R-1025-PR

June 1972

Aircraft Planned Inspection Policies: A Briefing

I. K. Cohen

A Report prepared for

UNITED STATES AIR FORCE PROJECT RAND

Rand
SANTA MONICA, CA. 90406

This research is supported by the United States Air Force under Project Rand—Contract No. F44620-67-C-0045—Monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of Rand or of the United States Air Force.

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PREFACE

This Report contains the text of a briefing by the author before the Project Rand Air Force Advisory Group in November 1970. It briefly summarizes to that date Rand's findings concerning aircraft inspection intervals and content at base and depot levels; no detailed data are presented. The material has been prepared in its current form so that persons interested in maintenance management will have access to the techniques discussed in the original briefing. The reader is cautioned that some issues covered in this Report, such as inspection interval sizes and procedures, have since undergone change.

The Corporation has a relatively long history of involvement in base level maintenance. In the light of previous empirical and theoretical research, Rand decided, in the summer of 1969, to undertake an extensive empirical analysis in the scheduled maintenance area because of the significant amount of resources allocated to this function, and because of an interest in achieving a better understanding of the interactions between scheduled and unscheduled maintenance. As the first step in this project, a preliminary examination was made of C-141 base level data, and of F-106 and F-4 depot level data. The findings were sufficiently persuasive to warrant immediate additional study of several other weapon systems.

Rand's preliminary findings were presented to the Director of Maintenance and Engineering, Hq USAF (AFSME), who dispatched a letter to Hq Air Force Logistics Command in May 1970 encouraging exploitation of the Rand findings for the C-141 fleet as well as for "its possible application to both field and depot inspection intervals of other weapon systems."

In line with AFSME guidance, a base level C-141 joint study was undertaken involving Hq AFLC, the Military Airlift Command, the Warner Robins Air Materiel Area, and Rand. Furthermore, a special AFLC study group with a charter to examine inspect-and-repair-as-necessary interval and content has incorporated Rand's methodology into its core study program, and has since examined several weapon systems that

undergo IRAN. This special study group has more recently turned its attention to scheduled maintenance at base as well as at depot level. Rand has continued to interact extensively with the AFLC study group, several AMA's, and several contractors. AFLC regulations regarding techniques to be used for establishing inspection intervals as well as interval decisions for some weapon systems have been affected by these studies.

SUMMARY

In the summer of 1969, Rand undertook a large effort in the scheduled maintenance area because of the significant amount of resources allocated to this function, and because of an interest in better understanding the interactions between unscheduled and scheduled maintenance. This Report summarizes to late 1970 Rand's findings concerning aircraft inspection intervals and content at base and depot levels.

Determining requirements for inspections--both interval and content--is a difficult problem. Scheduled inspection policy statements typically have weak analytic underpinnings because no formal decision-making methods exist for reaching inspection content, interval, and location decisions. Therefore decisions tend to be based largely on tradition, experience, and intuition.

To provide an opportunity for observing aircraft performance at intervals other than those specified by policy for base level inspections, we proposed a series of field tests that would have systematically produced alternative intervals. The maintenance-operations performance of aircraft functioning under each alternative would be evaluated in order to arrive at improved intervals.

As an initial step in the inspection interval project, we visited the C-141 organization at Travis Air Force Base in November 1969 to assess whether the setting was an appropriate one for the field test. Surprisingly, we found that a field test was unnecessary. From discussions during that visit, and a review of some data at Travis, it appeared that the information that might be obtained through field test was already available for establishing improved inspection intervals at base level.

In 1966, MAC switched from a flying hour (periodic) inspection of their C-141s to an isochronal (calendar time) inspection system. This allowed us to study variability in interval size between inspections for a number of measures of interest including flying hours, landings, and calendar time. We found considerable variability among these measures from aircraft to aircraft. Furthermore, maintenance personnel at all levels reported that there was no observable difference in aircraft

performance as a function of, for instance, variable flying hours. Aircraft with many flying hours between inspections appeared to perform no differently (operations and maintenance measures) than aircraft with fewer flying hours between inspections.

In view of the variability in interval size between inspections for the C-141, and our inability to observe performance degradation within the experienced variability, these data support almost a doubling of the size of interval between inspections. A qualitative engineering evaluation tends to confirm this conclusion.

After noting the C-141 isochronal experience, we made the obvious connection with IRAN inspections, which are scheduled in accordance with the isochronal system. An early review of F-106 (and F-4) depot level data indicated that available evidence on these aircraft, however preliminary, was sufficiently persuasive to warrant immediate study of several weapon systems.

The initial years of the F-106 were characterized by a heavy modification program. The extent of this program was apparently so great that full IRANs, which were supposed to be performed at 24-month intervals, were deferred for considerable periods. Again, we performed careful analyses to determine whether differences existed in aircraft performance and the amount of maintenance required as a function of interval size. The data analyzed for a sample period between July 1968 and early 1970 suggest that the then current 24-month full IRAN interval could be extended significantly.

The number of systems whose intervals can be extended, and the amount of such extensions, is probably large enough to raise a number of institutional issues. For example, depot level interval extensions could make available for reprogramming a significant number of resources. Furthermore, since a considerable amount of IRAN is accomplished under contract, the issue about whether the current organic/contractor mix is appropriate, given interval extensions, needs to be addressed. This study does not discuss such larger institutional issues.

Four major points are covered in this Report:

1. The state-of-the-art, which does not permit designation of the optimum or best inspection interval.

2. Our development of a means of arriving at improved intervals.

3. The use of this method for setting major inspection intervals at base and depot levels. For depot level, much of the data required are available; for base level, the data exist for a limited number of weapon systems, and it will be necessary to generate the information for most weapon systems. The data can be generated by the controlled introduction of variability in interval size.

4. A suggested levels of maintenance study. Such a study would be the next logical step for Rand.* It would examine organizational, intermediate, and depot levels, and evaluate a number of consolidation alternatives.

    a. Use regional bases within a command to accomplish major inspections.

    b. Use a single base within a command to accomplish major inspections.

    c. Perform all major weapon system inspections at an AMA.

    d. Use some combination of the foregoing.

