348	27	13	2603	1.04	7.47
8-10							
AUG	761	86	1	7	660	.87	7.67
SEP	583	65	4	--	866	1.49	13.32
OCT	770	85	3	--	1157	1.50	13.61
NOV	932	108	14	14	2351	2.39	21.77
DEC	927	103	10	1	1941	2.09	18.84
TOTAL	4023	447	32	22	6975	1.73	15.60
10-12							
AUG	65	6	--	--	6	.09	1.00
SEP	106	10	--	--	4	.03	.40
OCT	230	21	--	--	112	.50	5.33
NOV	219	20	--	1	319	1.45	15.95
DEC	215	20	3	--	239	1.11	11.95
TOTAL	835	77	3	1	680	.81	8.33
12-14							
AUG	52	4	--	--	--	--	--
SEP	13	1	--	--	33	2.53	33.00
OCT	13	1	--	--	--	--	--
NOV	103	8	--	--	8	.07	1.00
DEC	104	8	--	--	38	.36	4.75
TOTAL	235	22	--	--	79	.27	3.59
GRAND TOTAL	11271	1951	120	85	21226	1.88	10.87

C-5 FLYING HOURS & MAINTENANCE ACTIONS FOR ALL AIRCRAFT
AUGUST 1976 - NOVEMBER 1976

FLIGHT LENGTH	FLYING HOURS	SORTIES	TOTAL EXCLUDING 01-09	MAINT. ACTIONS PER FLY HR	MAINT. ACTIONS PER SORT
0-2					
AUG	55	45	135	2.45	3.00
SEP	46	37	403	9.76	10.89
OCT	84	69	628	7.48	9.10
NOV	38	35	380	10.00	10.86
DEC	53	44	401	7.56	9.11
TOTAL	276	230	1947	7.05	8.46
2-4					
AUG	314	106	257	.82	2.42
SEP	165	52	542	3.28	10.42
OCT	124	73	463	3.73	6.34
NOV	224	69	360	1.61	5.22
DEC	232	70	237	1.02	3.38
TOTAL	1059	370	1859	1.75	5.02
4-6					
AUG	564	113	617	1.09	5.46
SEP	476	95	1475	3.10	15.53
OCT	582	116	1368	2.35	11.79
NOV	383	76	652	1.70	8.53
DEC	295	57	592	2.00	10.39
TOTAL	2300	457	4704	2.04	10.29
6-8					
AUG	405	56	178	.44	3.13
SEP	282	39	265	.94	6.79
OCT	641	91	566	.88	6.22
NOV	671	93	545	.81	5.86
DEC	494	69	509	1.03	7.37
TOTAL	2493	348	2063	.82	5.92
8-10					
AUG	761	86	498	.65	5.79
SEP	583	65	603	1.03	9.28
OCT	770	85	914	1.19	10.75
NOV	982	108	1649	1.63	15.27
DEC	927	103	1458	1.57	14.15
TOTAL	4023	447	5122	1.27	11.45
10-12					
AUG	65	6	6	.09	1.00
SEP	106	10	--	--	--
OCT	230	21	99	.43	4.71
NOV	219	20	256	1.16	12.80
DEC	215	20	176	.81	8.80
TOTAL	835	77	537	.64	6.97
12-14					
AUG	52	4	--	--	--
SEP	13	1	32	2.46	32.00
OCT	13	1	--	--	--
NOV	103	8	7	.06	.87
DEC	104	8	36	.34	4.50
TOTAL	285	22	75	.26	3.40
GRAND TOTAL	11271	1951	16307	1.44	8.35

APPENDIX 2

EXPLANATION OF WORK UNIT CODES (WUC)

C-5A Ref: TO 1C-C5A-06

WUC	DESCRIPTION
01	Ground Handling, Servicing and Related Tasks
02	Aircraft Cleaning
03	Scheduled Inspections
04	Special Inspections
05	Preservation, Depreservation, and Storage
06	Arming and Disarming
07	Preparation and Maintenance of Records
09	Shop Support General Codes
11	Airframe
12	Cockpit and Fuselage Compartments
13	Landing Gear
14	Flight Controls
23	Turbofan Power Plant System
24	Auxiliary Power Plant System
41	Air Conditioning, Pressurization, and Surface Ice Control
42	Electrical Power Supply
44	Lighting System
45	Hydraulic and Pneumatic Power Supply
46	Fuel System
47	Oxygen System
49	Miscellaneous Utilities

51	Instruments
52	Autopilot
55	Malfunction Detection Analysis/Recording System
61	HF Communications
62	VHF Communications
63	UHF Communications
64	Interphone
65	IFF
66	Emergency Communications
71	Radio Navigation
72	Radar Navigation
91	Emergency Equipment
97	Explosive Devices and Components

