AD-779 958

MAJOR ITEM SPECIAL STUDY (MISS), CH-47A GAS TURBINE ENGINE (T55-L-7C)

Army Aviation Systems Command
St. Louis, Missouri

May 1974

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Security Classification

DOCUMENT CONTROL DATA - R & D AD-779 958

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US Army Aviation Systems Command Directorate for Product Assurance St. Louis, MO 63166	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

3. REPORT TITLE

Major Item Special Study (MISS), CH-47A Gas Turbine Engine

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Interim; Jan 1964-July 1973

5. AUTHOR(S) (First name, middle initial, last name)

Personnel of the Directorate for Product Assurance
Systems Performance Assessment Division

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1974	14	

8a. CONTRACT OR GRANT NO. N/A b. PROJECT NO. N/A c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 74-28 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES N/A	12. SPONSORING MILITARY ACTIVITY US Army Aviation Systems Command ATTN: AMSAV-LS P.O. Box 209 St. Louis, MO 63166

13. ABSTRACT

Major Item Special Study (MISS) reports are performed on DA Form 2410 reportable components. These are time change items and certain condition change items selected because of high cost or need for intensive management. Basically, the MISS reports are concerned with analyzing reported removal data presented in the Major Item Removal Frequency (MIRF) report. The failure modes reported for each removal are examined and grouped into categories which are intended to clarify the intent of the data reporting. From this data, removal distribution can be plotted and an MTR (mean time to removal) can be calculated. The MISS reports then investigate possible cost savings based on total elimination of selected failure modes. These modes are chosen because of the percentage of failures they represent and/or because they appear to be feasible Product Improvement Program (PIP) areas. (U)

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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UNCLASSIFIED
Security Classification

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Major Item						
Major Item Removal Frequency (MIRF)						
Failure Modes						
Removals						
Gas Turbine Engines						

UNCLASSIFIED

Security Classification

USAAVSCOM TECHNICAL REPORT 74-28

MAJOR ITEM SPECIAL STUDY (MISS), CH-47A GAS TURBINE ENGINE (T55-L-7C)

FSN 2840-950-6875 PN 2-000-030-18

INTERIM REPORT
prepared by the personnel of the

DIRECTORATE FOR PRODUCT ASSURANCE
SYSTEMS PERFORMANCE ASSESSMENT DIVISION

Period Covered by Data

JAN 01, 1964 THRU JULY 01, 1973

Published: MAY 1974

US ARMY AVIATION SYSTEMS COMMAND
St. Louis, MO

Approved for public release;
distribution unlimited

III

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1. INTRODUCTION

The following report is designed to illustrate cost savings which would result from specific efforts in the areas of product improvement in quality and design. For the purpose of this study the cost savings produced in the area of product improvement are based on total elimination of a certain failure mode or modes. Appropriate modes are chosen because of their proportion of the total removals or their proportion in combination with other similar modes. These eliminated removals are then assumed to follow the distribution of the remaining removal modes. The actual cost savings are determined from the increase in the mean time to removal based on the new removal distributions. The data used and methods involved are described in the following paragraphs.

1.1 PURPOSE

The objective of this study is based on several factors. While the specific objective of this report is to identify and quantify possible cost savings through product improvements, the following parameters may also be affected by implementation of the actions proposed in this report.

1.1.1 Mission reliability is increased due to fewer failures.

1.1.2 The maintenance manpower requirements are decreased due to fewer spares replacements.

1.1.3 Product Improvement Program (PIP) Candidates are identified and reflected as potential savings in materiel and manpower.

1.1.4 Aircraft availability is increased due to decreased downtime for replacements.

1.1.5 Spares requirements are reduced due to decreases in the number of replacements.

1.1.6 It is possible to project spares requirements based on removal frequencies, flight hour programs, new vs overhaul replacement policies and the number of aircraft in the inventory.

1.1.7 Problem areas are identified where the state of the art is not satisfying the operational requirements, indicating that R&D efforts are needed for developing new materials and processes.

1.1.8 Problem areas are identified where improvements are needed in operation and maintenance (for example: pilot technique in avoiding striking objects and unnecessary replacements).

