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CRITICAL EXAMINATION OF C-130 PROGRAMMED DEPOT MAINTENANCE (PDM) INDUCTION METHODOLOGY: DETERMINING PDM INTERVALS

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Maj. John A. Daniels

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Preface

This paper examines the current USAF criteria for inducting C-130 aircraft into programmed depot maintenance (PDM) based on the mission, design, series (MDS) of the aircraft. An alternative approach using an analytical model is developed to attempt to refine the current process. I became interested in refining C-130 PDM intervals while serving as the C-130 Structural Engineering Branch Chief in the C-130 System Program Office (SPO). It was my observation that many C-130 operators and maintainers did not understand how the PDM intervals had been established over the many years of C-130 operations.

I would like to thank Colonel Gregory A. Siegel, C-130 System Program Director, for sponsoring this research effort and giving his support to my interviews and correspondence with C-130 SPO personnel. The superb technical support of Mr. Raymond Waldbusser, C-130 Aircraft Structural Integrity Manager (ASIP), was invaluable in completing this research. Mr. Waldbusser provided critical data for this effort and provided common sense answers to difficult questions. Finally, I would like to express my gratitude to Major Marsha Kwolek, ACSC/DEC, for serving as my Faculty Research Advisor and providing guidance and direction during the preparation of this paper.

Abstract

The current USAF process for establishing intervals between C-130 PDM does not account for the wide range of aircraft variables within each aircraft MDS. This paper develops an analytical model, based on five unique aircraft variables, to provide C-130 maintainers with a prediction tool to forecast when a C-130 aircraft requires PDM. These five variables include: aircraft age, total flying hours, average yearly flying hours, mission profile (expressed as a severity factor), and operating location of the aircraft. Interviews with C-130 SPO personnel, combined with use of the *C-130 Service Life Data Base*, provided the required data to develop the C-130 PDM interval model.

The C-130 PDM interval model developed in this paper allows maintainers and operators to predict the optimum time between C-130 PDM activities. It eliminates the requirement to base PDM intervals on aircraft MDS. As a result, there is a potential for significant savings by deferring PDM for a portion of the C-130 fleet. Finally, the PDM interval model developed in this paper may be applicable for other DOD aircraft which use aircraft MDS as the determinant of PDM intervals.

Chapter 1

Introduction

> *The existing procedures by which the Air Force is currently managed have served it well, but times have changed; procedures must be reviewed to determine which ones can be kept, which ones must be changed, and where shortcomings suggest new procedures are required, which ones must be added.*
>
> —USAF Scientific Advisory Board

Since the C-130 Hercules made its first flight in 1954, over 2000 aircraft have rolled off the C-130 production line in Marietta, Georgia. For most of these four decades, maintainers have struggled with developing and refining procedures to maintain the C-130 fleet.

The current C-130 programmed depot maintenance (PDM) process is complex and is governed by numerous technical orders and policy directives. Just as the Air Force is reengineering the sustainment of aircraft components under the "lean logistics" banner, the current aircraft PDM process is in need of similar scrutiny. The often over used slogan "just in time repair" has as much relevance to aircraft PDM as it does to repairing line replaceable units (LRUs). Inducting a C-130 aircraft into PDM typically costs close to one million dollars and takes the aircraft away from the operator for 120 days.[1] If an aircraft PDM can be deferred one or more years, the cost savings in terms of both money and aircraft downtime are significant, especially considering the size of the C-130 fleet.

Therefore, an analytical model which predicts when a C-130 aircraft requires PDM is a worthy endeavor.

The purpose of this paper is to develop an analytical model to provide C-130 maintainers with a tool to predict the time between PDM activities. The time between PDM is referred to as the PDM interval. A detailed discussion of the composition of the C-130 fleet and the current method of determining PDM intervals will provide the background necessary to develop the proposed C-130 PDM interval model.

Notes

[1] C-130 System Program Office, 16 October 1996 Interview. Aircraft Structural Integrity Manager, WR-ALC/LBR.

Chapter 2

The C-130 Fleet

> *The [C-130] Hercules genealogist soon learns that some of the boughs of the C-130 tree are about to break with the weight of the number of variants that have proliferated since the birth of mama and papa back in Burbank [California].*
>
> —*C-130 The Hercules*

The C-130 Hercules has indeed been a workhorse for the Department of Defense (DOD) since 23 August 1954, when the new turboprop transport aircraft made its first flight.[1] The success of the C-130 aircraft is one reason operators around the world are now maintaining a weapon system that is often times older than the pilots who fly them.

The USAF maintains and operates a fleet of over 700 C-130 aircraft (see Table 1). These aircraft are operated by six major commands (MAJCOMs), the Air National Guard (ANG), and the Air Force Reserve (AFRES). In addition to multiple operators, USAF C-130s are based in 56 locations around the world. These locations possess a variety of climates which result in a wide range of corrosive effects within the C-130 fleet. In addition, the C-130 fleet boasts an extremely diverse set of missions. From fighting forest fires to providing close air support, the C-130 has proved itself as a highly adaptable platform. "In all, there have been more than fifty *major* versions just in the U.S."[2] As you might expect, multiple operators, numerous operating locations, and a wide range of mission profiles have greatly complicated the development of a "one size fits all" maintenance strategy for the fleet. These complications impact the establishment of PDM intervals for the C-130 fleet.

Table 1. USAF Summary of C-130 Aircraft by Operator

MDS	ACC	AETC	AFMC	AFRES	AFSOC	ANG	PACAF	USAFE	TOTAL
NC-130A			1						1
C-130E	106			35	4	73	8	19	245
EC130E	7					8			15
MC-130E				6	8				14
NC-130E			1						1
C-130H	40			80		146	21		287
AC-130H					8				8
EC-130H	14		1						15
LC-130H						7			7
MC-130H		3			21				24
NC-130H			2						2
WC-130H				10					10
C-130J	2								2
HC-130N				4		6			10
HC-130P	9			5		7			21
MC-130P		4		5	19				28
AC-130U			1		12				13
TOTAL	178	7	6	145	72	247	29	19	703

Source: Program Management/Configuration Control and Tracking System (PM/CCAT), C-130 System Program Office, Robins AFB GA, 14 November 1996.