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*This study was begun in 1971.

ACKNOWLEDGMENT

The material in this Report was originally published as a Working Note which included the charts and text as briefed to the Project Rand Air Force Advisory Group. I am indebted to Miss Roberta Schneider who rewrote the material and put it into its current format.

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I. INTRODUCTION

Rand has a long history in the study of maintenance and maintenance management. In the summer of 1969, the Corporation undertook a large effort in the scheduled maintenance area because of the significant amount of resources allocated to this function, and because of an interest in better understanding the interactions between unscheduled and scheduled maintenance.* This Report, which documents a presentation to the Project Rand Air Force Advisory Group, summarizes to late 1970 Rand's findings concerning aircraft inspection intervals and content at base and depot levels.

SIZE OF STUDY AREA

At base level, we can identify some 80,000 to 100,000 men in aircraft maintenance for the major strategic, general purpose, and airlift aircraft. Perhaps 25 percent of all base maintenance manhours for cargo-type aircraft are spent on inspection and fix-related activities. For fighter aircraft, over 25 percent of the on-aircraft maintenance manhours are spent in such inspections. From these figures, we can infer that approximately 20,000 USAF manpower authorizations are related to base level major inspections.

At depot level, FY 1970 Total Obligational Authority for maintenance is approximately $1.3 billion. The portion of this amount attributable to IRAN organic/contractor labor is about $350 million.

Besides such costs, aircraft availability is affected. Up to an estimated 10 percent of additional airframes are allowed to fill the depot-visit pipeline for modifications as well as for IRANs (inspection and repair as necessary).

TECHNICAL PROBLEM IN INTERVAL SETTING

Determining requirements for inspections--both interval and content--is a difficult problem. Scheduled inspection policy statements

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*T. S. Donaldson and A. F. Sweetland, The Relationship of Flight-line Maintenance Manhours to Aircraft Flying Hours, The Rand Corporation, RM-5701-PR, August 1968.

typically have weak analytic underpinnings. Furthermore, no formal decisionmaking methods exist for reaching inspection content, interval, and location (base or depot) decisions. Therefore decisions tend to be based largely on tradition, experience, and intuition.

Several factors make it difficult to study inspection requirements. Generally, field level inspections are conducted at specified flying hour intervals, independent of environmental or mission considerations. The desirability of a longer-than-specified interval between inspections cannot be determined because available data do not permit extrapolation.

The lack of experience with alternative intervals at base level makes it difficult for the decisionmaker as well as for the analyst. Given "satisfactory" performance at a given interval, there is understandable reluctance to experiment with an increased interval. On occasion, intervals have been changed. These changes, however, have typically taken place because of resource considerations rather than because of improved understanding of inspection requirements.

To provide an opportunity for observing aircraft performance at intervals other than those specified by policy for base level inspections, Rand proposed a series of field tests that would have systematically produced alternative intervals. The maintenance-operations performance of aircraft functioning under each alternative would have been evaluated in order to arrive at improved intervals.

MAJOR EVENTS

As an initial step in the interval inspection project, then, we visited the C-141 organization at Travis Air Force Base in November 1969 to assess whether the setting was an appropriate one for a field test. Surprisingly, we found that a field test was unnecessary. From discussions during that visit, and a review of some data extracted from records, it appeared that a significant means was already available for establishing improved inspection intervals at base level. In 1966, MAC switched from a flying hour inspection of their C-141s to an

isochronal inspection system.* These data allowed us to study the effect that variability in factors such as flying hours had upon the aircraft.

Also, an early review of F-106 and F-4 depot level data indicated that available evidence on these aircraft, however preliminary, was sufficiently persuasive to warrant immediate study of several weapon systems. This point of view was presented to the Director of Maintenance Engineering, Hq USAF (AFSME), and the Director of Materiel Management, AFLC, at a March 1970 briefing. As a result, the Director of Maintenance Engineering dispatched a letter to Hq AFLC in May 1970 encouraging exploitation of the Rand findings for the C-141 fleet as well as for "its possible application to both field and depot inspection intervals of other weapon systems."** In line with AFSME guidance, a base level C-141 joint study was undertaken involving Hq AFLC, MAC, WRAMA, and Rand. Furthermore, a special AFLC study group with a charter to examine IRAN interval and content incorporated Rand's proposed methodology into its core study program. At the time of this presentation, several weapon systems that undergo IRAN were being analyzed by the AMAs and by several contractors, with Rand also participating in this detailed effort.

ORGANIZATION

The remainder of the Report is organized as follows. Section II discusses data collected on the C-141 and the F-106 weapon systems. Section III examines the risks involved in extending inspection intervals. Section IV describes Rand's proposed levels of maintenance study. Section V contains our conclusions.

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*Calendar policy under which aircraft are grounded when they exceed a particular number of days between inspections.

**See Appendix for copy of letter.

II. STUDY EXPERIENCES

This section discloses, in abbreciated form, some data for the C-141 and the F-106. The C-141 data involve base level inspections; the F-106 data involve depot level IRAN inspections.

FIELD LEVEL INSPECTIONS AT TRAVIS

In our visit to Travis, we found the usual preflight, postflight, and special inspections that are typically embedded in other regularly scheduled inspections.

Of special interest were the inspections identified as minor and major isochronals because they are costly inspections driven by calendar time rather than by flying hours.* When the C-141 was initially introduced into service, it was scheduled into periodics every 400 flying hours. When MAC switched to the isochronal system in 1966, major isochronals were performed every 70 days with a minor isochronal 35 days preceding and following each major. When this study was undertaken in the summer of 1969, major isochronals were performed every 90 days, with a minor isochronal 45 days preceding and following each major.

With regard to depot level maintenance, the C-141 IRAN interval is now three years, with the IRAN divided into three increments. Increments 1 and 2 are performed at base level in the first and second years, respectively. Increment 3 is performed at the depot every third year.