APPENDIX 3

MISSION CODE ANALYSIS

NOVEMBER 1976

NOVEMBER 1976

	BLANK MISSION CODE			MI MISSION CODE			OTHERS			TOTAL		
FLIGHT LENGTH	SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE
0-1	13	148	11.38	1	39	39.00	1	-	0	15	187	12.46
1-2	9	220	24.44	6	9	1.50	5	65	13.00	20	294	14.70
2-3	13	111	8.53	4	26	6.50	1	4	4.00	18	141	7.23
3-4	29	205	7.06	13	4	.30	9	122	13.55	51	331	6.49
4-5	27	240	8.88	1	-	0	7	78	11.14	35	318	9.08
5-6	24	285	11.87	12	76	6.33	5	78	15.60	41	439	10.70
6-7	19	158	8.31	6	40	6.66	2	32	16.00	27	230	8.51
7-8	44	387	8.79	16	43	2.68	6	16	2.66	66	446	6.75
8-9	34	405	11.91	9	28	3.11	1	-	0	44	433	9.84
9-10	44	1292	29.36	18	521	28.94	2	95	47.5	64	1908	29.81
TOTAL	256	3451	13.48	86	786	9.13	39	490	12.56	381	4727	12.40

ASPIN-WELCH TEST (SEE REF 10)

November 1976

X_1 = Blank Mission Code

X_2 = M1 Mission Code

X_3 = Total of All Mission Codes

$\bar{X}_1$ = 13.48 Maintenance Write-ups per Sortie

$\bar{X}_2$ = 9.13 Maintenance Write-ups per Sortie

$\bar{X}_3$ = 12.40 Maintenance Write-ups per Sortie

$$S_1^2 = \frac{\sum (X_1-\bar{X}_1)^2}{N_1-1} = 57.48 \qquad \frac{S_1^2}{N_1} = \frac{57.48}{10} = 5.748$$

$$S_2^2 = \frac{\sum (X_2-\bar{X}_2)^2}{N_2-1} = 178.08 \qquad \frac{S_2^2}{N_2} = \frac{178.08}{10} = 17.808$$

$$S_3^2 = \frac{\sum (X_3-\bar{X}_3)^2}{N_3-1} = 47.96 \qquad \frac{S_3^2}{N_3} = \frac{47.96}{10} = 4.796$$

$$C_{12} = \frac{5.748}{5.748 + 17.808} = .2440$$

$$C_{13} = \frac{5.748}{5.748 + 4.796} = .5451$$

$$C_{23} = \frac{17.808}{17.808 + 4.796} = .7878$$

ASPIN-WELCH TEST (Cont'd)

November 1976

$$\frac{1}{n_{12}} = \frac{C_{12}^2}{N_1-1} + \frac{(1-C_{12})^2}{N_2-1} = \frac{.0595 + .5715}{} = .0701 \quad ; n_{12} = 14$$

$$\frac{1}{n_{12}} = \frac{C_{13}^2}{N_1-1} + \frac{(1-C_{13})^2}{N_3-1} = \frac{.2971 + .2069}{9} = .0560 \quad ; n_{13} = 18$$

$$\frac{1}{n_{23}} = \frac{C_{23}^2}{N_2-1} + \frac{(1-C_{23})^2}{N_3-1} = \frac{.6206 + .0450}{9} = .0739 \quad ; n_{23} = 14$$

$$t_{12} = \frac{13.48 - 9.13}{5.748 + 17.808} = .8963 \quad ; P = .3$$

$$t_{13} = \frac{13.48-12.40}{5.748 + 4.796} = .3326 \quad ; P = .7$$

$$t_{23} = \frac{9.13 - 12.40}{17.808 + 4.796} = -.6878 \quad ; P = .5$$

In all cases tested, we conclude that the samples came from the same universe; that is, "blank" mission code and "M1" mission code have the same maintenance writeup rate per sortie as the universe of all mission codes.

APPENDIX 4

MISSION CODE ANALYSIS

DECEMBER 1976

DECEMBER 1976

FLIGHT LENGTH	BLANK MISSION CODE SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	MI MISSION CODE SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	OTHERS SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE	TOTAL SORTIES	WRITE-UPS (ALL WUC)	WRITE-UPS PER SORTIE
0-1	8	239	29.87	3	10	3.33	2	19	9.50	13	268	20.61
1-2	19	204	10.73	11	55	5.00	1	36	36.00	31	345	11.12
2-3	6	58	9.66	5	16	3.20	2	16	8.00	13	90	6.92
3-4	31	195	6.29	21	1	.04	5	41	8.20	57	237	4.15
4-5	13	298	22.92	2	18	9.00	4	40	10.00	19	356	18.73
5-6	23	292	12.69	13	65	5.00	2	48	24.00	38	405	10.65
6-7	15	222	14.80	4	2	.50	5	47	9.40	24	271	11.29
7-8	24	137	5.70	19	101	5.31	2	16	8.00	45	254	5.64
8-9	16	97	6.06	35	770	22.00	-	-	-	51	867	17.00
9-10	30	706	23.53	21	368	17.52	1	-	-	52	1074	20.65
TOTAL	185	2448	13.23	134	1406	10.49	24	313	13.04	343	4167	12.14

ASPIN-WELCH TEST (SEE REF 10)