Notes

[1] Peacock, Lindsay. *Mighty Hercules The First Four Decades*. Royal Air Force Benevolent Fund Enterprises, 1994.

[2] Ibid., 1.

Chapter 3

Current Method for Determining PDM Intervals

> *The maintenance engineering objective is to assure that the best, most timely, and most economical means, consistent with mission requirements, are used to satisfy all approved requirements.*
>
> *—Depot Maintenance of Aerospace Vehicles and Training Equipment*

The current PDM intervals for the C-130 fleet are prescribed in USAF Technical Order 00-25-4, *Depot Maintenance of Aerospace Vehicles and Training Equipment*. The current intervals (depicted in Table 2) are based on the mission, design, series (MDS) of the C-130. Note from Table 2 that the current PDM intervals vary from 48 months to 69 months, depending on the MDS and operating location (for PACAF bases only) of the aircraft. For example, the AC-130H gunship operated by Air Force Special Operations Command (AFSOC) has a PDM interval of 48 months, while a "typical" C-130H (which carries cargo and performs airdrops) has a PDM interval of 69 months.

Current PDM intervals are reviewed regularly by WR-ALC engineers, who consider numerous factors.[1] First, the MDS of the aircraft and the mission profiles flown by the aircraft are considered. For example, AFSOC C-130s operate under very stressful conditions, including carrying heavy payloads and often flying at low altitudes, many times over salt water or sand.[2]

Table 2. Current C-130 PDM Intervals

MDS Designation	PDM Interval (months)
AC-130H*	48
MC-130E*	48
PACAF C-130s	48
AC-130H	60**
WC-130H	60**
MC-130E	60**
C-130E	69***
C-130H	69***
HC-130H	60***
HC-130N	60***
HC-130P	60***
MC-130H	60****
AC-130U	60****

*** aircraft with TO 1C-130-1340 wing**
**** Mid-interval inspection at 30 months**
***** 78-0806 and subsequent - initial PDM at 168 months**
****** Initial PDM at 144 months**

Source: USAF Scientific Advisory Board, *Life Extension and Mission Enhancement for Air Force Aircraft*, Volume II, August 1994, 1.

For this reason, the PDM intervals for AFSOC aircraft are typically lower than those for the rest of the C-130 fleet. Note also from Table 2 that the PACAF C-130s have a 48-month PDM interval. This shorter interval is due to the highly corrosive environment found at PACAF installations.[3] It is important to note that PDM is considered preventative maintenance and the primary driver for C-130 PDM is corrosion.[4]

There are many other factors that are currently used to determine PDM intervals. For example, product improvements, such as a new center wing, and improved materials used on newer model C-130s. Also, the Aircraft Structural Integrity Program (ASIP) is a big player in the PDM process. ASIP provides a time-phased set of actions to be performed at optimum times during the life cycle of the weapon system to ensure the structural integrity and service life of the aircraft.[5] ASIP is primarily concerned with fatigue cracking of the aircraft structure, not corrosion. Another factor in determining PDM intervals is the analytical condition inspection (ACI). ACIs are used to systematically disassemble and inspect a representative sample of aircraft to find deficiencies in the aircraft structure. An additional factor used to adjust PDM intervals is the controlled interval inspection (CIE). CIEs look at a representative number of aircraft to decide if the PDM interval can be extended.

In conjunction with the aircraft manufacturer (Lockheed-Martin), the C-130 SPO is also developing the aircraft corrosion tracking system (ACTS). The ultimate goal of ACTS is to be able to predict where on the aircraft corrosion will occur.[6] In addition, the corrosion and repair recording (CARR) program is used to feed data into ACTS. Dobbins AFB is now using ACTS, as is the Baltimore ANG. Other units are currently sending their corrosion-related data to the C-130 SPO, pending worldwide implementation of ACTS and CARR. Finally, discrepancies found during PDM are evaluated for their effect on PDM intervals.

As you can see, the C-130 SPO currently generates a great deal of PDM-related data that affects PDM intervals. However, integrating this data into a cohesive, understandable PDM interval predictor is very difficult.

Notes

[1] Jackson, Capt Dee J. and Kramer, Capt Edward R. *Letter Report Review of Air Force Depot Induction Frequencies*, Air Force Logistics Management Agency, June 1994.

[2] USAF Scientific Advisory Board, *Life Extension and Mission Enhancement for Air Force Aircraft*, Volume II, August 1994.

[3] Ibid., 3.

[4] Ibid.

[5] Ibid., 1.

[6] Ibid., 3.

Chapter 4

Alternative Approach to Determining PDM Intervals

> *The real challenge is not to put a new idea into the military mind but to put the old one out.*
>
> —Sir Basil Liddell Hart

As discussed in some detail in the preceding chapter, a lot of effort has gone into determining the current C-130 PDM intervals. But is the current method of establishing PDM intervals, based on the MDS of the aircraft, the optimum criterion? Is there a viable alternative approach to establishing PDM intervals based on the "uniqueness" of each C-130 aircraft (even among those with the same MDS). The purpose of this chapter is to determine if an analytical model can be developed to facilitate "just in time PDM" for the C-130 fleet. If one considers the analogy of maintaining an automobile, is it reasonable to assume that *all* Pontiac Firebird owners should overhaul their engines and paint their cars after a specified time interval? Perhaps not, so let us develop a systematic process to determine PDM intervals.

In order to develop a C-130 PDM interval model, we need to consider the primary factors that affect PDM intervals. For simplicity, let us assume the primary variables which affect the PDM interval for a specific aircraft are: aircraft age, flying hour total, average yearly flying hours, mission profile, and operating location of the aircraft. Bear in mind the variables selected here are not as important as the methodology used to develop the PDM interval model. One advantage of developing a model is that C-130 maintainers and operators can tailor the model based on the factors they believe are most important. They may decide other factors may be equally important (e.g. maintenance practices, number of landings, etc.). To further simplify this analysis, I will consider the 291 C-130H model aircraft only. Recall from Chapter 3, TO 00-25-4 specifies the PDM interval for C-130H aircraft to be 69 months (with the exception of PACAF C-130H aircraft, which have a PDM interval of 48 months).