THE C-141 EXPERIENCE

As indicated, the Travis visit did offer a number of surprises. There was considerable variability in interval size between inspections for a number of measures-of-interest including flying hours, landings, and calendar time. Furthermore, maintenance personnel at all levels reported that there was no observable difference in aircraft performance

*We did not address the calendar time inspection known as the home station check performed every ten days.

as a function of, for example, (variable) flying hours. Aircraft with many flying hours between inspections appeared to perform no differently (operations and maintenance measures) than those with fewer flying hours between inspections.

If these opinions were indeed valid ones, there would be sufficient grounds for a policy change. Such a policy would entail inspecting aircraft more consistently at longer intervals.

Periodic Policy

Under the periodic policy, the C-141 was inspected at 400 hours, with grounding occurring at 400 ± 10% hours. Chart 1 shows both flying hours and calendar days observed between periodics. For flying hours, the control variable, a "well-behaved" distribution occurs, with a bunching-up at the 400 flying-hour interval, and some outliers on both the low and high sides; for calendar days, however, a considerable variation in distribution occurs.

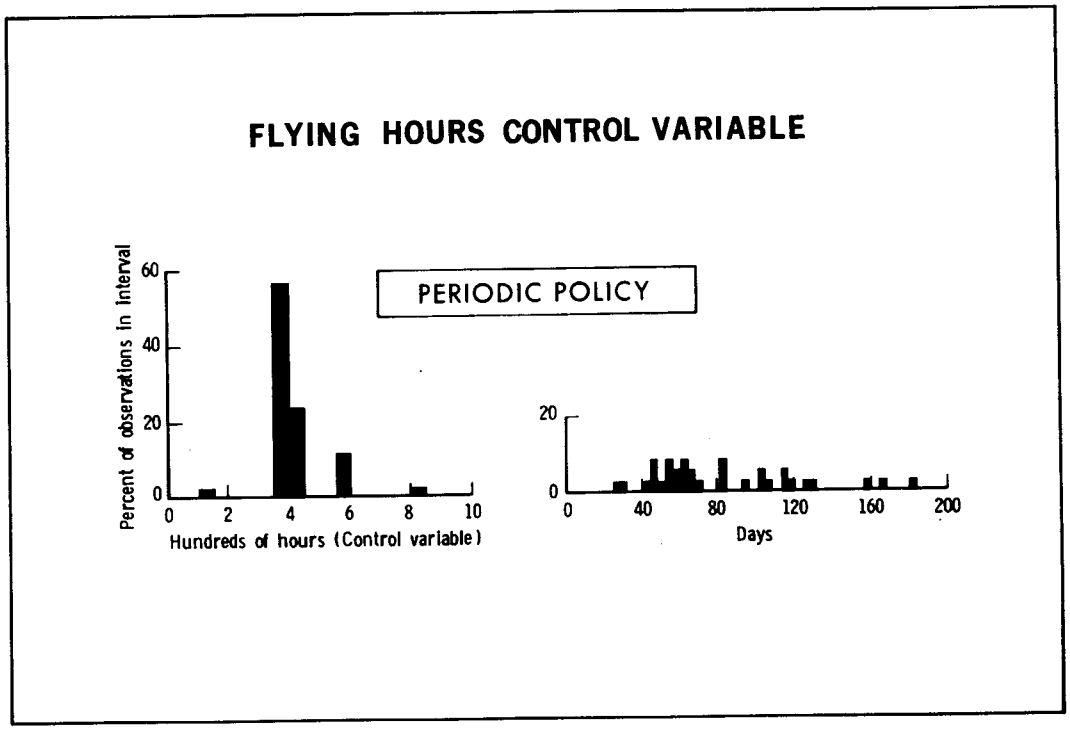

Chart 1

Periodic/Isochronal Policies Comparison

Chart 2 compares flying hours and calendar days observed between periodic and isochronal policies. Sharp contrasts are apparent between the two techniques. Under the isochronal system, which uses days as the control variable, a "well-behaved" distribution of days occurs; for flying hours, however, a considerable variation in distribution occurs.* Looking at the plot, a dense distribution of flying hours ranging from about 60 to about 900 occurs between major isochronals. In the past, the C-141 had a Lead-The-Force (LTF) program. Had the LTF experience been included in the plot, we would have had about 1400 flying hours between these majors.