1.1.9 Improved reliability standards are established for future similar components.

1.2 SCOPE AND LIMITATIONS

The basic source of data for this study is the Major Item Removal Frequency (MIRF) report of the Reliability and Maintainability Management Improvement Techniques (RAMMIT) system. The data is stratified according to removal modes and flight hour intervals. The data is further examined by specific reasons for removals and redistributions are made with the assumption that selected failure modes can be eliminated entirely through Product Improvement Programs (PIP). While this data is limited to first removals of new items, similar studies may be performed on overhauled items. No attempt is made to develop the means of eliminating failure modes or extending the retirement life interval. This report does show the magnitude of possible benefits to be derived if appropriate actions are taken.

1.3 METHODS

The specific method employed in this study is explained in Section 3. Generally, a cost savings is calculated based on an increase in the mean time to removal by elimination of selected failure modes.

For the purpose of cost calculations, a new Gas Turbine Engine acquisition cost is estimated to be $69,606, while overhaul is estimated to be $20,184 per unit assembly. The manhour cost per replacement is $135.45 based on $10.50 per manhour and the average manhours reported for replace actions.

1.4 APPLICABLE DOCUMENTS

TM 38-750

TB 55-1500-307-25

TB AVN 23-65

Master Data Record T55-L-7C Turbine Engine

Major Item Removal Frequency Report CH-47A Aircraft

2. REMOVALS

DA Form 2410, as applicable to Army Aviation is a six copy form. It is used to provide installation, removal, overhaul, operating time and control information for reportable aircraft components and parts. The components included under the 2410 reporting system, and in this study, are time change items and certain condition change items selected because of high cost or need for intensive management. This study utilizes the removal copy of the 2410 data system, as organized in MIRF to analyze the number of removals with respect to the reported flight hours since new of the component.

The failure modes reported for each removal are examined and divided into categories which are intended to clarify the intent of the data reporting. As the categories are often not as definitive as might be desired, this statification allows a generalization of the causes of removals to two main categories: failures and non-failures. These are represented graphically in Illustration 1. Note that failures accounted for 40.2% of all removals while non-failures comprised the remainder of 59.8%. The non-failure categories include those that require overhaul and those that do not, as shown in Table 1.

For the purpose of this study there are two types of failures. They are induced failures which include all those removals that resulted from failure not attributable to an actual material defect and material failures which imply a direct discrepancy or deficiency of the quality and/or design of the component. The reported modes for these categories are also displayed in Table 1. Illustration 2 shows that induced failures accounted for 27.5% of all failures, while the remainder of failures, 72.5%, were due to material failures. Of these material failures, 24.1% were due to cracks and 19% were due to leakage as shown in Illustration 3. Table 2 lists the total removals by flight hour interval in each of the categories described above. The intent of this study is to show the effect of the elimination of these removals due to cracks and leakage in the engine assembly. Cracks and leaking failures will be considered as high mode failures in this study.

TABLE 1

CLASSIFICATIONS OF REMOVAL CATEGORIES TO REFLECT INTENT OF REPORTING

FAILURES

MATERIAL FAILURES (Those removals which indicate a deficiency or discrepancy in the quality and/or design).

Worn Excessively	Leaking
Broken	Metal on Magnetic Plug
Torque Incorrect	Internal Failure
Corroded	Oil Consumption Excessive
Cracked	Overheats
Low Lube Pressure	Surged
Burned	Low Power on Thrust
	Bearing Failure

INDUCED FAILURES (Those removals which are a result of conditions imposed upon the item for which it was not designed).

Foreign Object Damage	Accident Damage
Contamination	Chipped
Hot Start	
Crash Damage	

NON-FAILURES

NON-FAILURES REQUIRING OVERHAUL (Those removals which were not due to a material failure or induced failure, but by the nature of their cause for removal require overhaul).

No Defect - MWO Compliance
No Defect - Removed for Scheduled Maintenance

NON-FAILURES NOT REQUIRING OVERHAUL (Those removals which were not due to a material or an induced failure and involved no defect).

