REVIEW AND EVALUATION OF ARMY AVIATION DEPOT NDI AND RELIABILITY CENTERED MAINTENANCE

Final Report

SwRI Project 17-7958-826

Prepared for

U.S. Army Aviation Systems Command
Depot Engineering and RCM Support Office
Corpus Christi Army Depot
Corpus Christi, Texas 78419-6195

Performed as a Special Task under the auspices of the Nondestructive Testing Information Analysis Center
Contract No. DLA900-84-C-0910, CLIN 0001AV

August 1988

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SAN ANTONIO HOUSTON

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R.T. Anderson, D. Henry (RTA), F.A. Iddings, V.G. Muller (SwRI)

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A summary of work performed on Depot Maintenance Handbooks, DMWRs, and support materials for the Reliability Centered Maintenance (RCM) Program. Forty DMWRs were evaluated and modified during the program. Copies of major contributions to the RCM program are included in the report as well as title pages of other documents produced and delivered to the Depot. Keywords:

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Final Report

SwRI Project 17-7958-826

by

R.T. Anderson, C.D. Henry, III
Reliability Technology Associates
Orland Park, Illinois

and

F.A. Iddings, V.G. Muller
Southwest Research Institute
San Antonio, Texas

Prepared for

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TABLE OF CONTENTS

1. INTRODUCTION

Southwest Research Institute (SwRI), under a special task assigned to the Nondestructive Testing Information Analysis Center (NTIAC), initiated a program in 1985 on the "Review and Evaluation of Army Aviation Depot NDI and Reliability Centered Maintenance." The final report for this program, funded by the U.S. Army Aviation Systems Command, is contained in this document.

The program objectives were to:

(1) Review and evaluate selected Army aviation depot maintenance work requirements (DMWRs) for nondestructive inspection (NDI) and reliability centered maintenance (RCM) techniques.

(2) Develop a plan for expanding the U.S. Army Aviation Systems Command (AVSCOM) RCM system at the Corpus Christi Army Depot (CCAD) to include more aircraft components than presently covered, define additional output products, and implement further the RCM process at CCAD.

(3) Develop an overall Army aircraft RCM program plan that is consistent with the depot-level RCM plan from (2).

With the assistance of Reliability Technology Associates (RTA), subcontractor to the program, the objectives of this program were met by completing the following tasks:

(1) Procedure for reviewing Army Aviation DMWRs for NDI techniques and RCM philosophy was formally submitted to AVSCOM's Depot Engineering and RCM Support Office (DERSO) and to SwRI by RTA in May 1986. After a pilot application, the procedure was expanded into a "Background, Assumptions, and Methods for Application of Reliability Centered Maintenance to Army Aviation DMWRs."

(2) Package of 40 DMWR reports, with final AVSCOM Engineering Directive (AEDs), along with the background, assumptions, and methods document cited previously was submitted to DERSO.

(3) In December 1987, reliability centered maintenance cost data for DMWRs were submitted to SwRI NTIAC.

(4) Necessary updates in the Depot Maintenance Handbook (NTIAC-85-1) were sent to SwRI NTIAC on April 29, 1988.

(5) An updated RCM plan was submitted in January 1988 to reflect preparation of the overall Army aircraft RCM program plan.

(6) Program criteria derived from Airframe Condition Evaluation/Aircraft Analytical Corrosion Evaluation (ACE/AACE) meeting viewgraphs were incorporated into both RCM plans.

(7) A detailed Army aircraft RCM program plan was presented to AVSCOM DERSO management personnel at a meeting on March 4, 1988.

Section 2 lists the work done by RTA in order to meet the program objectives. Section 3 presents the evaluation done by SwRI on the DMWR documents, and Section 4 covers suggested recommendations for the program.

A listing of the title pages for the 40 Army Aviation DMWRs is found in Appendix A. Only the title pages are included since the 40 documents total over 1000 pages of material. Additional documents produced during this program are contained in Appendix B.

2. WORK EFFORT PERFORMED BY RELIABILITY TECHNOLOGY ASSOCIATES

The RTA group performed a major portion of the work defined for this program. The following is a listing of the work submitted to SwRI by RTA at the end of the program:

- Forty DMWR documents along with their corresponding AEDs.
- "Procedure for Review of Army Aviation DMWRs for RCM Philosophy," May 1986.
- "Application of Reliability Centered Maintenance to Depot Maintenance Work Requirements: Background, Assumptions, and Methods for Application to Army Aviation DMWRs," September 1987.
- "Reliability Centered Maintenance Cost Data for DMWR," December 1987.
- "Updates to Depot Maintenance Handbook (NTIAC-85-1)," April 29, 1988.
- ACE/AACE Viewgraphs.
- "The Five-Year RCM Program Plan," May 1988.

As can be surmised from the above documentation, RTA played a vital role in the execution of the program objectives.

3. SwRI REVIEW OF THE NDI APPROACHES USED IN THE DMWRs

Southwest Research Institute performed a focused review of the NDI approach applied in 40 Army Aviation DMWRs. A large portion of the DMWR documents specified a visual inspection *only*. The definition of a visual inspection is defined as "looking at a surface either directly, with the aid of a mirror, or with a magnifying glass for the purpose of identifying signs of deterioration or damage." The DMWRs that recommend a visual inspection only specify detection of such flaws as cracks, nicks, and corrosion; however, very few of these DMWRs mention the flaw size to be detected.

One DMWR reviewed by SwRI that did specify flaw size was DMWR-55-1520-234: AH-1S helicopter. The various components of the AH-1S helicopter currently are inspected visually using this procedure to evaluate corrosion damage. On page 13 of the procedure, large areas of corrosion can be accepted if the depth of damage is less than 5 percent of the thickness. Isolated spots can be accepted up to a depth of 10 percent. Specifically, the inspection of diagonal braces (Task 110) requires replacement of components with dents, nicks, and corrosion damage in excess of 0.010 inch. The specified visual inspection, however, is qualitative and cannot produce repeatable and accurate quantitative measurements.

SwRI suggests the following alternative to the existing NDI approach in DMWR-55-1520-234. Under contract to McClellan AFB, SwRI developed two NDI approaches to quantitatively measure the chaffing damage in hydraulic control tubes of various aircraft. The two approaches use focused ultrasonic and miniaturized eddy current sensors, respectively. Both approaches have been successful in measuring chaffing damage (or pit depth) with an accuracy of 0.001 inch. These approaches are proposed for the evaluation of various components of the AH-1S helicopter.

Because of the difference in geometry and material composition between helicopter components and hydraulic control tubes, the sensors will need to be modified for application on the AH-1S. The modified sensors would be tested on the helicopter for accuracy, and the cost and benefits of the inspection would then be determined.

SwRI's final suggestion is that a reevaluation be done on the DMWRs that specify a visual inspection only. SwRI believes that a visual inspection alone could be an unsafe practice and might also result in a more costly operation.