Primary Factors That Affect PDM Intervals

First, the age of an aircraft can reasonably be expected to affect PDM intervals. One might expect that the older an aircraft, the more likely the aircraft is to experience corrosion damage. The USAF Scientific Advisory Board noted ". . . intervals between programmed depot maintenance are increasing, which is inconsistent with maintenance requirements for aging aircraft."[1] Aircraft age may be a significant factor affecting PDM intervals for older C-130s, some of which are well over 30 years old. If the data from the *C-130 Service Life Data Base* is examined for the C-130H fleet, the range in aircraft age is significant (see Table 3).

Table 3. C-130H Fleet Aircraft Age

Oldest Aircraft	**364 months**
Newest Aircraft	**7 months**
Average Aircraft Age	**120 months**

Source: C-130 System Program Office, *C-130 Service Life Data Base*, 2 January 1997.

Secondly, the total flying hours on an aircraft may affect the PDM interval. Flying hour totals on an airframe contribute to fatigue cracking and can reasonably be expected to affect corrosion, since the aircraft is exposed to moisture during almost all flight operations. Table 4 shows the wide range of total aircraft hours for the C-130H fleet.

Table 4. C-130H Fleet Aircraft Total Flying Hours

High Time Aircraft	**15,600 hours**
Low Time Aircraft	**20 hours**
Average Aircraft Time	**5,200 hours**

Source: C-130 System Program Office, *C-130 Service Life Data Base*, 2 January 1997.

Thirdly, the number of hours flown per year may affect the PDM interval for the same reasons mentioned in the above paragraph. Aircraft which fly much more frequently than other aircraft may require more frequent PDM intervals. Obviously, this factor impacts the total flying hours. Table 5 depicts data for the C-130H fleet in terms of number of flying hours per year.

Table 5. C-130H Fleet Flying Hours per Year

High Yearly Hours	**687 hours**
Low Yearly Hours	**268 hours**
Average Yearly Hours	**482 hours**

Source: C-130 System Program Office, *C-130 Service Life Data Base*, 2 January 1997.

Fourthly, the mission profile flown by each aircraft will affect the PDM interval. For every USAF C-130, the C-130 SPO has calculated the “severity factor.” This factor is used to quantify the airframe stresses experienced by the aircraft. This data is critical to the USAF ASIP (see Chapter 3 for ASIP description). “The severity factor is an indication of how the mission profile has affected the crack growth rates in the center wing lower surface panels ... *in general, the higher the severity factor, the more severely the aircraft has been used* (e.g. more high speed, low level flight at higher gross weight).”[2] Each C-130 aircraft is assigned a severity factor and tracked in the *C-130 Service Life Data Base* maintained by the ASIP Manager in the C-130 SPO. These severity factors are calculated from service life data (documented on AFTO Form 151A) provided by the operating locations and are updated on a monthly basis. It is important to note that an aircraft with a severity factor twice that of another aircraft "has a center wing lower surface crack growth rate twice that of the aircraft with the lesser severity factor."[3]

Table 6. C-130H Fleet Mission Lifetime Severity Factor

High Severity Factor	**7.68**
Low Severity Factor	**.09**
Average Severity Factor	**1.94**

Source: C-130 System Program Office, 2 January 1997 Correspondence with Aircraft Structural Integrity Program (ASIP) Manager, WR-ALC/LBR, 2.

Finally, the operating location will affect the PDM interval. An aircraft based at Davis-Monthan in Arizona would not be expected to experience the same rate of corrosion as an aircraft based in Japan or Hawaii. According to the USAF Scientific Advisory Board, "corrosion is one of the most expensive maintenance issues for the Air Force."[4] Corrosion severity factors have been established for most USAF operating locations. The higher the corrosion severity factor, the more likely corrosion will occur. As one would expect, these factors vary widely depending upon the geographic location of the base (e.g. proximity to salt water), and other environmental factors such as industrial "fallout" from factories. Table 7 depicts the corrosion factors for most of the C-130H operating locations. Recall from Chapter 3, the PDM interval for PACAF C-130H aircraft is 48 months (vs 69 months) due to corrosion. However, a close look at Table 7 indicates several other C-130H operating locations have the same *high* corrosion factor of "25" found at Elmendorf AFB (PACAF). When one examines the data from Tables 3 through 7, it is apparent that there is a wide range in the variables affecting PDM intervals for the C-130H fleet. *Given* *this wide range of data, it may be beneficial to account for these variations and develop our PDM interval model based on specific aircraft ("just in time PDM"), rather than MDS.*

Table 7. Summary of C-130H Bases, Corrosion Factors, and MAJCOMs

Location	Corrosion Factor	MAJCOM
Baltimore	5	ANG
Channel Islands	25	ANG
Charleston	10	ANG
Charlotte	*	ANG
Cheyenne	5	ANG
Dallas	10	ANG
Davis Monthan	5	ACC
Dobbins	10	AFRES
Duke Field	25	AFRES
Dyess	5	ACC
Edwards	10	AFMC
Eglin	25	AFMC
Elmendorf	25	PACAF
Harrisburg	*	ANG
Hickam	25	ANG
Hurlburt	25	AFSOC
Kadena	25	AFSOC
Keesler	25	AFRES
Kirtland	10	AETC
Kulis	25	ANG
Little Rock	10	ACC/ANG
Louisville	10	ANG
Mansfield	5	ANG
Martinsburg	5	ANG
Maxwell	10	AFRES
McEntire	10	ANG
Mildenhall	*	AFSOC
Minneapolis	5	AFRES
Mitchell	5	AFRES
Moffett	25	ANG
Moody	10	ACC
Nashville	20	ANG
New Orleans	25	ANG
Niagara	5	AFRES
Ontario	20	AFMC
Patrick	25	ACC/AFRES
Peoria	*	ANG
Peterson	10	AFRES
Pittsburgh	10	AFRES
Pope	10	ACC
Portland	10	AFRES
Quonset	25	ANG
Ramstein	*	USAFE
Reno	10	ANG
Rockwell	10	AFMC
Savannah	25	ANG
Schenectady	10	ANG
Selfridge	5	ANG
St Joseph	10	ANG
St Paul	*	ANG
Suffolk	5	ANG
Will Rogers	5	ANG
Willow Grove	10	AFRES
Wilmington	10	ANG
Yokoto	10	PACAF
Youngstown	10	AFRES

* indicates data was not available for these bases

Source: C-130 System Program Office, 15 January 1997 Correspondence with Aircraft Structural Integrity Program (ASIP) Manager, WR-ALC/LBR.