Cannibalization
No Defect
Component Removed to Facilitate Other Maintenance

ILLUSTRATION 1

TOTAL REMOVALS PER FLIGHT HOUR INTERVAL
CH-47A GAS TURBINE ENGINE (T55-L-7C)
FSN 2840-950-6875 PN 2-000-030-18

FIRST REMOVAL OF NEW ITEMS: 199 TOTAL REMOVALS

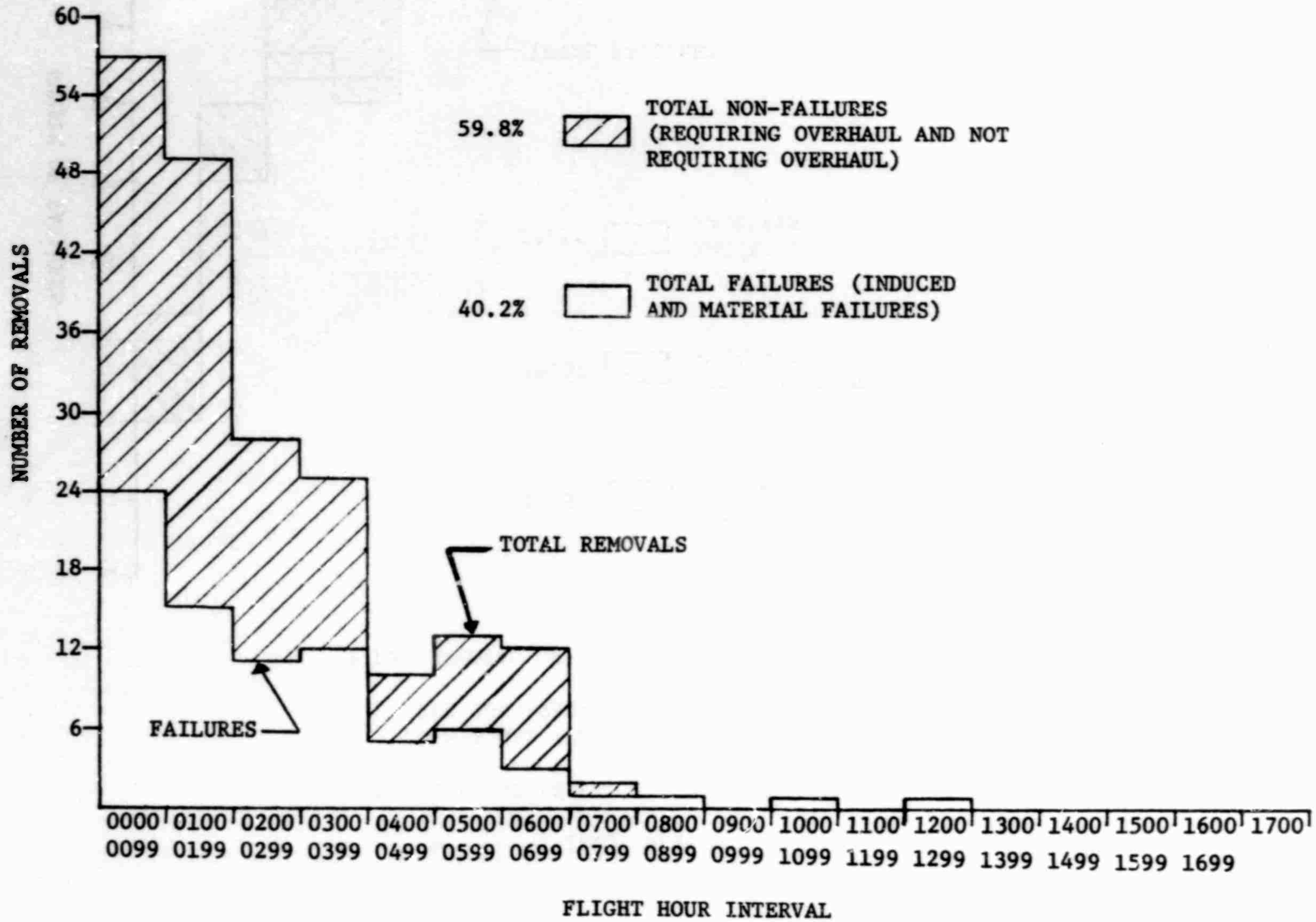

ILLUSTRATION 2

TOTAL FAILURES PER FLIGHT HOUR INTERVAL