4. RECOMMENDATIONS

As a result of the evaluation of the 40 DMWRs, the following recommendations are proposed as a means of improving the NDI approach:

(1) Every Army component brought in for inspection should have a critical or noncritical label. A critical component would be one that (1) is life threatening or (2) results in damage to the crash aircraft. A noncritical component would be one that does not destroy human life or the aircraft. This type of labeling will help to evaluate the level of NDI required for the individual component. For example, the NDI approach for a noncritical component might include a visual and penetrant inspection. On the other hand, the NDI approach for a critical component should include some of the more sophisticated disciplines; i.e., ultrasonics and eddy current. NDI of components after disassembly and before assembly should reduce dollars being lost due to wasted manhours for assembly of defective components or failure of the component during flight.

(2) Most of the DMWR documents reviewed reference other material that is not attached to the document itself. The referenced material should all be included in the specific DMWR document. This will help the reader and result in a saving of time.

(3) Identification of the flaw size common to each component would help to evaluate the proper NDI approach. If no history of flaw size exists, an evaluation of the component application should be performed to determine the probable type of flaw.

Based on SwRI's evaluation, a flow chart is found in Figure 1 on a proposed NDI approach that may be applied to the 40 DMWR documents. In addition, a breakdown of the NDI evaluation of the 40 DMWR documents is presented in Table 1.

SwRI believes that the results of this program have served in applying the RCM philosophy to the 40 Army Aviation components, and in providing supporting documentation on the development of the RCM program. (See Appendix B for RTA documents to support RCM program development.) In order to improve the reliability of the NDI inspection, a program such as outlined in Figure 1 should be pursued.

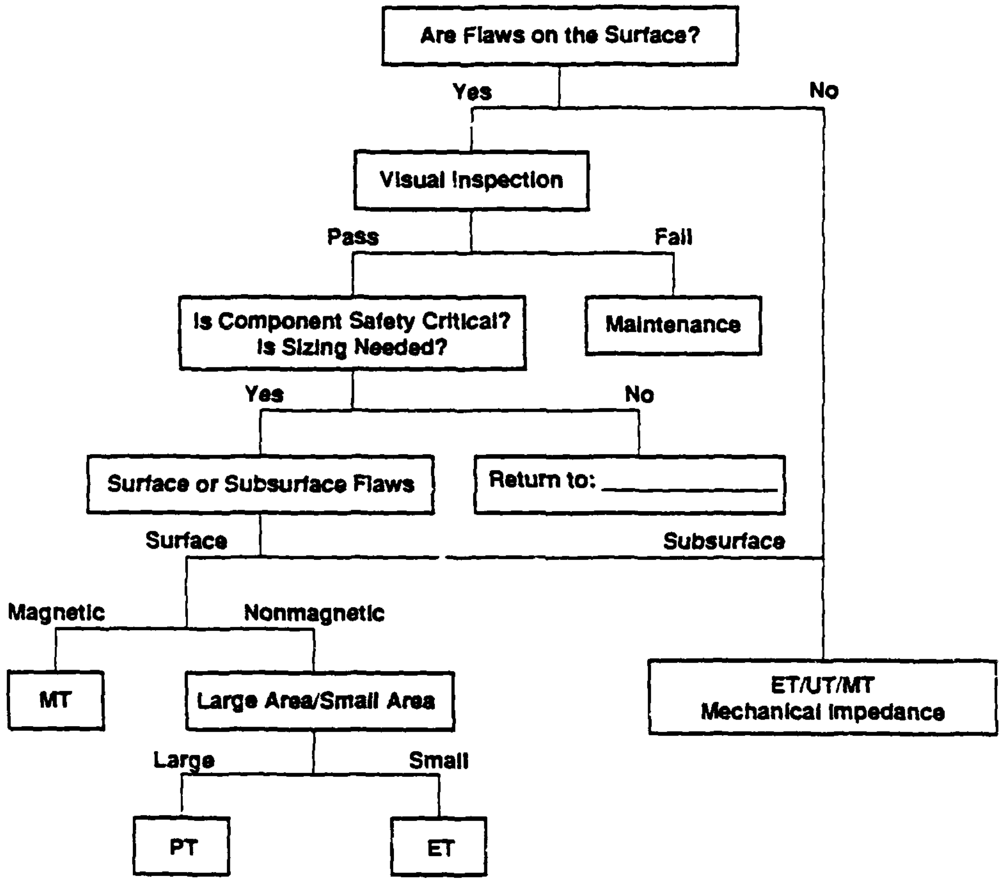

Figure 1. Proposed NDI approach for Army Aviation Components

Table 1

DMWR #/Component	Existing NDI Approach	SwRI Proposed Approach; Comments
55-1520-234 AH-1S Helicopter	Visual only	Magnetic particle (MT), penetrant testing (PT); ultrasonic (UT) and eddy current (ET) testing for inspection of diagonal brace tubes for corrosion damage.
55-1520-228 OH-58A Helicopter	Visual, MT, PT	In addition to the existing NDI approach, use ET and UT on specific components, i.e., corroded panel, bulk-head, and tail boom of honeycomb and composite material structures.

Table 1 (Cont'd)

DMWR #/Component	Existing NDI Approach	SwRI Proposed Approach; Comments
55-1560-196 Main Rotor Hub	Visual only	MT and/or PT i.e., detection of cracks inside of bolt holes, splines.
55-1650-290 Stick Boost Dual Actuating Cylinder	Visual only	MT and/or PT; ET for detection of flaws on inner bores of cylinders and bolt holes.
55-1615-114 Controllable Swashplate Assemblies	Visual only	MT and/or PT; ET for detection of cracks inside of bolt holes/splines.
55-1615-162 Tail Rotor Blade and Hub	Visual only	MT and/or PT.
55-1650-160 Electrohydraulic Servo-Actuator	Visual only	MT and/or PT.
55-1680-266 Electromechanical Linear Actuator	Visual only	MT and/or PT.
55-2915-147 Fuel Pump and Filter Assembly	Visual only	MT and/or PT.
55-2915-284 Centrifugal Fuel Booster Pump	Visual only	MT and/or PT.
55-2995-107 Hydraulic Starter Assembly	Visual only	Satisfactory
55-1615-112 Rotary Wing Head Assembly	Visual only	MT and/or PT; ET for determining depth of cracks from the surface and UT for determining subsurface flaws.
55-1615-158 Main Rotor Hub	Visual only	MT and/or PT.
55-1650-150 Irreversible Hydraulic Pressure Valve	Visual only	MT and/or PT.