PDM Interval Model Development

I propose a simple relationship exists between the PDM interval and the five factors discussed above (aircraft age, flying hour total, average yearly flying hours, mission profile (stated in terms of severity factor), and operating location of the aircraft). Therefore:

$$\text{PDM Interval} = [F1(wt1) + F2(wt2) + F3(wt3) + F4(wt4) + F5(wt5)] \qquad \text{(Eq 1)}$$

Where:

F1 is aircraft age factor; wt1 is importance of F1 to PDM interval
F2 is flying hour total; wt2 is importance of F2 to PDM interval
F3 is average yearly flying hours; wt3 is importance of F3 to PDM interval
F4 is aircraft lifetime severity factor; wt4 is importance of F4 to PDM interval
F5 is corrosion factor of operating location; wt5 is importance of F5 to PDM interval

A close look at Equation 1 and the data shown in Tables 3 through 7 indicates that the data for the five factors (F1 through F5) must be normalized to make any sense. It would not make sense to plug 15,600 flight hours (see Table 4) into Equation 1 when you might use a very small number for severity factor. If we did not normalize the data, the large numbers (like total flight hours) would dominate our calculations and smaller numbers (like severity factors and corrosion factors which may be critical to the PDM interval) would not affect the calculated PDM interval. Therefore, the data (for F1 through F5) in the *C-130 Service Life Data Base* must be normalized for each aircraft in the C-130 inventory; this is a very simple task. For example (from Table 4), for total aircraft flying hours the highest time aircraft has 15,600 flight hours. If we want to assign a number between 1 and 5 to represent total aircraft flying hours (F2), we simply “band” the data as follows:

F2 = 1 (for aircraft between 0 and 3,120 total flight hours)
F2 = 2 (for aircraft between 3,120 and 6,240 total flight hours)
F2 = 3 (for aircraft between 6,240 and 9,360 total flight hours)

F2 = 4 (for aircraft between 9,360 and 12,480 total flight hours)
F2 = 5 (for aircraft between 12,480 and 15,600 total flight hours)

Following the exact same procedure (i.e., “banding”) for the variables F1, F3, F4, and F5 using Tables 1, 3, 4, and 5 yields the following values:

F1 = 1 (for aircraft between 0 and 73 months old)
F1 = 2 (for aircraft between 73 and 146 months old)
F1 = 3 (for aircraft between 146 and 218 months old)
F1 = 4 (for aircraft between 218 and 291 months old)
F1 = 5 (for aircraft between 291 and 364 months old)

F3 = 1 (for aircraft between 0 and 137 average flying hours per year)
F3 = 2 (for aircraft between 137 and 275 average flying hours per year)
F3 = 3 (for aircraft between 275 and 412 average flying hours per year)
F3 = 4 (for aircraft between 412 and 550 average flying hours per year)
F3 = 5 (for aircraft between 550 and 687 average flying hours per year)

F4 = 1 (for aircraft between 0 and 1.54 lifetime severity factor)
F4 = 2 (for aircraft between 1.54 and 3.07 lifetime severity factor)
F4 = 3 (for aircraft between 3.07 and 4.61 lifetime severity factor)
F4 = 4 (for aircraft between 4.61 and 6.14 lifetime severity factor)
F4 = 5 (for aircraft between 6.14 and 7.68 lifetime severity factor)

F5 = 1 (for aircraft between 0 and 5 corrosion factor)
F5 = 2 (for aircraft between 5 and 10 corrosion factor)
F5 = 3 (for aircraft between 10 and 15 corrosion factor)
F5 = 4 (for aircraft between 15 and 20 corrosion factor)
F5 = 5 (for aircraft between 20 and 25 corrosion factor)

The only other concern is to determine wt1 through wt5 in Equation 1. Here is where the PDM interval model demonstrates its flexibility. C-130 maintainers may decide that corrosion (based on operating location) has twice the impact on PDM intervals as the average number of flying hours per year. If this is the case, then wt5 would be assigned a value twice that of wt3. For simplicity, I will assign the following values for wt1 through wt5.

wt1 = 1 (for importance of aircraft age in affecting the PDM interval)
wt2 = 1 (for importance of total aircraft flying hours in affecting the PDM interval)
wt3 = 1 (for importance of average yearly flying hours in affecting the PDM interval)
wt4 = 2 (for importance of lifetime severity factor in affecting the PDM interval)

wt5 = 2 (for importance of operating location in affecting the PDM interval)

Thus, it is assumed that aircraft usage (severity factor) and aircraft operating location (corrosion factor) are twice as critical as the other three variables (aircraft age, total aircraft flying hours, and average number of hours flown per year). Using the analogy of a car, the manner in which it is driven and the environment where the car is operated are more important (in my opinion) than its age, its total accumulated mileage, and its annual mileage. Again, the methodology used, and not the numbers selected, is what is important. This will discussed in more detail later in this chapter in the section on refining the PDM Interval Model.

Applying the PDM Interval Model to the C-130 Service Life Data Base

One of the obvious advantages of the PDM Interval Model is that all the data needed to calculate the PDM intervals already exists at the C-130 SPO. Additional data does not have to be obtained from C-130 operating locations. Equation 1 may be easily applied to the C-130H portion (291 aircraft) of the *C-130 Service Life Data Base*. The PDM interval expressed in Equation 1 now becomes a measurable (and explainable) indicator of when a specific C-130H aircraft requires PDM. Bear in mind the PDM interval expressed in Equation 1 is not expressed in months--it is an indicator (relative to other C-130H aircraft) of the predicted combination of effects on the PDM interval due to aircraft age, flying hour total, average yearly flying hours, mission profile (stated in terms of severity factor), and operating location of the aircraft. Let us take a closer look at the data resulting from our calculations (see Figure 1). Note from Figure 1 that the “non-dimensional” PDM interval (as calculated from Equation 1) ranged from a low of 9.00 to a high of 28.00. In addition, there were large numbers of aircraft between the low of 9.00 and the high of 28.00.