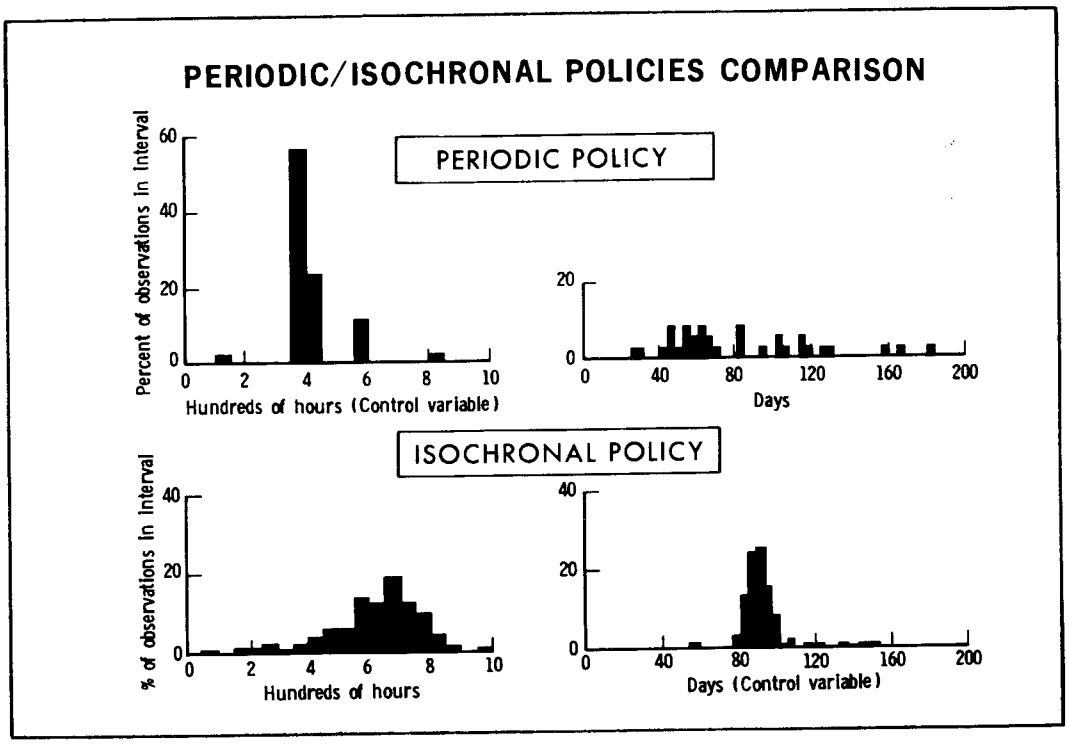

Chart 2

*Plots shown are for major isochronals only, which are performed at 90-day intervals.

Probability of Unscheduled Maintenance

We examined several performance measures to determine whether performance varies as a function of interval size between inspections.

One measure is the probability that unscheduled maintenance will occur, causing a non-operational-ready condition on the aircraft at landing following either operational (airlift) sorties, or local (training) or functional check flights (FCF), Chart 3. We examined this measure for days immediately preceding and immediately following an isochronal. Basically, we found no important differences in this measure either before or after the inspection. For the local and FCF sorties, however, we observed a statistically significant "improvement" in aircraft for five days before the inspection. We also observed that for two days following the inspection, there was a statistically significant improvement in the apparent performance of aircraft on operational sorties. Though not shown on the chart, we also observed no difference before and after inspection for "high" and "low" flyers.

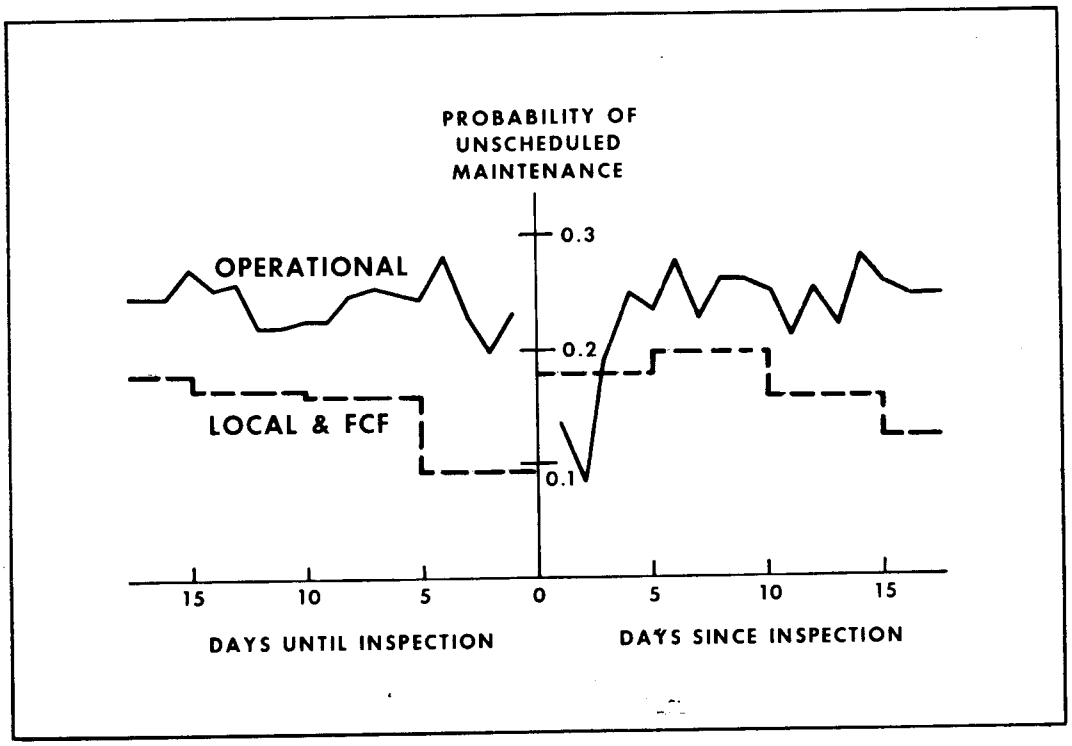

Chart 3

Average Aircraft--Days Lost to Inspections

One indication of the cost for major inspections at Travis AFB is shown in Chart 4, which gives the average number of aircraft days lost to the indicated inspection types. Note the time lost in post-dock status. And note that each aircraft loses, on average, 69 days per year to base level inspections of the type indicated. About two hundred maintenance people are associated with the minor isochronal, major isochronal, and the IRAN increment 1 and 2 docks at Travis.

AVERAGE AIRCRAFT - DAYS LOST TO INSPECTIONS

	PRE-DOCK	IN-DOCK	POST-DOCK	PER YEAR
MINOR ISOCHRONAL	2	1	2.5	22
MAJOR ISOCHRONAL	2	1	7	30
MAJOR + INCREMENT	2	5	10	17
			TOTAL	69

Chart 4

Conclusions

Considering the varied interval sizes between inspections for the C-141, and our inability to observe performance degradation within the experienced variability, these data support a one-half reduction in inspection workload. A qualitative engineering evaluation tends to confirm this. A limited number of items only would have to be provided

for in the home station check or some other inspection if the minor and major inspection intervals were extended. Given current (1970) programmed flying hours for the C-141, the doubling of the indicated intervals would still permit intervals that have been previously experienced.

The C-141 experience, in moving from the periodic to the isochronal scheduling system, suggests the need for a scheduled inspection technique that would retain the desirable attributes of the isochronal and overcome its limitations. Thus, such a technique should do the following:

1. Be easy to implement and administer.
2. Offer high certainty in predicting the flow of workload into inspection docks.
3. Place some kind of control on the high end of the distribution of flying hours between inspections.
4. Eliminate inspections on aircraft with low numbers of flying hours accumulated since the last inspection.