Table 1 (Cont'd)

DMWR #/Component	Existing NDI Approach	SwRI Proposed Approach; Comments
55-1650-227 Control Valve Manifold Package	Visual only	MT and/or PT.
55-1650-322 Servo-Cylinder	Visual only	MT and/or PT; ET for inspection of inner bores of housing.
55-1680-289 Electromechanical Linear Actuator	Visual only	MT and/or PT for cracks on gear and housing.
55-2915-148 DP-D3 Gas Turbine Fuel Control	Visual only	MT and/or PT.
55-2925-245 DC - Starter Generator	Visual only	Satisfactory
55-1615-113 (CH-47) Aft Rotary Wing Drive Shaft Assembly	Visual only	MT and/or PT.
55-1615-102 (AH-15) Main Rotor Hub Assembly	Visual only	MT and/or PT.
55-1615-159 (OH-58) Tail Rotor Gear Box	Visual only	MT and/or PT.
55-1615-125 AH-1G/Q 90° 90° Gear Box Assembly	Visual only	MT and/or PT.
55-1615-277 AH-15 90° Gear Box	Visual	MT and/or PT.
55-1560-127 UH-1 90° Gear Box	Visual	MT and/or PT.
55-1615-153 CH-47C Engine Transmission Assembly	Visual only	MT and/or PT.
55-1615-152 CH-47C Combining Transmission Assembly	Visual only	MT and/or PT.

Table 1 (Cont'd)

DMWR #/Component	Existing NDI Approach	SwRI Proposed Approach; Comments
55-1615-116 CH-47 Aft Transmission Assembly	Visual only	MT and/or PT.
55-1615-117 CH-47 Forward Transmission Assembly	Visual only	MT and/or PT.
55-1650-157 CH-47 Fan Motor	None available	Visual, MT, and/or PT.
55-1520-210 UH-1H Helicopter	Visual only	MT and/or PT; UT and ET for inspection of honey-comb composite structures
55-1615-275 AH-15 Transmission Assembly	Visual only	MT and/or PT.
55-1615-157 OH-58 Transmission Assembly	Visual only	MT and/or PT.
55-2840-113 T53 Engine	Visual/dimensional check	Visual, MT and/or PT; UT and ET for blade inspection.
55-2840-254 T55-L-712 Aircraft Gas Turbine Engine	Visual/dimensional check	MT and/or PT; UT and ET for blade inspection.
55-2840-231 T63-A-5A T63-A-700 Engine Assembly	Visual and MT	Satisfactory
55-2915-149 Power Turbine Governor Model AL-L3	Visual only	MT and/or PT.
55-2840-242 Engine Assembly Model T63-A-720	Visual and MT	Satisfactory
55-1615-156 Transmission	Visual and MT	Visual, MT and/or PT; UT for cracks, pits, and corrosion detection.

Table 1 (Cont'd)

DMWR #/Component	Existing NDI Approach	SwRI Proposed Approach; Comments
55-1610-222 U-21 Propeller Governor	Visual and MT	Satisfactory

APPENDIX A
TITLE PAGES OF DEPOT MAINTENANCE WORK REQUIREMENTS

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FINAL DMWR REPORT

DMWR Number 55-1520-228

This Document Contains 65 Pages.

Army Model OH-58A Helicopters

NSN 1520-00-169-7137

Submitted to
U.S. Army Materiel Command
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Submitted by
U.S. Army Aviation Systems Command
Depot Engineering and RCM Support Office
Depot Engineering Support Division

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FINAL DMWR REPORT

DMWR Number 55-2915-284

This Document Contains 8 Pages.

Centrifugal Fuel Booster Pump
NSN 2915-00-996-2169
NSN 2915-00-999-3705

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U.S. Army Materiel Command
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FINAL DMWR REPORT

DMWR Number 55-1615-162

This Document Contains 13 Pages.

Tail Rotor Blade
NSN 1615-00-121-6545
and
Tail Rotor Hub
NSN 1615-00-121-7354

Submitted to
U.S. Army Materiel Command
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FINAL DMWR REPORT

DMWR Number 55-1560-196

This Document Contains 11 Pages.

Main Rotor HuB
NSN 1615-00-788-5321
NSN 1615-00-833-1556
NSN 1615-00-213-7261
NSN 1615-01-056-4550

Submitted to
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FINAL DMWR REPORT

DMWR Number 55-1615-114

This Document Contains 11 Pages.

Controllable Swashplate Assemblies

Part Numbers

114R3304-15 through 20
114R3304-22, -24, -25, and -27
114R3304-506 through -508
114R3304-510 and -512

114R3305-5 through -14, -16, and -18
114R3305-20, -22, -23, -25, -27, and -29
114R3505-7, -8, -12, -15 through -18, -20, -21, and -22

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FINAL DMWR REPORT

DMWR Number 55-1615-112

This Document Contains 11 Pages.

Rotary-wing Head Assembly

NSN 1615-00-004-8885
NSN 1615-00-004-8887
NSN 1615-01-105-6435
NSN 1615-01-105-6437
NSN 1615-01-231-1830
NSN 1615-01-105-6438
NSN 1615-01-113-0460

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DMWR Number 55-1615-158

This Document Contains 12 Pages.

Main Rotor Hub
NSN 1615-00-125-4051
NSN 1615-00-106-8285
NSN 1615-01-030-6652

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FINAL DMWR REPORT

DMWR Number 55-1650-322

This Document Contains 11 Pages.

Servo Cylinder
NSN 1650-00-872-1141
NSN 1650-00-183-5949
NSN 1650-01-016-3572

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FINAL DMWR REPORT

DMWR Number 55-1650-290

This Document Contains 11 Pages.

Stick-Boost Dual Actuating Cylinder

Part Numbers
114H5600-3; 114H5600-8;
114H5600-9; 114H5600-10; and
114H5600-14 Through 114H5600-17

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FINAL DMWR REPORT

DMWR Number 55-1650-150

This Document Contains 10 Pages.

Irreversible Hydraulic Pressurized Valve

NSN 1650-833-1600
NSN 1650-992-0940
NSN 1650-911-7349
NSN 1650-130-5964

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U.S. Army Materiel Command
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FINAL DMWR REPORT

DMWR Number 55-2915-147

This Document Contains 11 Pages.

Fuel Pump and Filter Assembly

NSN 2915-00-924-7791

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FINAL DMWR REPORT

DMWR Number 55-1650-227

This Document Contains 9 Pages.

Control Valve Manifold Package
NSN 1650-00-731-1569
NSN 1650-00-691-3026
NSN 1650-01-098-7712

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FINAL DMWR REPORT

DMWR Number 55-1650-160

This Document Contains 6 Pages.