CH-47A GAS TURBINE ENGINE (T55-L-7C)
FSN 2840-950-6875 PN 2-000-030-18

FIRST REMOVAL OF NEW ITEMS: 80 TOTAL FAILURES

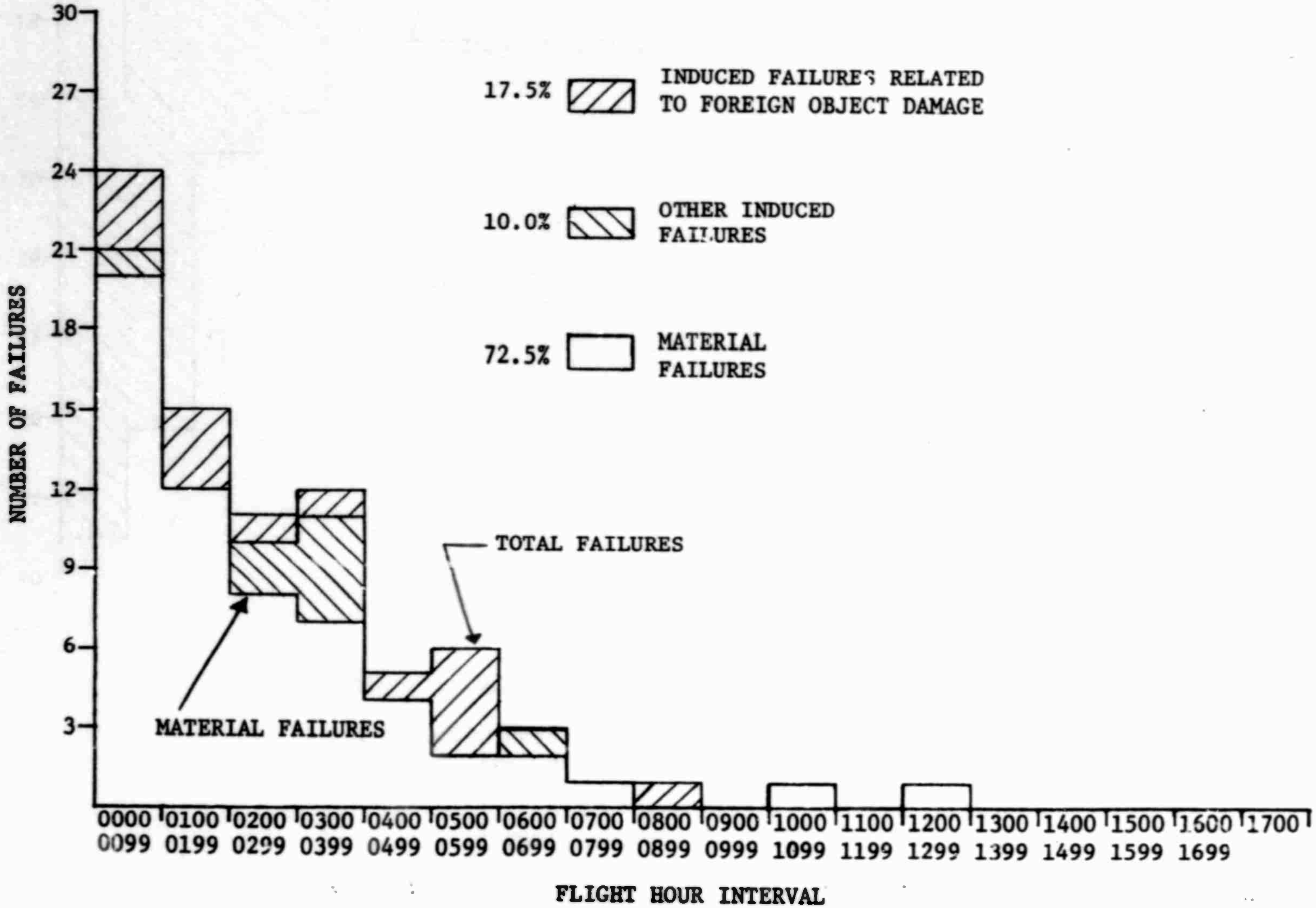

ILLUSTRATION 3

TOTAL MATERIAL FAILURES PER FLIGHT HOUR INTERVAL
CH-47A GAS TURBINE ENGINE (T55-L-7C)
FSN 2840-950-6875 PN 2-000-030-18
FIRST REMOVAL OF NEW ITEMS: 58 MATERIAL FAILURES