Rand is developing such a technique, the SASM model, which should interest all commands.*

THE F-106 EXPERIENCE

The situation with regard to the F-106 depot level IRAN inspection also presented some unexpected information.** After noting the

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*The technique was completed in 1971. SASM (Simple Adaptive Scheduling Mechanism) considers flying hours as the critical stress measure. The technique retains the isochronal's desirable workloading properties of keeping a smooth flow of aircraft moving into inspection, while reducing flying hour variance among aircraft by scheduling airplanes with the most hours flown since their last inspection into repair before those with fewer hours.

SASM works in this manner. For a relatively long interval (perhaps a fiscal quarter), fix the dates on which inspections will be started. Then, periodically match specific tail numbers to start dates over shorter intervals (perhaps weekly). The airplanes chosen to be inspected on the "weekly" plan will be the ones that have flown the most since their last inspections as of the time when the matching is done. For details, see Louis Miller, A Simple Adaptive Scheduling Mechanism for Planning Base Level Inspections, The Rand Corporation, R-938-PR, February 1972.

**Theodore S. Donaldson, A Study of IRAN Effectiveness for the F-106, The Rand Corporation, R-755-PR, October 1971.

C-141 isochronal experience, we made the obvious connection with IRAN inspections, which are scheduled in accordance with the isochronal system. Thus, we expected to find considerable variability in flying hours between inspections. And we did. Much to our surprise, however, we also found considerable variability in the calendar time interval between IRANs.

Interval Summary

The initial years of the F-106 were characterized by a heavy modification program. The extent of this program was apparently so great that IRANs were deferred for considerable periods. Also, before the conventional IRAN of some 5000 to 6000 manhours was initiated, essential IRANs were accomplished in association with mod speedlines. Estimations indicate that these essential IRANs used from 10 to 15 percent of the IRAN manhours expended in a so-called full IRAN.

In any event, if we make no distinction between a full and an essential IRAN, we see from the top distribution on Chart 5 many cases in which the interval between IRAN visits, regardless of type, is 48 months.* The F-106 is currently undergoing full IRANs at the 24-month interval and this accounts, in part, for many cases at the 24-month interval. If we consider full IRANs only, we see considerably greater variability. From the distribution in the lower portion of Chart 5, we see intervals extending beyond 96 months.

Analysis

As with the C-141, we did considerable analysis in an effort to discern differences in aircraft performance and amount of maintenance required as a function of interval size. In these studies we used measures derived from the ADCM 66-28 system, which provides, on a fairly detailed debriefing form, a combination of operations and maintenance data. We also used a variety of manhours (standard) expended at the depot in the IRAN. Our sample is limited to visits made between

*Includes interval from acquisition date to date of initial IRAN.

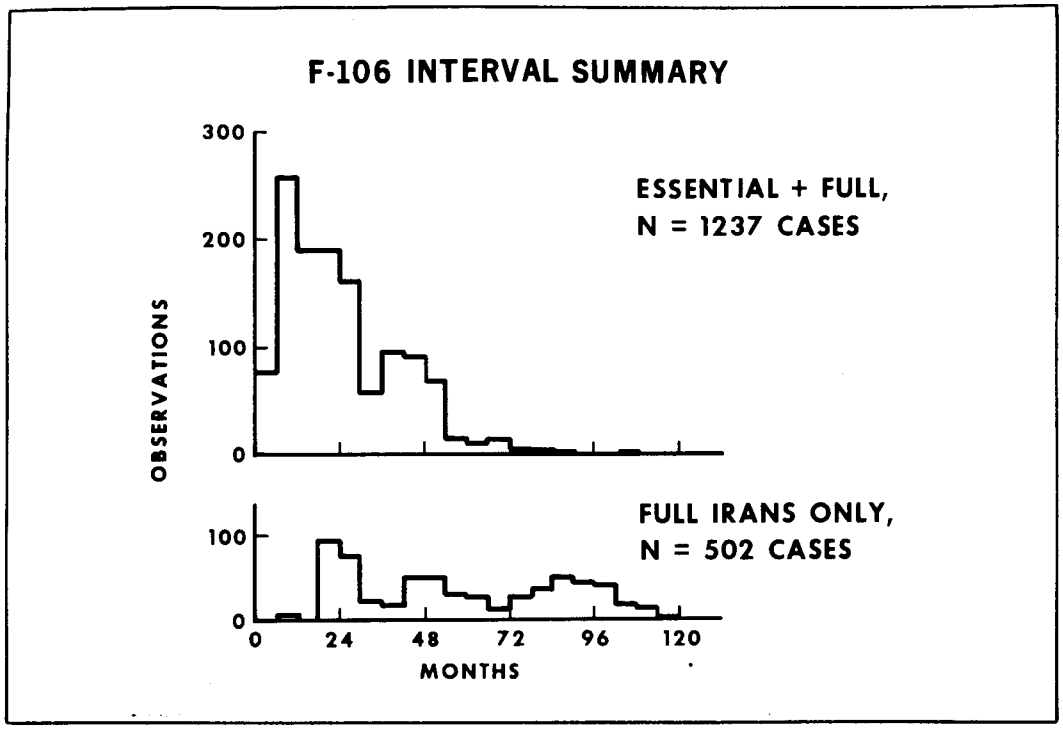

Chart 5

July 1968 and early 1970. It excludes consideration of the essential IRAN visits.

In our analysis we observed the aircraft's condition before and after IRAN for such 66-28 measures as criticality of malfunction, number of write-ups, and missed intercepts. For similar measures, we also observed aircraft performance as a function of interval size for the full IRANs. As indicated in Chart 6, we failed to discern any differences, except one; for about 20 sorties following an IRAN, the number of write-ups increased, as reported by the 66-28 system.

At the time of this presentation, Convair was extending our analysis to determine whether performance differences can be observed in such data systems as AFM 66-1 and AFM 65-110. In any event, the data that we analyzed (which include engineering judgments obtained by SAAMA analysts) suggest that the current 24-month full IRAN interval can be conservatively extended up to 48 months.