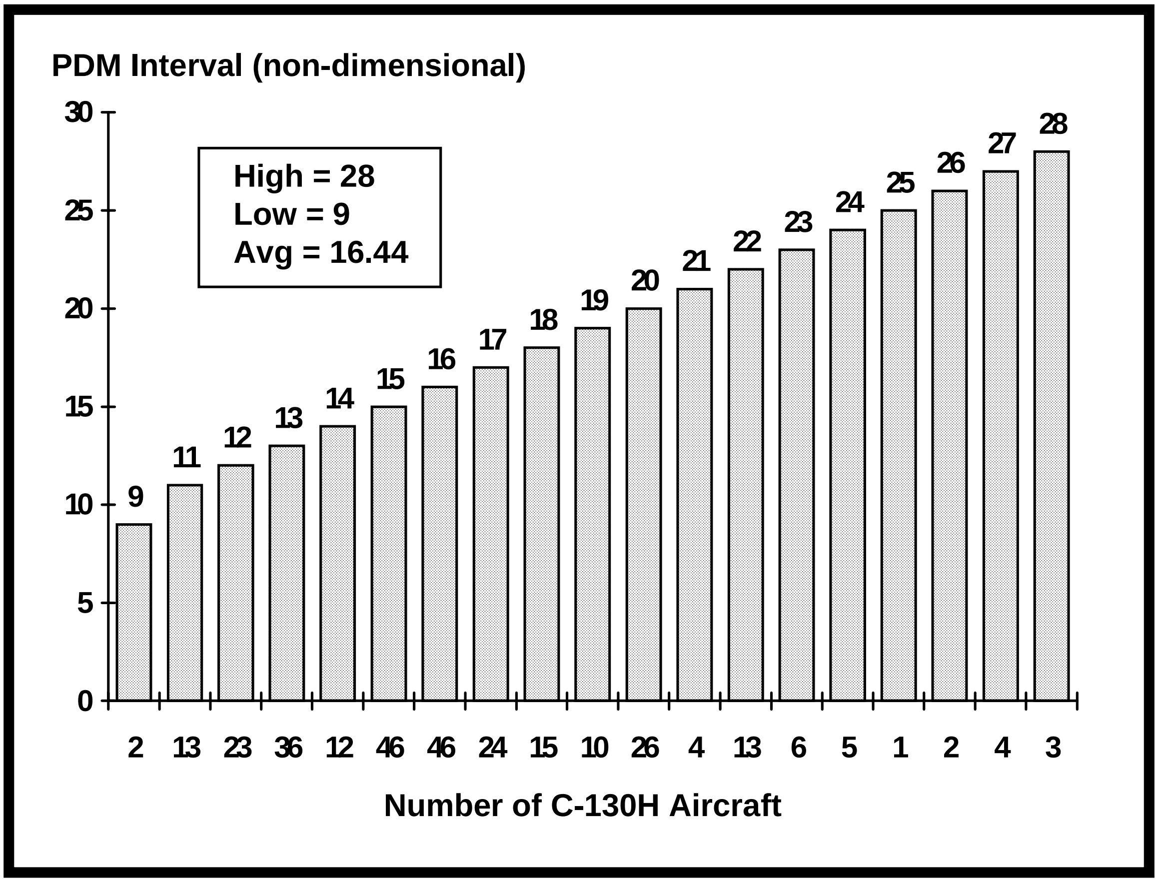

Figure 1. Number of C-130H Aircraft vs. "Non-Dimensional" PDM Interval

Keep in mind that the higher the "non-dimensional" PDM interval the *more* likely the aircraft is to require a shorter PDM interval (in terms of time in months). At first glance, this would indicate (based on our assumptions so far) that for the entire C-130H fleet, a fixed PDM interval may not be the best practice. Also, of considerable interest is that the four highest "non-dimensional" PDM intervals (25, 26, 27, and 28) depicted in Figure 1 were calculated for PACAF aircraft at Elmendorf AFB. This lends some support to the lower PDM interval (of 48 months) specified by TO 00-25-4 for PACAF C-130H aircraft. What needs to be done now to complete the analysis is to correlate the "non-dimensional" PDM interval depicted in Figure 1 with time (specifically in months).

Defining the "Non-Dimensional" PDM Interval in Time (Months)

Assuming the 48-month PDM interval for PACAF C-130H aircraft prescribed in TO 00-25-4 is a "good" number established over many years of maintenance experience, we can correlate our highest "non-dimensional" PDM interval (28.00, see Figure 1) with 48 months. In addition, assuming the 168-month initial PDM for *new* C-130H aircraft prescribed in TO 00-25-4 is a "good" number established over many years of maintenance experience, we can correlate our lowest "non-dimensional" PDM interval (9.00, see Figure 1) with 168 months. By establishing this relationship, we can construct the straight line shown in Figure 2. Note that Figure 2 assumes a linear relationship between the upper and lower PDM intervals. Although this linear assumption may not be totally precise, it allows for model simplification. Verifying the validity of our linear assumption using PDM maintenance findings will be discussed later in this chapter. Notice from Figure 2 that the upper and lower bounds of the PDM interval specified in TO 00-25-4 have not changed (168 months and 48 months respectively). *From Figure 2, note that it is now possible to stratify all the C-130H aircraft between these upper and lower PDM interval bounds*. Also, correlating the 69-month PDM interval (specified by TO 00-25-4) with our "non-dimensional" PDM interval indicates the 69-month PDM interval may be conservative (see Figure 2; note the number of aircraft above the 69-month interval line). Therefore, the PDM Interval Model (as developed) indicates that a PDM interval based on the MDS of the aircraft may not be the optimum criteria.

Figure 3 depicts proposed PDM intervals for the C-130H fleet based on the PDM interval model. It is important to note that our model predicts the PDM interval by individual aircraft serial number, *not* by aircraft MDS.