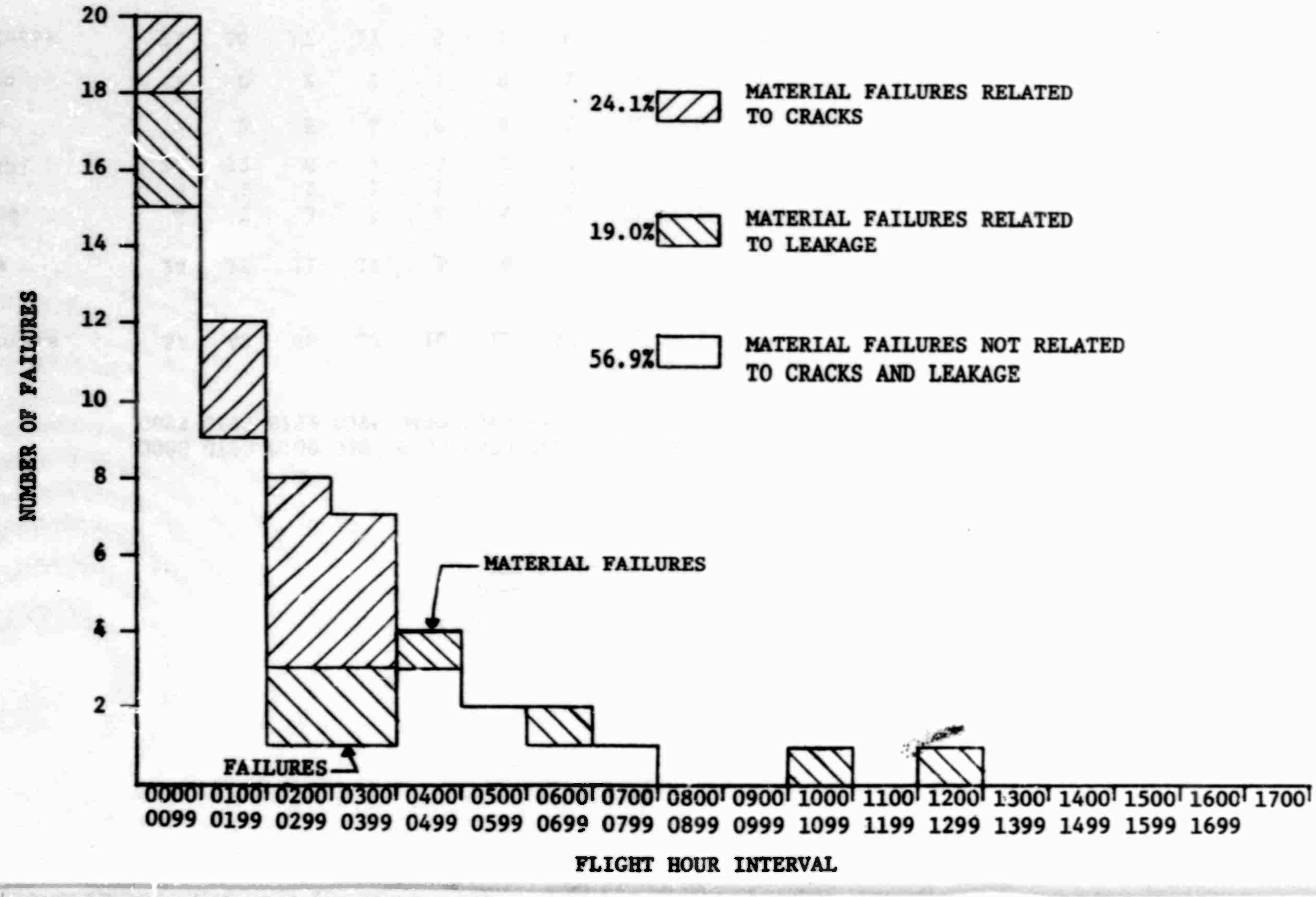

TABLE 2

FLIGHT HOUR DISTRIBUTION OF TOTAL REMOVALS

CH-47A GAS TURBINE ENGINE (T55-L-7C)