F-106 ANALYSIS

AIRCRAFT PERFORMANCE (ADC 66-28)	RESULTS
● BEFORE VS AFTER IRAN	
– BREAK CONDITION	—
– WRITE-UPS	INCREASE AFTER IRAN
– INTERCEPTS	—
● AS A FUNCTION OF INTERVAL SIZE	
– BREAK CONDITION	—
– WRITE-UPS	—
– INTERCEPTS	—
DEPOT MAINTENANCE	
● VARIOUS MHR MEASURES	—

Chart 6

III. RISKS

Given some exposure to variability in interval sizes, and our inability to observe differences in performance as a function of the observed variability, we now consider the risks involved in deciding to extend IRAN intervals. This discussion briefly summarizes the nature of the evidence that will typically be available to the decisionmaker. We illustrate what happens when interval changes take place, and we attempt to summarize the risks.

INTERVAL EXTENSIONS

How difficult a decision is it to extend inspection intervals? Since lives and mission could be involved, there is ample reason to be cautious. Unfortunately, no adequate theory or understanding of the failure process exists to provide much comfort to the decisionmaker. But we are likely to have a range of experiences that do provide significant empirical information. For example, perhaps an aircraft has been operating at a particular interval without degradation. Furthermore, maintenance managers may have had occasion to observe a range of intervals, as shown for the F-106, without any apparent negative effect where variability does exist. Interval size variation could have been systematically induced through what AFLC is calling CIE programs (for Controlled Interval Extensions) for a sample of aircraft. CIE aircraft might also have failed to indicate performance degradation. Also, engineering judgments might have confirmed the foregoing types of experiences.

Despite such experiences and judgments, decisionmakers might continue to worry about interval extension. Such concern is perhaps understandable because of inadequacies in the data systems used to measure performance degradation and maintenance effort expended.

By examining in some detail inspection intervals on each aircraft when a decision is made to extend, it is possible to add to the decisionmaker's pool of relevant information.

INTERVAL EXTENSION SCENARIO

Consider the scenario shown in Chart 7. A hypothetical fleet of 200 aircraft is on a 24-month IRAN, which means that an aircraft's inspection interval between successive IRAN completion dates is 24 months. Assume that there are sufficient resources to IRAN 100 aircraft a year, that each aircraft goes through the IRAN once during the 24 months, and that the completion dates are uniformly spaced over time.

A decisionmaker extends the IRAN interval from 24 to 36 months.* Assume that the resources available to accomplish the IRAN are cut back from 100 inspections per year to 66, and aircraft continue to be inspected at the lower rate.

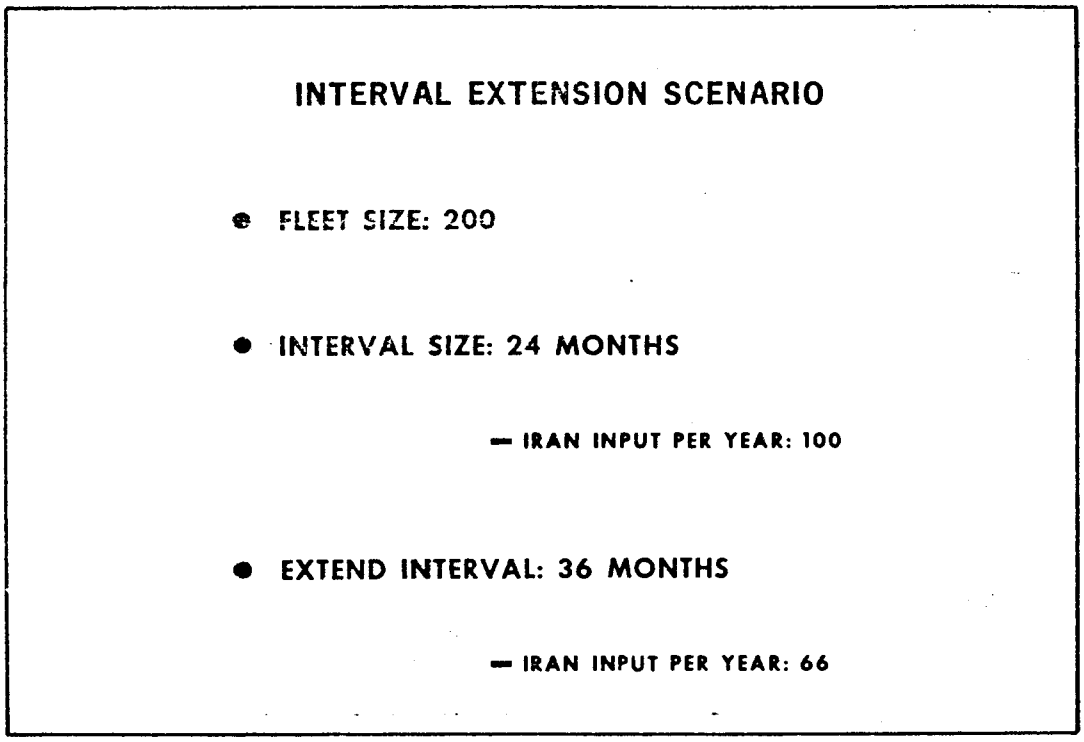

Chart 7

*This decision might have been based on a number of reasons including resource constraints, Controlled Interval Extension programs, and/or past variability confirmed by engineering appraisals. The evidence for making the interval change is not particularly pertinent to the point being made here.

TRANSITION BETWEEN INSPECTION POLICIES

Under the described scenario, it turns out that six months after introducing the new policy, the mean number of months between IRANs for that portion of the fleet that has been IRANed (33 aircraft) has shifted upward only one month from 24 to 25. The mean for the entire fleet of 200 aircraft is only slightly above 24 months, and the longest existing IRAN interval at this time is 26 months.