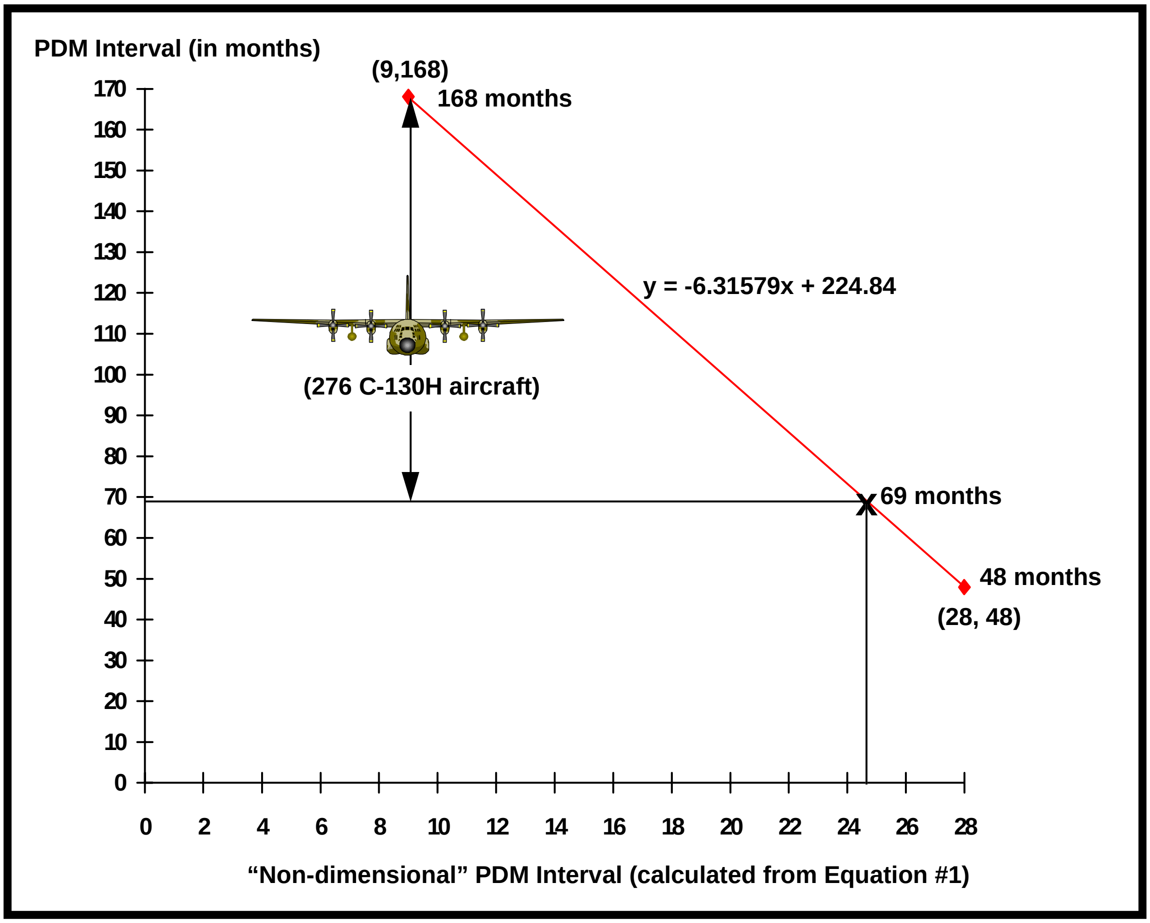

Figure 2. “Non-Dimensional” PDM Interval vs. Time (in months)