FSN 2840-950-6875 PN 2-000-030-18

FLIGHT HOUR INTERVAL

	0000 0099	0100 0199	0200 0299	0300 0399	0400 0499	0500 0599	0600 0699	0700 0799	0800 0899	0900 0999	1000 1099	1100 1199	1200 1299	1300 1399	1400 1499	1500 1599	1600 1699	ABOVE 1700	TOTAL
All Removals	57	49	28	25	10	13	12	2	1	0	1	0	1	0	0	0	0	0	199
Failures	24	15	11	12	5	6	3	1	1	0	1	0	1	0	0	0	0	0	80
Induced	4	3	3	5	1	4	1	0	1	0	0	0	0	0	0	0	0	0	22
FOD	3	3	1	1	1	4	0	0	1	0	0	0	0	0	0	0	0	0	14
Material	20	12	8	7	4	2	2	1	0	0	1	0	1	0	0	0	0	0	58
Cracks	2	3	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
Leakage	3	0	2	2	1	0	1	0	0	0	1	0	1	0	0	0	0	0	11
Non-Failures	33	34	17	13	5	7	9	1	0	0	0	0	0	0	0	0	0	0	119
Overhaul	5	5	0	0	1	3	6	0	0	0	0	0	0	0	0	0	0	0	20
Non-Overhaul	28	29	17	13	4	4	3	1	0	0	0	0	0	0	0	0	0	0	99

3. DESIGN AND QUALITY IMPROVEMENT

This chapter illustrates possible cost savings and avoidance based on total elimination of cracks and leaking failures. This assumption necessitates a redistribution of the eliminated failures bacause all items are eventually removed at TBO, if not sooner, due to other reported removal modes. The redistribution process involved assumes that the eliminated high mode failures would not have failed by any other failure mode prior to the actual failure. After this time (flight hour interval) they are assumed to follow the distribution of the remaining removals. Thus, at each flight hour interval the high mode failures are redistributed according to the remaining distribution (i.e., all other failure or non-failure modes). At each flight hour interval a proportional number of removals is added to all subsequent intervals, and when this process is repeated to TBO, a revised distribution is calculated. Since hand calculations were extensive and laborious, a Fortran computer program was written and used for the redistribution. This distribution is shown in Table 3 which illustrates the breakdown of removals by flight hour interval before and after the eliminated removals are redistributed.

Potential cost savings are based on an increase in mean time to removal (MTR) from the original distribution to the revised distribution. In order to calculate these cost savings an inventory of 187 aircraft flying 49.1 hours per month is assumed for both the original and revised distributions. Each of these distributions is limited to removals that require replacement by a new or overhauled component. Thus, any increase in MTR causes a decrease in the number of replacements and therefore a reduction on the cost of replacements.

Illustration 4 graphically illustrates the increase in mean time to removal after elimination of the high mode failures. The distributions before and after the elimination are shown with shaded areas to show the decrease in the number of early failures due to cracks and leaking failures. The increase in mean time to removal in this study is 15 hours which, based on the 220,360 flight hours per year (187 aircraft x 12 months x 49.1 hours x 2 engines per aircraft), yields an annual decrease of 38 removals.

The cost savings or cost avoidance indicators are on an annual basis as shown in Table 4. The costs represent replacement by new or overhaul parts as well as the manhour cost of removal. The range of savings, then, is from $772,139 (assuming replacement by overhauled items) to $2,650,171 (assuming replacement by new items). These cost indicators do not include the total logistical cost inputs but indicate the significant costs for acquisition versus overhaul of the T55-L-7C Gas Turbine Engine.