Electrohydraulic Servoactuator

NSN 1650-00-011-9022

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FINAL DMWR REPORT

DMWR Number 55-2995-107

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Hydraulic Starter Assembly

NSN 2995-00-012-3383
NSN 2995-01-072-5918

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FINAL DMWR REPORT

DMWR Number 55-2925-245

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DC Starter-Generator
NSN 2925-00-912-3993
NSN 2925-00-179-7143

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DMWR Number 55-2915-148

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Model DP-D3
Gas Turbine Fuel Control
NSN 2915-00-931-8357
NSN 2915-00-781-6769
NSN 2915-00-179-5587
NSN 2915-00-134-7807
NSN 2915-00-130-6095
NSN 2915-00-134-4564

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FINAL DMWR REPORT

DMWR Number 55-1680-266

This Document Contains 9 Pages.

Electro-mechanical Linear Actuator

NSN 1680-00-922-2701
NSN 1680-00-140-3522

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Depot Engineering Support Division

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FINAL DMWR REPORT

DMWR Number 55-1680-289

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Electromechanical Linear Actuator
NSN 1680-00-103-0029
NSN 1680-00-117-9484
NSN 1680-01-120-7642
NSN 1680-01-120-7641

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FINAL DMWR REPORT

DMWR Number 55-2840-113

This Document Contains 39 Pages.

Turboprop Engine

NSN	2840-00-957-2853	Model T53-L-15
	2840-00-116-7134	T53-L-701
	2840-00-176-9132	T53-L-701A

Shaft Turbine Engine

NSN	2840-00-134-4803	Model T53-L-13B
	2840-00-621-1860	T53-L-703

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FINAL DMWR REPORT

DMWR Number 55-1610-222

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Propeller Governor
NSN 1615-00-019-5130

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U.S. Army Materiel Command
Materiel Readiness Support Activity

Submitted by
U.S. Army Aviation Systems Command
Depot Engineering and RCM Support Office
Depot Engineering Support Division

September 1987

APPLICATION
OF
RELIABILITY CENTERED MAINTENANCE
TO
DEPOT MAINTENANCE WORK REQUIREMENTS

FINAL DMWR REPORT

DMWR Number 55-2915-149

This Document Contains 11 Pages.

Model AL-L3
Power Turbine Governor
NSN 2915-00-179-5588
NSN 2915-00-130-6096

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APPLICATION
OF
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TO
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FINAL DMWR REPORT

DMWR Number 55-2840-231

This Document Contains 24 Pages.

Engine Assembly

Models T63-A-5A and T63-A-700
NSN 2840-00-923-6023
NSN 2840-00-179-5536

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APPLICATION
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FINAL DMWR REPORT

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Transmission Assembly

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APPLICATION
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FINAL DMWR REPORT

DMWR Number 55-1615-275

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NSN 1615-01-010-0952
NSN 1615-01-014-6006
NSN 1615-01-047-3762

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APPLICATION
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FINAL DMWR REPORT

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NSN 1615-00-089-6509
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APPLICATION
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TO
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FINAL DMWR REPORT

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Engine Assembly

Model T63-A-720
NSN 2840-01-013-1339

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TO
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FINAL DMWR REPORT

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Aircraft Gas Turbine Engine, NSN 2840-01-030-4890, Model T55-L-712

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APPLICATION
OF
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FINAL DMWR REPORT

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UH-1H/UH-1V/EH-1H/EH-1X Helicopters

NSN 1520-00-087-7637 (UH-1H)
NSN 1520-01-043-4949 (UH-1V)
NSN 1520-00-368-8442 (EH-1H)
NSN 1520-01-042-9396 (EH-1X)

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APPLICATION
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TO
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FINAL DMWR REPORT

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Fan Motor

NSN 1650-00-948-0968

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TO
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Forward Transmission Assembly
NSN 1615-01-051-2663
NSN 1615-01-092-9777
NSN 1615-01-092-9776
NSN 1615-01-112-5842
NSN 1615-01-112-5841
NSN 1615-01-138-2582
NSN 1615-01-138-2579
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APPLICATION
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RELIABILITY CENTERED MAINTENANCE
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FINAL DMWR REPORT

DMWR Number 55-1615-116

This Document Contains 30 Pages.

Aft Transmission Assembly
NSN 1615-00-621-1852
NSN 1615-01-051-2665
NSN 1615-01-114-0871
NSN 1615-01-138-2584
NSN 1615-01-138-2583

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APPLICATION
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TO
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FINAL DMWR REPORT

DMWR Number 55-1615-152

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COMBINING TRANSMISSION ASSEMBLY
NSN 1615-01-054-7272
NSN 1615-01-106-5592

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FINAL DMWR REPORT

DMWR Number 55-1560-127

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Ninety Degree Gear Box
NSN 1615-00-918-2677

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FINAL DMWR REPORT

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Engine Transmission Assembly
NSN 1615-00-079-1007
NSN 1615-01-057-5608
NSN 1615-01-149-8197

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FINAL DMWR REPORT

DMWR Number 55-1615-277

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Ninety Degree Gear Box
NSN 1615-00-008-7748

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Depot Engineering and RCM Support Office
Depot Engineering Support Division

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FINAL DMWR REPORT

DMWR Number 55-1615-125

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90° Gearbox Assembly
NSN 1615-00-490-5877

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APPLICATION
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FINAL DMWR REPORT

DMWR Number 55-1615-159

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Tail Rotor Gearbox
NSN 1615-00-122-5150
NSN 1615-00-432-2492

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TO
DEPOT MAINTENANCE WORK REQUIREMENTS

FINAL DMWR REPORT

DMWR Number 55-1615-102

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Main Rotor Hub Assembly
NSN 1615-00-918-9357
NSN 1615-00-933-6823
NSN 1615-00-033-6313
NSN 1615-01-017-9926
NSN 1615-01-014-6007

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TO
DEPOT MAINTENANCE WORK REQUIREMENTS

FINAL DMWR REPORT

DMWR Number 55-1615-113

This Document Contains 16 Pages.

Aft Rotary Wing Drive Shaft Assembly
NSN 1615-00-019-5174
NSN 1615-01-096-1025

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TO
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FINAL DMWR REPORT

DMWR Number 55-1520-234 (Draft)

This Document Contains 323 Pages.

AH-1S (Modified) Helicopter

NSN 1520-00-504-9112

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Depot Engineering Support Division

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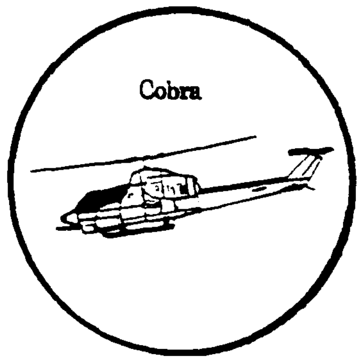
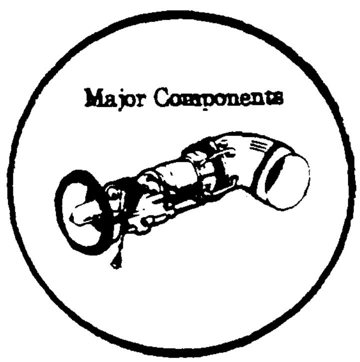
THE FIVE YEAR RCM PROGRAM PLAN

THE FIVE YEAR RCM PROGRAM PLAN





U.S. ARMY AVIATION SYSTEMS COMMAND

MAY 1988

FOREWORD

The purpose of this five-year reliability-centered maintenance (RCM) program plan for the U.S. Army Aviation Systems Command (AVSCOM) is to provide a framework for facilitating and enhancing the accomplishment of RCM engineering functions and to more fully implement the RCM process on Army aviation systems and components in accordance with the policies of DOD Directive 4151.16, AR 750-1, AR 700-127, AR 70-1, and MIL-STD-1388. Integrated into the plan are the methods and procedures given in AMC Pamphlet No. 750-2, "Guide to Reliability-Centered Maintenance".