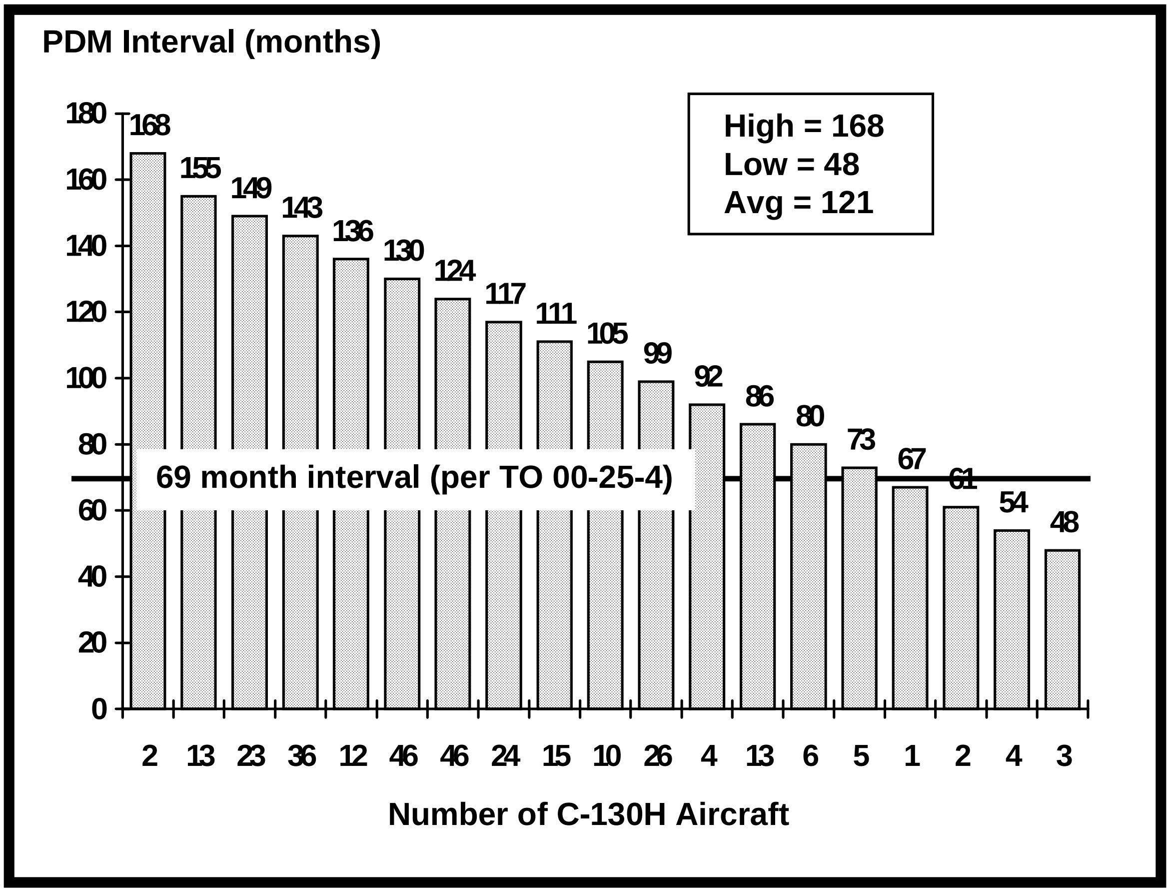

Figure 3. Proposed PDM Intervals (in months) vs. Number of C-130H Aircraft

Note from Figure 3 that the PDM interval model predicts a 168-month PDM interval for only two of the C-130H aircraft. A glance at the supporting data (see spreadsheet in Appendix A) indicates that these two aircraft are serial numbers 9406705 and 9203284. As you can see, the spreadsheet in Appendix A can be used to predict the PDM interval for *each* C-130H aircraft in the USAF fleet. This capability is critical because C-130 operators must forecast their PDM requirements in order to accurately predict funding for future years.

Managed Risk versus Risk Avoidance—Refining the PDM Interval Model

The PDM model demonstrated above indicates that PDM intervals for the C-130 fleet can be determined using an analytical model. But how do we know if the model works? First, data must be analyzed for each aircraft undergoing PDM. This data should be analyzed by SPO engineers to refine the PDM interval model. For example, PDM data may indicate that the corrosion factor impacts the PDM interval even more that the weighted factor (see Chapter 4, Equation 1) used in the PDM interval model. If this is the case, the value for “wt5” (see Chapter 4, Equation 1) should be increased and the numbers for PDM intervals should be recalculated. In addition, data from operational units and ASIP data should also be used to refine the PDM interval model by adjusting the other factors (as required) used in the PDM interval model. Continuous feedback is required to manage the risk associated with refining PDM intervals. The information revolution has made a PDM interval model both feasible and relatively simple and *allows us to go beyond the conservative (i.e. risk avoidance) approach of predicting PDM intervals based on aircraft MDS*. Figure 4 depicts the PDM interval model graphically.

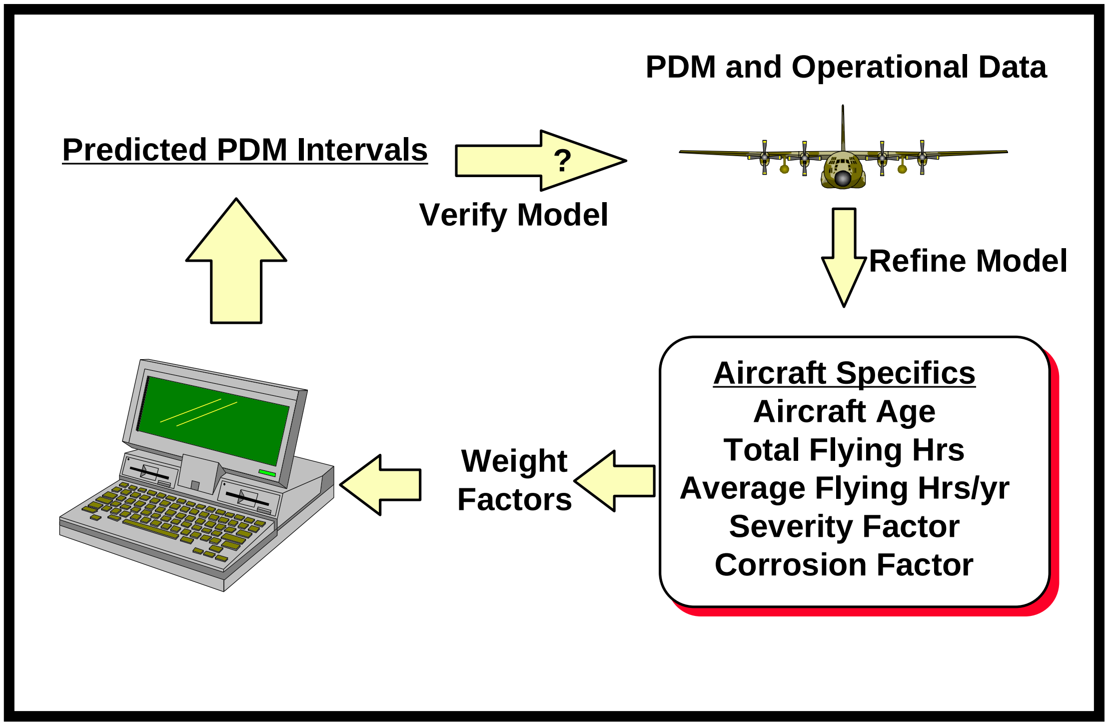

Figure 4. Proposed PDM Interval Model

The PDM and operational data depicted in Figure 4 also make it possible to *consider* expanding the upper limit of the current PDM interval (168 months). Again, this should only be done if the data from PDM and ACTS indicate this interval can safely be extended.

Advantages of the PDM Interval Model

There are many advantages in adopting the PDM interval model. The model is flexible and allows tailoring based on maintenance findings. The model is applicable to the entire C-130 fleet and may have application to other USAF (and DOD) aircraft currently using MDS as the PDM interval determinant. The model also has the potential for huge cost savings by deferring PDM activities. In addition, data required for the PDM interval model is already being collected. The model also has the potential to improve C-130 fleet management by providing advanced indications of aircraft with increasing maintenance requirements; these aircraft may be retired or transferred to less severe operating locations. In addition, ANG and AFRES bases that operate C-130s purchased in the same year now have a model that allows them to predict which of their aircraft will require PDM first and to see exactly how PDM intervals are determined (and adjusted) for their aircraft. Finally, PDM intervals are still predicted in advance to allow operators time to schedule aircraft downtime and project budgets to cover PDM costs.