TABLE 3

NUMBER OF REMOVALS PER FLIGHT HOUR INTERVAL
REQUIRING NEW OR OVERHAULED REPLACEMENT ITEMS

CH-47A GAS TURBINE ENGINE T55-L-7C
FSN 2840-950-6875 PN 2-000-030-18

FLIGHT HOUR INTERVAL

	0000 0099	0100 0199	0200 0299	0300 0399	0400 0499	0500 0599	0600 0699	0700 0799	0800 0899	0900 0999	1000 1099	1100 1199	1200 1299	1300 1399	1400 1499	1500 1599	1600 1699	1700 1799	TOTAL
Original Distribution (Before Elimination and Redistribution of cracks and leaking failures)	29	20	11	12	6	9	9	1	1	0	1	0	1	0	0	0	0	0	100
Revised Distribution (After Elimination and Redistribution of cracks and leaking failures)	25	18	5	8	6	12	11	1	1	0	0	0	0	0	0	0	0	0	87

ILLUSTRATION 4

NUMBER OF REMOVALS PER FLIGHT HOUR INTERVAL BEFORE AND AFTER
REDISTRIBUTION OF CRACKS AND LEAKING FAILURES
CH-47A GAS TURBINE ENGINE T55-L-7C
FSN 2840-950-6875 PN 2-000-030-18

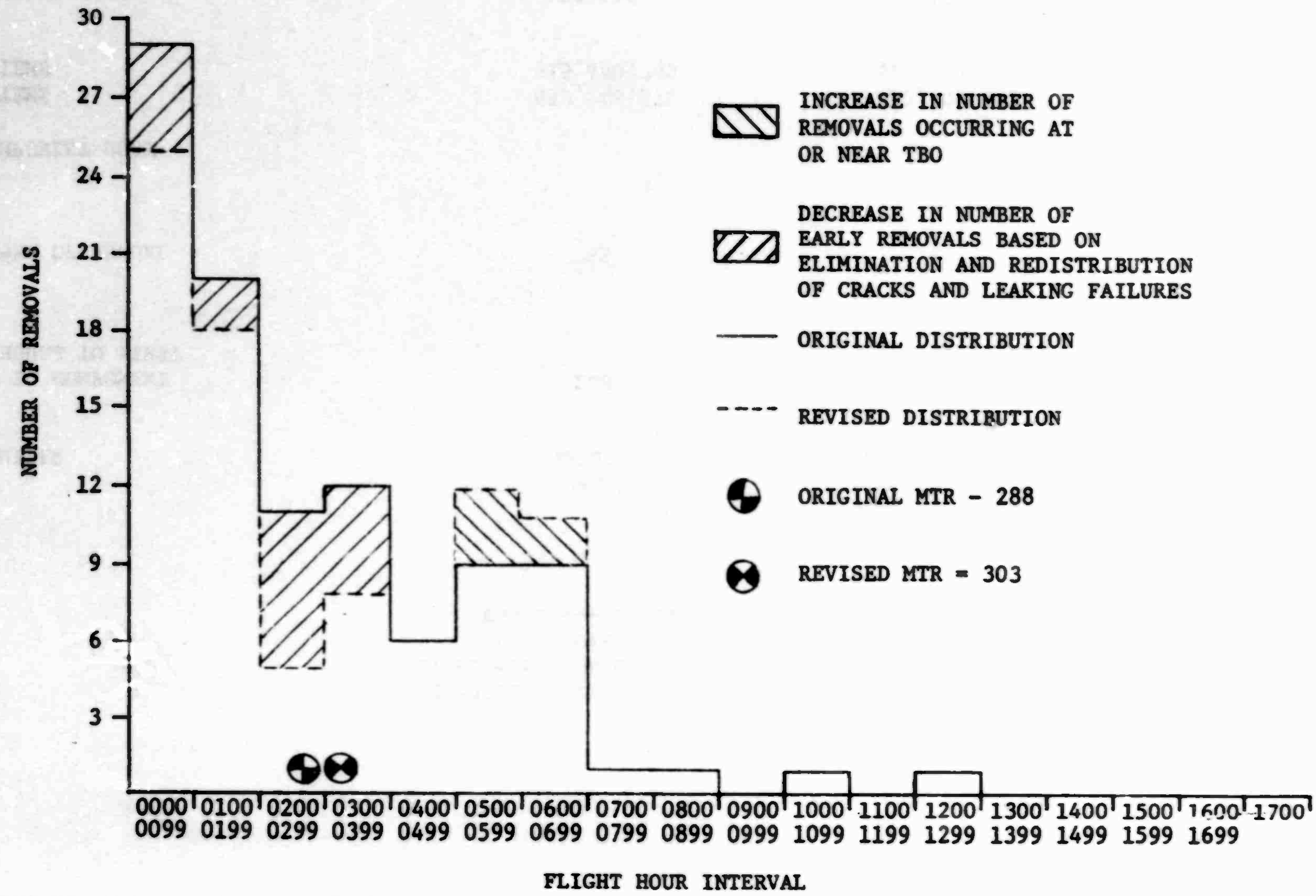

TABLE 4

POTENTIAL ANNUAL COST SAVINGS TO BE REALIZED
BY ELIMINATION OF CRACKS AND LEAKING FAILURES
CH-47A GAS TURBINE ENGINE T55-L-7C
FSN 2840-950-6875 PN 2-000-030-18