This RCM plan describes the overall RCM process as it applies to new Army aircraft as well as fielded aircraft. The plan describes the overall RCM process functions, responsibilities and interfaces with unit, intermediate and depot maintenance organizations, logistics, and other command-wide programs and functions.

This plan establishes new programs for the five-year period starting in fiscal year (FY) 1988 and is oriented toward enhancing the Directorate of Maintenance capability to support HQ AVSCOM, Systems Managers and the Corpus Christi Army Depot's (CCAD) projected work load for FY 1988-94. Specific programs focus on:

(1) The development of improved, cost-effective maintenance plans, work requirements and material management techniques
(2) The application of the RCM decision logic to prioritized aircraft
(3) The collection, reduction and entry of expanded data into the AVSCOM RCM data bank
(4) The performance of more complete RCM data analysis and the preparation of comprehensive user reports
(5) The preparation of maintenance support guidelines and training material, the implementation of RCM training and the establishment of a more cost-effective RCM and integrated logistic support (ILS) interface.

Timelines and milestones are provided for the required program activity. The plan defines user requirements and identifies the need for automation. It provides a basis for prioritizing individual programs and for identifying necessary resources for their implementation.

The plan will be updated to reflect any changes in conditions and program emphasis. The Maintenance Directorate appreciates the help of those that contributed to this plan and welcomes any comments or suggestions for consideration during the preparation of subsequent updated plans.

DANIEL J. RUBERY
COL, GS
Director of Maintenance

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1.0 INTRODUCTION

1.1 Objectives and Scope

Reliability-centered maintenance (RCM) is a systematic, disciplined methodology used to identify maintenance needed to ensure preservation and/or restoration of the inherent system reliability, safety, and mission accomplishment at a minimum expenditure of resources and to prevent indiscriminate maintenance which is not cost-effective. Its specific objectives, as delineated in AMC-P750-2, are to:

(1) Establish design priorities which facilitate preventive maintenance.
(2) Plan preventive maintenance tasks that will restore safety and reliability to their inherent levels when equipment/system deterioration has occurred.
(3) Obtain the information necessary for design improvement of those items whose inherent reliability proves inadequate.
(4) Accomplish these goals at a minimum total cost, including maintenance costs and the costs of residual failures.

RCM is based upon the premise that maintenance cannot improve upon the safety or reliability inherent in the design of a hardware system. Good maintenance can only preserve these characteristics. The RCM philosophy dictates that maintenance shall be performed on critical components only when it will prevent a decrease in reliability and/or deterioration of safety to unacceptable levels or when it will reduce life-cycle cost; maintenance shall not be performed on noncritical components unless it will reduce life-cycle cost.

Application of the RCM process involves evaluating maintenance based on equipment functions and failure modes. AVSCOM has developed a maintenance-task oriented logic analysis process for Army aircraft systems and components based on the MSG-3 decision logic (see Appendix A). This RCM logic analysis is applied to determine if any of the following three processes are effective in preventing a maintenance significant component failure mode:

(1) Condition monitoring where degradation prior to functional failure can be detected in sufficient time by instrumentation (i.e., temperature, pressure, vibration indicators)
(2) On-Condition where degradation prior to functional failure can be detected by periodic inspections and evaluations
(3) Hard-time replacement where degradation, because of age or usage, prior to functional failure can be prevented by a replace/overhaul task at a predetermined, fixed interval (generally in terms of operating time or flying hours)

Using available system safety and reliability (historical/failure mode and effects) data, RCM identifies those components which are critical in terms of mission accomplishment and operating safety. It determines the feasibility and desirability of maintenance, it highlights maintenance problem areas for redesign consideration, and it provides supporting justification for maintenance.

1.2 Background

RCM interfaces with the **Integrated Logistic Support (ILS)** activity. ILS is the process of defining support requirements that are optimally related to design and can be obtained at minimum cost during the operational phase. It is a systematic, comprehensive process conducted in accordance with MIL-STD-1388-1A. An effective ILS activity provides:

- Continual information exchange between the system designers and the maintenance/logistics disciplines.
- A data base for the performance of analysis (life cycle cost, etc.) and trade-off studies.
- A structured means of establishing the maintenance program and identifying logistics support requirements.
- A method of identifying deviations from anticipated behavior/operational goals so that corrective action may be taken.

Data produced by the ILS activities form the basis for design/support trade-offs while alternative design concepts are being explored. The ILS requirements are documented in a series of worksheets known as Logistic Support Analysis Records (LSAR) in accordance with MIL-STD-1388-2A and used subsequently to establish support resource requirements. RCM analysis data are major inputs to the ILS process and appear on the LSAR "B" sheet along with reliability and maintainability (R&M) data. "B" sheet data provide the basis for preparing the other MIL-STD-1388 LSAR worksheets used to establish support resource requirements. The result of the complete RCM/ILS process is the compilation of a Provisioning Master Record (PMR) from which procurement of support items is derived. Resulting data are also used as direct input into, or as source information for, the development of other ILS data products including technical manuals and personnel and training requirements.

Figure 1-1 depicts the process by which development data and, later during deployment, actual experience data are used to establish ILS requirements through application of RCM analysis.

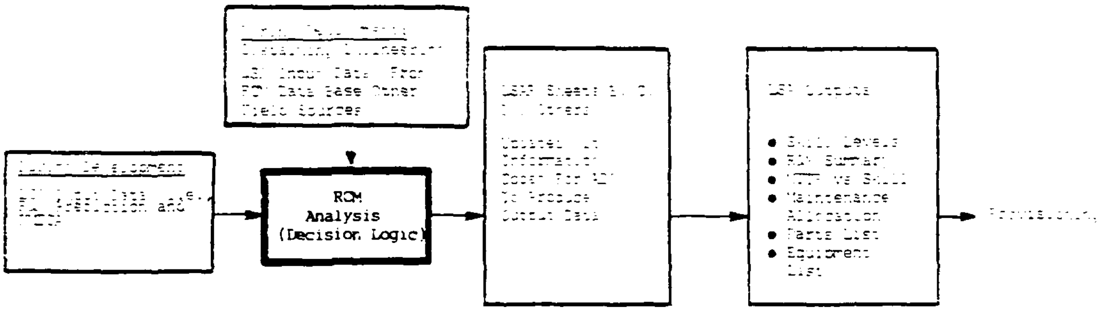


Figure 1-1 The RCM ILS Process

The RCM-driven ILS process is initiated early in the development of a new system to impact design and operational concepts; to identify the gross logistic resource requirements of alternative concepts; and to relate design, operational, manpower, and support characteristics to readiness objectives and goals. Support plans and requirements are optimized by allocating tasks to specific maintenance levels and formulating design recommendations to reduce maintenance times or to eliminate special support requirements, etc.