As depicted in Chart 8, during the first year of transitioning to the 36-month policy, the 66 aircraft that flow through IRAN will have intervals ranging from 24 to 28 months; in the second year, the next 66 aircraft will have intervals ranging from 28 to 32 months; and in the third year, the last 66 aircraft will have intervals ranging

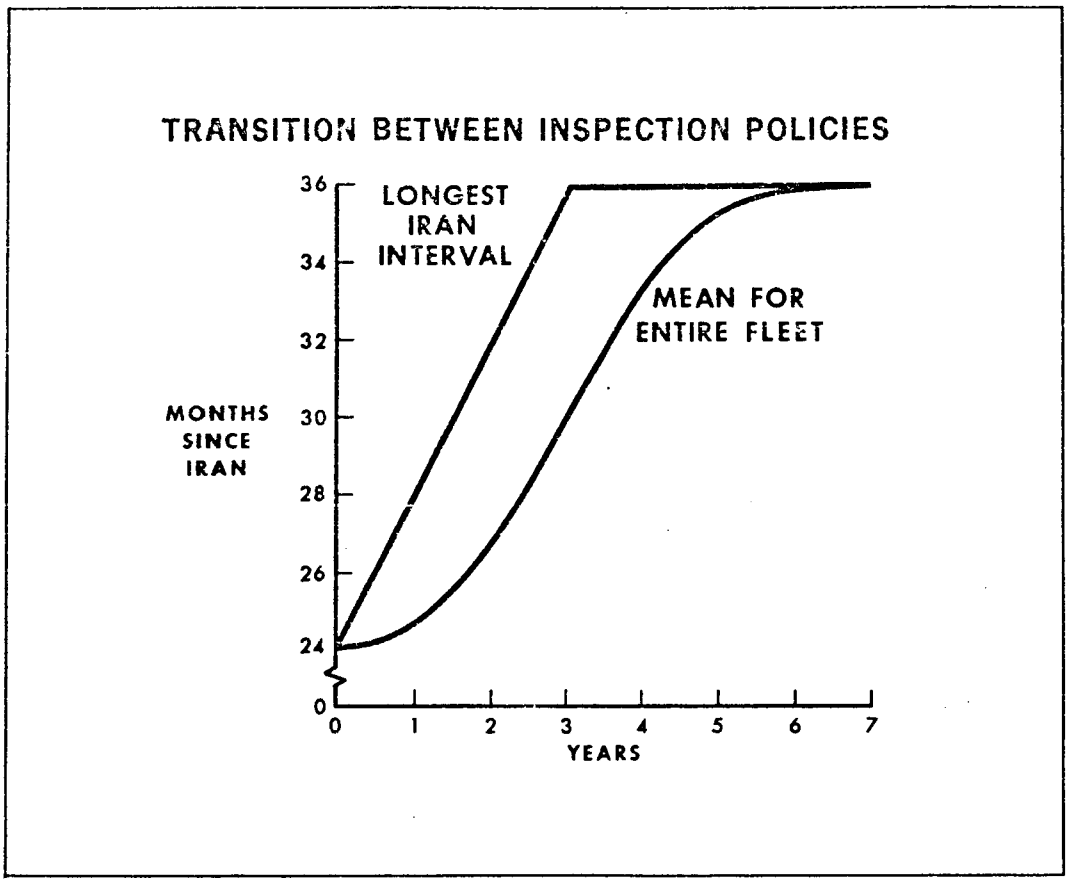

Chart 8

from 32 to 36 months (with the 200th aircraft being the only one to reach the 36-month interval). The fleet will require another three years for all aircraft to reach the 36-month interval.

Our several assumptions are likely to be different than the situation existing for a particular system in the real world; however, we believe that for most present USAF systems, the basic principle holds that though a change in interval policy occurs suddenly, nothing is going to suddenly happen to the fleet. It is likely to take time to transition from one policy to another.

RISK RECAP

Given that evidence suggests an interval change for a particular aircraft fleet, and given that the transition from the existing policy to the new one is likely to occur slowly, the risk is also likely to be reasonable. With slow maturation, it becomes plausible to track the fleet's behavior as it transitions to the new IRAN interval. Control mechanisms would include measurements of aircraft experiencing extended intervals. The operating organization might routinely analyze available data systems regarding the operational and maintenance performance of such aircraft. Engineers might make base visits to examine (and discuss) aircraft condition, especially as observed in base docks. Such routine or extra-routine action might also be given to aircraft flowing through the IRAN facility. Thus, the slow maturity and the reasonable opportunity to check the effects of extended intervals give the decisionmaker what seems like ample opportunity to take corrective action should unforeseen difficulties arise.

Although extending a fleet's inspection interval takes considerable time, the dollars involved in IRAN for resources such as personnel are obtained "immediately" for use elsewhere. But extending intervals poses critical institutional issues. The data disclosed for the F-106 IRAN are not unique. Similar evidence probably exists for most weapon systems undergoing IRAN. Thus, an AFLC organization-wide problem is likely. A cutback in IRAN might severely weaken an AMA, whose longer run requirements may make elimination of IRAN resources questionable.

Also, contractors perform about 50 percent of the IRAN workload. The larger effects of cutbacks in contracts obviously require study and high level decisionmaker attention. This study does not address these larger institutional issues.

IV. LEVELS OF MAINTENANCE

During this inspection interval and content study, we developed information that appears to challenge the current levels of maintenance doctrine. This section discusses the current doctrine, its possible need for change, and the implications of such a change. The levels-of-maintenance issue appears to be a logical next study for Rand.

DOCTRINE

Information being developed challenges the basic policy that maintenance echelons exist because of uniqueness; i.e., unique skills and equipment exist at each level. This no longer seems to be true.

Maintenance personnel concerned with depot IRANs have frequently commented to us that if base level maintenance performed its function adequately, there would be little work left for the depot. Similarly, inspection dock personnel at base level have suggested that if flightline personnel fixed all discrepancies known to them and within their skill and equipment capability, there would be little work left for base docks.

AFLC's engineering evaluations indicate that the number of so-called hard-core depot level tasks appear to be limited. Similarly, Rand's engineering evaluations have thus far indicated that docks fix few items that are related to safety and mission and that are not known to the flightline. The work these docks perform seems dominated by "housekeeping" tasks that do not appear to be directly related to safety and mission.