PARAMETER	CURRENT VALUE	DESIGN AND QUALITY IMPROVED VALUE (CRACKS & LEAKING FAILURES ELIMINATED)	NET ANNUAL CHANGE
MEAN TIME TO COMPONENT REMOVAL (HOURS TO FIRST REMOVAL)	288	303	15 ↑
TOTAL NUMBER OF ANNUAL REMOVALS	765	727	38 ↓
ANNUAL COMPONENT COST			
NEW ITEMS	$53,248,576	$50,603,552	$2,645,024 ↓
O/H ITEMS	$15,440,760	$14,673,768	$ 766,992 ↓
ANNUAL MANHOUR COST	$103,619	$98,472	$5,147 ↓
TOTAL ANNUAL REPLACEMENT COSTS			
NEW ITEMS	$53,352,195	$50,702,024	$2,650,171 ↓
O/H ITEMS	$15,544,379	$14,772,240	$772,139 ↓

NOTE: All the above figures are based on 187 aircraft flying 49.1 hours per month.

4. SUMMARY

Thorough analysis of DA Form 2410 data on the CH-47A Gas Turbine Engine indicates that a problem exists with respect to the number of engines that are failing due to cracks and leakage. The flight hour distribution for all failure and non-failure removals were presented in this report, and the total material failures per flight hour interval were shown, illustrating that proportion which failed due to high mode failures. Approximately 43.1% of all material failures were removed for cracks and leaking failures.

It is readily apparent that this failure mode deserves particular attention. This is the one big problem area that is both well-defined and potentially solvable. The obvious conclusion is that the failure mode should be eliminated. This analysis was not directed toward the development of solutions for high-frequency removal categories, but the identification of them and the potential cost savings to be realized by their elimination. The completed analysis followed this basic tenet.

Assuming the problem could be completely eliminated, the high mode failure distribution was removed from the overall removal distribution. It was then assumed that if the turbine engines had not failed for that reason, they would have survived at least as long as they did, and then be removed according to the remaining removal distribution. This redistribution was performed, thereby creating a theoretical total increase in the Mean Time to Removal (MTR) of 15 flight hours. In effect, this would give 2,805 additional flight hours of operational service for the same number of removals on a fleet of 187 aircraft if the cracks and leaking failure problems were eliminated.

It follows that a higher MTR implies fewer component removals for a given flight hour profile. Using the standard flight hour profile of 2 engines per aircraft x 187 aircraft flying 49.1 hours per month for 12 months, basic comparisons were made in the number of high mode failure removals for the existing removal distribution and the non-high mode failure removal distribution. Cost comparison indicators of the current and theoretically improved Gas Turbine Engine were calculated with the potential cost savings shown. The component costs used were the estimated procurement cost for a new item and the estimated cost for overhaul of the item. Depreciation, storage, shipping, etc., were not considered in development of cost indicators for this analysis. The total potential cost savings revealed in this study may be found in Table 4. The range of savings is from $772,139 to $2,650,171 per year.

The analytical technique just described as having been performed on the CH-47A Gas Turbine Engine (i.e., removal of abnormally high failure modes) can be performed on any 2410 reportable item. As previously stated, no attempt has been made to redesign an item, only to point out its major deficiencies and identify them as candidates for a Product Improvement Program. By improving the removal characteristics of this component with a PIP program, benefits other than the direct cost considerations would be realized. This would include increased availability and mission capability, decreased logistics requirements, and higher reliability of the component and the entire aircraft system. Also, the characteristics of the theoretically improved item can be used as a standard which would give the minimum acceptable reliability characteristics of future generation like items.