The ILS activities are based on data derived from performance information, failure factor estimates, RCM logic analysis and support plans. During early development, the failure factor estimates needed as input to ILS activities are derived from similar fielded equipment. Later in development (and during deployment), the failure factors are derived from detailed R&M analysis. The R&M data include Mean Time Between Failures (MTBF); Mean Time To Repair (MTTR); and Failure Mode, Effects and Criticality Analysis (FMECA). The MTBF, MTTR and FMECA data elements are major inputs to the RCM/ILS process and appear on the LSAR Data Record B in accordance with MIL-STD-1388-2A.

A system reliability prediction performed during development establishes the MTBF and part failure mode/rate numerics. The prediction and its associated mathematical models are generally derived from MIL-HDBK-217 and from other sources. The prediction establishes the basic part/component replacement rates of the design and is used as input to logistics support analysis (LSA) and trade-off studies of alternative design concepts.

Similarly, MIL-HDBK-472 is used for maintainability prediction and particularly for deriving factors for repair time, maintenance frequency per operating hour, preventive maintenance time and other maintainability factors. The techniques given in MIL-HDBK-472, in general, involve the determination of MTTR using failure rates obtained from the reliability prediction and maintenance time factors derived from a review of the system design characteristics. Conceptually, the repair of hardware items after the occurrence of a failure necessitates the initiation of a corrective maintenance task which ultimately results in the interchange of a replaceable part or assembly. In order to achieve a complete "repair," various activities both before and after the actual interchange are necessary. This includes activities for localization, isolation, disassembly, interchange, reassembly, alignment and checkout.

The composite time for all repair activities is called the repair time. The part/assembly failure rates and repair times are combined to arrive at a weighted corrective maintenance action rate. The prediction process also involves preparing a functional-level diagram for the system and determining the repair time for each replaceable item. The functional-level diagram reflects the overall maintenance concept and the complete replacement breakdown for all items that comprise the system.

MIL-HDBK-472 information allows the analyst to determine (via the RCM/ILS process) the number of people required to maintain a given number of systems within a specified operating/calendar time period. In conjunction with maintainability predictions, additional maintenance data supplied by the contractor allow decisions to be made regarding difficulty of maintenance (which translates into skill levels of personnel), tools and equipment required, consumable items used while performing maintenance and facilities required.

Critical to RCM and ultimately logistic support analysis is FMECA. The FMECA identifies potential failure modes, thus establishing the initial basis for formulating maintenance task requirements. A FMECA systematically identifies the likely modes of failure, the possible effects of each failure, and the criticality of each effect on equipment function, safety or some other outcome of significance.

The R&M predictions and the FMECA for a development system are generally performed by the prime contractor as part of the Reliability, or Product, Assurance Program; however, the analyses must be coordinated with the RCM program and the results must be made available as essential input to RCM logic analysis and other RCM functions. This coordination should address timing of the analyses, their level of detail and the specific documentation requirements.

During deployment, as operating experience is gained, activities focus on determining the actual reliability-age characteristics and applying the RCM decision logic to respond to failures not anticipated during development, to assess the desirability of additional maintenance tasks, and to eliminate the cost of unnecessary and over-intensive maintenance resulting from the use of default answers in the initial RCM logic analysis. Actual experience data, such as that compiled and incorporated into the RCM data bank at CCAD or that which can be derived from the readiness, supply and maintenance reporting systems, are used to update the failure factors which are used as the basis for these activities.

The cornerstone of an effective ILS process is the **RCM logic analysis.** It is conducted in accordance with AMC-P 750-2 to identify maintenance problem areas for design consideration and to establish the most effective preventive maintenance program. The logic is applied to the individual failure modes of each repairable component identified by the FMECA. A progressive determination is made on how impending failures can be detected and corrected in order to preserve, to the degree possible, the inherent levels of reliability and safety designed in the system. The complete process involves four major steps:

STEP 1 Perform FMECA

STEP 2 Apply RCM decision logic to each repairable component failure mode in order to determine the optimum combination of maintenance tasks including hard time, on-condition and condition monitoring or if redesign is needed in order to prevent a failure mode

STEP 3 Implement the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals

STEP 4 Apply a sustaining engineering effort using actual reliability-age experience data to optimize the program

AVSCOM has developed a computer-aided decision logic process where simple "yes" or "no" answers to the logic questions are entered directly into a computer system. This computer-aided RCM decision logic process is described in Appendix A. Use of the automated decision logic during Step 2 of the RCM process (once it is analyzed and revised to meet the provisions of AMC-P 750-2) ensures the development of high quality maintenance plans in less time and at lower costs. It establishes a system maintenance history that would allow correlation to the actual experience of specific parts and their failure modes and criticalities. It assures that all maintenance significant parts and their failure modes and criticalities are considered in the establishment of maintenance requirements. The system allows for routine, on-line information exchange among AVSCOM engineering and maintenance staff and management. It provides the capability to manage and audit the RCM process over the entire system life cycle.

The most cost-effective maintenance task(s) is then specified (during Step 3) for each component failure mode by evaluating the consequences of failure and by taking its cause into account from the RCM decision logic analysis. To illustrate the logic analysis, following are three questions which are addressed in order to specify the optimum combination of on-condition, condition monitoring and hardtime replacement maintenance tasks for a given component. Appendix A provides a description of the complete logic process.

- Is an on-condition maintenance (OCM) task to detect potential failure applicable and effective?

  An OCM task involves examining the condition of a hardware item using a specific checklist, inspection procedure, standard or Army regulation. It may include a functional check to determine if one or more functions of an item performs within specified limits.

- Is a crew monitoring maintenance task applicable and effective?

  This task involves monitoring by the crew of instrumentation and recognition of potential failures through the use of normal physical senses (e.g., odor, noise, vibration, temperature, visual observation, changes in physical input force requirements, etc.). To be effective, reduced resistance to failure must be detectable and rate of reduction in failure resistance must be predictable. Indicators that annunciate failures at the time of occurrence are not applicable. Examples include the detection of leaky seals through noting excessive oil consumption or smoky engine operation, the detection of clogged start fuel nozzles by difficult engine starting, and the detection of minor cracks in engine components by a decrease in available engine power.