December 1976

X_1 = Blank Mission Code

X_2 = M1 Mission Code

X_3 = Total of All Mission Codes

$\overline{X}_1$ = 13.23 Maintenance Write-ups per Sortie

$\overline{X}_2$ = 10.49 Maintenance Write-ups per Sortie

$\overline{X}_3$ = 12.14 Maintenance Write-ups per Sortie

$$S_1^2 = \frac{\sum (X_1-\overline{X}_1)^2}{N_1-1} = 72.85 \qquad \frac{S_1^2}{N_1} = \frac{72.85}{10} = 7.285$$

$$S_2^2 = \frac{\sum (X_2-\overline{X}_2)^2}{N_2-1} = 64.94 \qquad \frac{S_2^2}{N_2} = \frac{64.94}{10} = 6.494$$

$$S_3^2 = \frac{\sum (X_3-\overline{X}_3)^2}{N_3-1} = 38.63 \qquad \frac{S_3^2}{N_3} = \frac{38.63}{10} = 3.863$$

$$C_{12} = \frac{7.285}{7.285+6.494} = 5.287$$

$$C_{13} = \frac{7.285}{7.285+3.863} = .6534$$

$$C_{23} = \frac{6.494}{6.494+3.863} = .6270$$

ASPIN-WELCH TEST (Cont'd)

December 1976

$$\frac{1}{n_{12}} = \frac{C_{12}^2}{N_1-1} + \frac{(1-C_{12})^2}{N_2-1} = \frac{.2795 + .2221}{9} = .0550 \quad ; \quad n_{12} = 18$$

$$\frac{1}{n_{13}} = \frac{C_{13}^2}{N_1-1} + \frac{(1-C_{13})^2}{N_3-1} = \frac{.4269 + .1201}{9} = .0607 \quad ; \quad n_{13} = 17$$

$$\frac{1}{n_{23}} = \frac{C_{23}^2}{N_2-1} + \frac{(1-C_{23})^2}{N_3-1} = \frac{.3931 + .1391}{9} = .0591 \quad ; \quad n_{23} = 17$$

$$t_{12} \quad \frac{13.23 - 10.49}{\sqrt{7.285 + 6.494}} = .7385 \quad ; \quad P = .4$$

$$t_{13} \quad \frac{13.23 - 12.14}{\sqrt{7.285 + 3.863}} = .3263 \quad ; \quad P = .7$$

$$t_{23} \quad \frac{10.49 - 12.14}{\sqrt{6.494 + 3.863}} = .5124 \quad ; \quad P = .6$$

In all cases tested, we conclude that the samples came from the same universe; that is, "blank" mission code and "M1" mission code have the same maintenance writeup rate per sortie as the universe of all mission codes.

APPENDIX 5

REGRESSION ANALYSIS

REGRESSION ANALYSIS

Based on 1951 sorties, 11271 flying hours, August - December 1976.

Regression Equation is in the form:

$$Y = C + AX_1 + BX_2$$

Y = Number of maintenance writings

C = A constant

A = Coefficient of variable X_1

X_1 = Number of flying hours

B = Coefficient of variable X_2

X_2 = Number of sorties

R^2 = Coefficient of determination

σ = Standard error of the estimate

WUC = Work unit code

R^2FH = Coefficient of determination when only flying hours are used as a predictor of maintenance writings

R^2S = Coefficient of determination when only sorties are used as a predictor of maintenance writeups.

GROUP	DESCRIPTION	MAINT WRITEUPS (ACTUAL)	R^2	σ	C	A	B	R^2FH	R^2S
ALL WUC		21226	0.643	353.487	-54.676	0.858	6.905	0.568	0.575
ACFT SYSTEMS	Excluding WUC 01-09	16307	0.667	262.687	-58.430	0.598	5.950	0.571	0.611
WUC 11	Airframe	3121	0.624	55.607	- 8.142	0.151	0.873	0.572	0.534
WUC 23	Turbofan Power Plant	1659	0.629	27.897	- 5.060	0.043	0.691	0.503	0.600
WUC 13	Landing Gear	1552	0.581	29.415	- 5.744	0.040	0.666	0.462	0.555
WUC 72	Radar Navigation	1337	0.621	24.536	- 4.983	0.061	0.420	0.559	0.543
WUC 55	Malfunction Detection Analysis Recording System	1276	0.601	24.007	- 6.634	0.026	0.620	0.453	0.585
WUC 41	Air Conditioning Pressurization & Surface Ice Cont.	835	0.588	15.715	- 2.293	0.034	0.275	0.518	0.526
WUC 51	Instruments	745	0.566	16.227	- 4.200	0.036	0.248	0.509	0.495
WUC 12	Cockpit & Fuselage Compartments	683	0.647	11.955	- 3.491	0.024	0.272	0.546	0.600
WUC 44	Lighting System	676	0.661	11.414	- 3.032	0.027	0.244	0.574	0.599
WUC 45	Hydraulic & Pneumatic Power Supply	667	0.590	11.963	- 1.359	0.021	0.243	0.497	0.548