Notes

[1] USAF Scientific Advisory Board, *Life Extension and Mission Enhancement for Air Force Aircraft*, Volume I, Executive Summary, August 1994.

[2] C-130 System Program Office, 2 January 1997 Correspondence with Aircraft Structural Integrity Program (ASIP) Manager, WR-ALC/LBR.

[3] Ibid.

[4] Ibid., 1.

Chapter 5

Summary

> *. . . the DOD must recognize the critical importance of widely applying advanced information technology . . . this is the direction in which world-class commercial firms are moving, and the DOD must be part of that transformation.*
>
> —*Defense Conversion*

As discussed in Chapter 3, over the past four decades the C-130 community has done a superb job maintaining an invaluable asset for the USAF. However, with the advent of the information revolution, the maintenance community is overdue in taking the next logical step of implementing "just in time PDM" for the entire C-130 fleet. Predicting the PDM intervals for *specific* aircraft is the logical alternative to predicting PDM intervals based on aircraft MDS. As was shown in Chapter 4, there is a wide range in aircraft variables within each MDS that should be taken into account--the PDM interval model makes this possible.

Recommendations for Senior USAF Leaders

1. Consider implementation of the PDM interval model for the C-130 fleet. In addition, consider the applicability of the PDM interval model for other USAF aircraft which also base PDM intervals on aircraft MDS. Implementation could be done in steps; for example, the PDM interval model could be refined by SPO engineers and used for a portion of the fleet as a "pilot" program.
2. Charter a team to calculate the cost savings associated with implementing the PDM interval model. In my opinion, the deferred PDM costs will be *substantial*.

3. Charter a team to integrate the PDM interval model with other existing systems (e.g., ACTS, ASIP, PDM discrepancies). Supporting data systems should provide “linked” capabilities with common format. In this area, civilian companies with “linked” data systems expertise should be consulted for assistance.
4. Sponsor research on the ability of the PDM interval model to be used to predict future PDM maintenance actions (in addition to PDM intervals). The USAF should not only implement “just in time PDM,” but we should also have “tailored PDM” based on what predicted maintenance actions should be accomplished during PDM. This research could significantly benefit the Aircraft Repair Enhancement Program (AREP) which is attempting to reduce the number of days an aircraft spends in PDM.

Appendix A

Modified C-130 Service Life Data Base

The C-130H portion of the *C-130 Service Life Data Base* (Excel format) was modified to support the calculations required by the C-130 PDM interval model. The first ten rows from this data base is shown in Table 8 below. The database was sorted by the PDM interval (last column) and aircraft entries (each row depicts data on a specific aircraft) are listed by descending PDM intervals as predicted by the PDM interval model.

Table 8. First Ten Rows of Modified *C-130 Service Life Data Base*

A/C Serial #	Flying Hrs	BASE	Lifetime Sev Fac	Flying Hrs per yr	A/C Age (Mos)	Corr Fac	F1	F2	F3	F4	F5	PDM Interval	PDM (Mos)
9406705	138.1	MARTINSBURG,WV	1.33	291.00	12	5.00	1.00	1.00	3.00	1.00	1.00	9.00	168
9203284	587.7	NIAGARA FALLS,NY	1.35	356.89	29	5.00	1.00	1.00	3.00	1.00	1.00	9.00	168
9406708	114.8	MARTINSBURG,WV	1.55	291.00	10	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9406706	129.1	MARTINSBURG,WV	1.67	291.00	12	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9203283	537.5	NIAGARA FALLS,NY	1.77	356.89	31	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9203286	513.8	NIAGARA FALLS,NY	1.89	356.89	29	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9406707	50.3	MARTINSBURG,WV	2.01	291.00	10	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9203288	579.9	NIAGARA FALLS,NY	2.15	356.89	27	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9203281	616.4	NIAGARA FALLS,NY	2.16	356.89	30	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155
9203285	537.8	NIAGARA FALLS,NY	2.17	356.89	29	5.00	1.00	1.00	3.00	2.00	1.00	11.00	155

Due to the large size of the modified *C-130 Service Life Data Base*, the entire spreadsheet was not "pasted" into this document. Each row in the spreadsheet contains information for a specific C-130 aircraft. For those individuals interested in developing a similar spreadsheet, the following information is provided.

Column 1 (“A/C Serial #”)	Aircraft serial number comes directly from *C-130 Service Life Data Base*.
Column 2 (“Flying Hrs”)	Total flying hours comes directly from *C-130 Service Life Data Base*.
Column 3 (“Base”)	This is the operating location of the specific aircraft listed in each row. Operating location comes directly from *C-130 Service Life Data Base*.
Column 4 (“Lifetime Sev Fac”)	This is the lifetime severity factor that represents the cumulative mission profiles the aircraft has been exposed to (i.e. how the aircraft has been used). This data comes directly from *C-130 Service Life Data Base*.
Column 5 (“Flying Hrs per Yr”)	This is the average number of hours the aircraft has flown per year (averaged over the last 2 years). This data comes directly from *C-130 Service Life Data Base*.
Column 6 (“A/C Age (Mos)”)	This is the aircraft age in months. This data comes directly from *C-130 Service Life Data Base*.
Column 7 (“Corr Fac”)	This is the corrosion factor established for the operating location of the aircraft (i.e. the base). See Table 7 for data.
Column 8 (“F1”)	This number represents the normalized value for aircraft age (see Chapter 4 for detailed explanation).
Column 9 (“F2”)	This number represents the normalized value for total flying hours (see Chapter 4 for detailed explanation).
Column 10 (“F3”)	This number represents the normalized value for average flying hours per year (see Chapter 4 for detailed explanation).
Column 11 (“F4”)	This number represents the normalized value for the lifetime severity factor (see Chapter 4 for detailed explanation).
Column 12 (“F5”)	This number represents the normalized value for the corrosion factor of the specific operating location (see Chapter 4 for detailed explanation).
Column 13 (“PDM Interval”)	This number represents the “non-dimensional” value calculated for the recommended PDM interval (see Chapter 4 for detailed explanation).
Column 14 (“PDM (months)”)	This number represents the recommended PDM interval in months (see Chapter 4 for detailed explanation).

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Air Command and Staff College
Maxwell AFB, Al 36112