- Is a replacement maintenance task to avoid failures or to reduce the failure rate applicable and effective?

  This task involves substituting a serviceable like type part, subassembly or module (component or assembly) for an unserviceable counterpart. It requires removal from service of an item at a specified life limit.

  This task is normally applied to so-called single celled parts such as cylinders, engine disks, safe-life structural members, etc. The item must show functional degradation characteristics at an identifiable age and a large proportion of units must survive to that age. Hard-time components are replaced at CCAD as part of the overhaul process.

Replacement at hard-time limits must be supported by statistically sound test data or statistical analysis of field data. The failure distribution should be determined in addition to the mean time or usage to failure. Replacement at hard-time limits is most effective when there is a close correlation between reliability and age e.g., the variance about mean time to failure is narrow.

Although "wearout" is a classic reliability concept, the existence of a well behaved wearout mechanism is not all that prevalent in the real world. Items in this class are generally simple (so-called "single-cell") components such as parts which are subject to metal fatigue or other kinds of mechanical wear which are well correlated with time, or time in use.

Recognition of the limitations of hard-time maintenance has led to emphasis on OCM concepts based on inspection. However, it must also be emphasized that OCM is only effective when potential failure can be ascertained reliably and inexpensively. In defining the OCM tasks, it must be kept in mind that detection prior to failure can be accomplished only if the inspection occurs during the period between the onset of noticeable and unacceptable deterioration and the occurrence of actual failure. The inspection interval selected should be the largest that provides an acceptable likelihood of successful detection.

The most sophisticated maintenance tasks are based on concepts of "Condition Monitoring" in which failure potential is under constant surveillance, (e.g. on-board diagnostics-PEATS). This is a technology limited approach which previously appeared only in very high-value (safety, cost or mission) items. With the emergence of new classes of effective and inexpensive sensors and microprocessors, "Condition Monitoring" is much more prevalent in Army aircraft.

Once the RCM logic process has been completed, the tasks in the scheduled maintenance program are then specified. This includes preparing specific requirements for servicing, condition monitoring, on-condition (ACE/AACE, PSA), adjust/align/calibrate, rework (repair)/overhaul, and replacement (at life-limits) in accordance with the decision logic results and output data.

To facilitate application of the RCM program (and extend useful life), design emphasis is placed on the use of proven long-life component parts, the use of easily accessible and interchangeable modules and units, the incorporation of ease of inspectability features and the addition of more sophisticated on-board diagnostic systems. This leads to more cost-effective maintenance and to the establishment of better indicators or precursors of failure which greatly improve the on-condition maintenance tasks, improve the condition monitoring tasks performed by the operating crew and extend the time limits for hard-time replacement tasks at the depot.

The RCM/ILS program integrates many of the relevant reliability, maintainability and safety program tasks and other special studies in order to achieve the common objective of orienting the development and operational phases toward a practical, supportable and affordable hardware system. It provides output data for trade-off analysis with the design engineering function and for preparation of optimum maintenance plans. These plans document the requirements and tasks to be accomplished for achieving, restoring, or maintaining the system's operational capability. The plans also establish requirements and/or interfaces for reliability, maintainability and safety program tasks, life-cycle cost analysis and other related program tasks or elements. They describe how the system will be maintained and the relationship to the overall maintenance concept. They provide definition as to what constitutes a repair action and the scope of maintenance activities planned for execution at the various level of repair. The plans specifically identify and define logistic support requirements including:

a. Maintenance tasks including requirements to support the system at each level of repair.
b. Spare provisioning
c. Tool and test equipment, including calibration equipment and calibration requirements.
d. Manpower-training and skill levels
e. Maintenance manuals and data
f. Training manuals
g. Support equipment/facilities

h. Shipping and transportation
i. Quality control
j. Configuration management

Maintenance planning starts during the early concept phase and the initial requirements are formulated during the demonstration and validation phase based on the R&M, FMECA and RCM analyses. The plans are updated as necessary during the course of the development program and reassessed after the system is fielded as part of a sustaining engineering activity to reflect revised R&M, FMECA and RCM logic analysis data derived from actual field experience information.

1.3 Format of the Plan

AVSCOM's RCM functions are described in Section 2.0. An overview of the new RCM programs planned for the five-year period starting in FY 88 is presented in Section 3.0. These new programs are intended to facilitate and enhance the accomplishment of the RCM functions. The next six sections (4.0 through 9.0) present more detailed descriptions of each of the RCM programs within the major program areas - Maintenance Planning; Methodology; RCM Application; Material Management; Maintenance Support Guides, Training and ILS Interface; and Data Elements and Utilization - and present timelines for their development and application.

This plan contains three appendices. Appendix A presents a description of AVSCOM's automated RCM decision logic process. Appendix B presents a procedure to review and to revise, as necessary, depot maintenance work requirements to reflect the RCM process. Appendix C presents an overview of the projected workload requirements at the Corpus Christi Army Depot.

2.0 THE RCM FUNCTIONS

The RCM functions and the respective responsible AVSCOM organizations are described in AVSCOM Regulation No. 750-XX, "Reliability Centered Maintenance of Army Aircraft, Components, and Associated Equipment" (currently under coordination) and are summarized in Table 2-1. Each of the RCM functions, and the organizations that are responsible, provide support, coordinate or are users of the functional outputs are identified in the table. The functions are defined solely in response to the regulation and are in no way prioritized with respect to program needs and budgetary constraints. As can be seen in the table, the Maintenance Directorate is the technical focal point for AVSCOM's RCM program and for the accomplishment of essential RCM management and engineering functions. Within the Maintenance Directorate, the Depot Engineering and RCM Support Office (DERSO), located at the Corpus Christi Naval Air Station (CCNAS) in conjunction with the Corpus Christi Army Depot (CCAD), is directly responsible for planning and implementing the RCM process on Army aviation systems and components. DERSO, in addition to its RCM responsibility, provides depot engineering support of CCAD and HQ AVSCOM operations throughout the materiel life-cycle. This includes providing maintenance engineering and consulting service in support of the disassembly, repair, overhaul, rebuild, testing and restoring of Army and cross service aircraft, systems and components and related ground support equipment at CCAD and worldwide as required.

The RCM functions are further described in the following paragraphs of this section.

2.1 RCM Management, Guidance and Integration

This function provides AVSCOM staff management and guidance for the RCM program on an overall non-system basis. It includes providing guidance for integrating RCM into other programs related to the development of a materiel support system.