More Appropriate in Earlier Times

In earlier times, current doctrine regarding levels of maintenance may have been more appropriate. The flightline's visibility regarding aircraft condition was more limited than it is today, so there was a considerable and continuing threat to safety and mission on the flightline. In this threatening environment it may have been especially important for frequent and intensive inspections and teardowns to assess an aircraft's condition more carefully than was possible on the flightline.

Less Appropriate in Recent Times

More recently, however, the flightline has had a better handle on aircraft condition. Its visibility has improved considerably because of such factors as improved instrumentation, built-in test equipment, and aerospace ground equipment. Furthermore, the threat has been reduced by increased redundancy and reliability.

Given this increased visibility, the flightline now corrects most safety and mission-related items; however, it knowingly defers to the docks some safety and mission-related items for a number of reasons, one being that the correction would require some considerable equipment teardown that would interfere with flight schedules. In any event, the improved visibility makes it possible for the flightline to concentrate on safety and mission requirements. It defers to the dock inspections predominantly those nonsafety or mission tasks--housekeeping tasks. This suggests two needs: rethinking of the requirement for three maintenance levels and development of a more appropriate policy regarding the use of different maintenance levels.

IMPLICATIONS

If many inspection tasks are not directly related to mission and safety, it may be desirable to combine some base and depot level tasks and reallocate them to different levels of maintenance, using economic criteria. Such a study would quite likely indicate opportunities to exploit economy-of-scale principles. To illustrate, consider the following example.

IRAN INCREMENT DOCK

Consider the base level IRAN increments at Travis. Given the requirement for two base level IRAN increments every three years for each aircraft, and given a fleet size of 56 aircraft, 37 1/3 increments are necessary each year. Given further that each increment is programmed for four days and given the need for about 20 unprogrammed days for personnel leaves, clean up, and the like, 169 dock days are required to support IRAN Increments 1 and 2. In a year, however, there are 260

dock days. Thus a surplus capacity of some 35 percent exists. In such situations, either alternative uses are found for dock resources, or as often happens, aircraft are brought into the dock at faster rates than policy requires. Such a course is followed to maintain high dock resource utilization.

This illustration, shown in Chart 9, is likely to have some generality. Given different fleet sizes at each base, with a fixed inspection interval that is not tied to fleet size, it is likely that different levels of efficiency in resource utilization occur from base to base. For such situations, exploitation of economy-of-scale principles may be useful.

IRAN INCREMENT DOCK
(TRAVIS AFB)

- **REQUIREMENT**
  - 56 AIRCRAFT × 2 INCREMENTS/3 YEARS
  - 37 1/3 INCREMENTS/YEAR
  - 4 DAYS EACH INCREMENT AND 20 FREE DAYS
  - 169 DOCK DAYS REQUIRED
  - AVAILABLE: 260
- **SURPLUS CAPACITY**
  - 35%
- **GENERALITY**

Chart 9

V. CONCLUSIONS

In summary, our study has not provided a means for calculating the optimum or best inspection interval. It has suggested that varying interval size can provide a practical means for determining a better interval from among the range of intervals experienced. Variability can be systematically induced through a variety of ways including Controlled Interval Extension programs. Of course, in addition to assessing statistically whether aircraft operation and maintenance vary as a function of interval size, it is necessary to augment such analyses with engineering and maintenance judgment in decisions regarding interval size and content. Our study experience indicates that a continuing capability is needed to analyze the management associated with scheduled inspections, including its scheduling and its contribution to mission effectiveness and safety.

More specifically, with regard to depot level IRANs, the interval size variability our method requires is believed to exist for practically all systems. Thus, in the near term, the issue is not one of inducing variability. AFLC and several of its contractors have under way studies for some systems undergoing IRAN. The basic thrust of such studies includes the types of analyses indicated here. We believe the studies will suggest that it is possible to extend IRAN intervals for most weapon systems without degrading mission or safety and without incurring undue risk. Decisions to extend intervals make it possible to capture immediately the dollars associated with some resources (e.g., manpower) allocated to IRANs. The likely number of systems whose intervals can be extended, and the likely amount of such extensions is large enough to raise a number of institutional issues. For example, some AMAs may be weakened because of interval extensions. Furthermore, since a considerable amount of IRAN is accomplished under contract, the issue about whether the current organic/contractor mix is appropriate, given interval extensions, needs to be addressed. This study does not discuss these larger institutional issues.

With regard to major base level inspections, the required variability and data to perform the analysis are probably available only for weapon systems on the isochronal policy. Weapon systems under the

periodic/phase policy probably have not experienced the necessary interval variation, and for these, variability will have to be induced. Since most weapon systems in inventory are under the periodic/phase policies, all commands need to become interested so that the required data can be obtained.

Finally, the data generated by this study indicate that the current levels of maintenance doctrine should be examined. The next logical step for Rand would be to undertake a study that evaluates alternative maintenance organization postures.* The proposed study would examine organizational, intermediate, and depot levels, and evaluate a number of consolidation alternatives:

1. Use regional bases within a command to accomplish major inspections.
2. Use a single base within a command to accomplish major inspections.
3. Perform all major weapon system inspections at an AMA.
4. Use some combination of the foregoing.

*This study was begun in 1971.

Appendix

C O P Y

5 May 1970

AFSME

RAND Proposal for a Study of C-141 Isochronal Inspection

AFLC (MCN)

1. Reference the RAND briefing on subject proposal.

2. The proposed study outlined in the referenced briefing appears to merit further investigation, not only as it relates to the C-141 fleet, but also its possible application to both field and depot inspection intervals of other weapon systems.

3. Request you take the lead with MAC and The RAND Corporation to determine the most profitable approach to this project.

4. Our C-141 shop, AFSMEMA, will monitor this project as it pertains to the C-141 inspection intervals and impacts on C-141 fleet performance.

FOR THE CHIEF OF STAFF

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C O P Y