2.2 RCM Programming, Budgeting, and Funding

This function identifies to the project manager, during the concept phase, funds needed for RCM implementation to ensure their inclusion in the budget, the project management plan (PMP), the coordinated test program (CTP), and other appropriate documentation. It includes identifying and forwarding RCM funding requirements to the pertinent budget element in sufficient time for inclusion in the budget. The individual project managers are responsible for programming and budgeting for resources identified as essential for application of RCM to assigned developmental systems. They are also responsible for stating RCM funding requirements, planned approach, and milestones for implementation of RCM in the PMP, the CTP, and other appropriate documentation.

2.3 RCM/ILS Review Team Establishment

This function establishes an RCM/ILS review team for each system development program to monitor the adequacy of the RCM effort and in particular to ensure an effective interface with the ILS activity. The individual project managers are responsible for providing (or requesting the Director of Maintenance to provide) a person to chair the review team charged

Table 2-1 RCM Functional Responsibility Matrix

RCM Function	Directorate of Maintenance — Division: M Management	Prov. & Tech Data	M Engr.	Depot	New Equip. Train.	DERSO	Directorate of Engineering	Directorate of Product Assurance	Program Offices
1. RCM management, guidance and integration	◆					●			
2. RCM programming, budgeting, and funding	◆			◆		●			◆
3. RCM/ILS review team establishment	■	■				●		■	■
4. RCM techniques (participation with higher commands)						●			
5. RCM requirements (inclusion in contract/program documents)									
a. Developmental Systems						◆			●
b. *Fielded (and late development)* systems						●			◆
c. Product improvements						◆			●
6. *Developmental systems: RCM application (life-cycle)*									
Concept exploration: RCM planning		■	■			◆			●
Demonstration and validation									
a. FMECA (functional); *design deficiences/improvements* identification						◆	■▲	◆	●
b. RCM decisions: LSA-B record, RCM/ILS objectives		■	■		▲	◆			●
c. Maintenance plan/contract M requirements						◆			●
d. LSAR/RCM program monitoring (by RCM/ILS review team)		■	■			●		■	■
Full scale development									
a. RCM/LSA documentation update		■	■		▲	◆			●
b. FMECA (hardware); historical data review						◆	■▲	▲	●
c. RCM logic analysis						◆			●
d. Maintenance task specification		▲	■		▲	◆	■		●
e. Corrective M analysis (MTBF, MTTR)		▲	■			■	■	◆	●
f. Maintenance plan evaluation/update						◆			●
g. RCM program monitoring (by RCM/ILS review team)		■	■			●		■	■
Production and deployment									
a. RCM based depot maintenance procedures (for MSIs)		▲	■			◆			●
b. RCM derived M documentation (technical publications)		●	■			■			◆
c. Maintenance task time analysis		▲				◆			◆
d. Maintenance concept/plan demonstration			■			■		●	◆
e. Sustaining engineering program						●			◆
f. Field feedback, assessment, analysis and adjustment		▲			▲	◆	▲	▲	●
7. Fielded systems: RCM application									
a. FMECA (hardware); historical data review						●	▲	▲	
b. RCM logic analysis						●	▲	▲	
c. M task specification/task time analysis						●			
d. IEWR reviews, schedules and final reports		◆	■			●		◆	
e. ACE/AACE program				●		●			
f. Bearing reclamation program		▲				●		◆	
g. Age exploration						●	▲	■	
8. RCM data bank	▲	▲	▲	▲	▲	▲●	▲	▲	▲
9. RCM cost avoidance/maintenance reduction and accomplishment reports		■		■		●			

● - Primary Responsibility
▲ - User

■ - Support
◆ - Coordinate, Review

1 - Overall Responsibility
2 - Technical Responsibility

with monitoring RCM implementation as a part of the ILS effort. DERSO and the Product Assurance Directorate are part of the review team and as such participate in monitoring the RCM implementation efforts.

2.4 RCM Techniques (Participation with Higher Commands)

This function participates with higher commands in developing, refining, and implementing RCM logic and analysis techniques. This includes investigating improved, cost-effective methods, covering on-condition, condition monitoring and hard-time maintenance. Many of the programs described in Sections 3.0 and 5.0 of this plan are to develop improved techniques that are oriented toward enhancing AVSCOM's capability to implement the RCM process on both new and fielded aircraft systems and components rapidly and cost effectively.

A key aspect of this function is to continually refine the RCM decision logic (see AMC-P750-2) to reflect the specific needs and characteristics of Army aircraft systems and components. AVSCOM has developed as part of this function an Army aircraft computer-aided RCM decision logic process. This computer aided RCM decision logic process is described in Appendix A.

2.5 RCM Requirements (Inclusion in Contract/Program Documents)

This function assures that RCM requirements, in the form of RAM and logistic support concepts/parameters, are identified to the applicable system or program manager for inclusion in contractual documents and in program documents (e.g., justification of major system new start (JMSNS), letter of agreement (LOA), required operational capability (ROC), letter requirement (LR), training device requirement (TDR), program management plan (PMP), acquisition plan (AP), request for proposal (RFP)). Detailed schedules for RCM analysis and planning for validation as well as the sustaining engineering effort which must be performed during the operational phase are to be prepared and reflected in the program requirement documents. This function also includes assuring that the contractural requirement for RCM is adequately cross-referenced when invoking the requirement for an LSA plan via Data Item DI-L-7017A. AMC PAM 750-2 provides guidance for applying RCM as part of the ILS process.

This function also determines when "full-up" RCM can and cannot be economically applied to fielded systems and those in late development phases. This includes maintaining formal records to document any decision.

This function also assures continuing application of RCM to all product improvements for assigned systems which were developed using RCM techniques.

2.6 Developmental Systems: RCM Application (Life-Cycle)

This function implements RCM for assigned systems in coordination with the system/program managers. The managers are responsible for providing (or assuring provision of) the ingredients essential to an overall, effective RCM program for assigned systems. This includes application of RCM tasks throughout a system's life-cycle. These life-cycle tasks are as follows:

<u>Concept Exploration</u>

The RCM tasks and how they interface with the ILS process are planned during this phase. The planning addresses the interrelated objectives of R&M, the maintenance plan and RCM and must be in accordance with the approach, milestones and funds required to implement RCM as specified in the PMP, CTP and other appropriate documentation. Historical data from existing systems are reviewed to relate past experience to the logistic support requirements of the new system. Logistic support alternatives are evaluated including the anticipated scheduled maintenance burden of each alternative and any anticipated advancement in reliability and safety design techniques which would impact the projected maintenance burden. The project manager is responsible for establishing the maintenance concept to include identification of the capability required to retain those safety and reliability parameters incorporated during design.

Demonstration and Validation

During this phase:

(1) A FMECA (functional) is performed, criticality thresholds are allocated to the system and subsystems consistent with R&M and safety objectives and any needed design improvements are determined and corrections identified. The maintenance plan identifies the capability needed to retain the safety and R&M parameters incorporated in the design. Failure modes remaining in the nonacceptable range are designated as design deficiencies to be corrected during the development phase.

(2) RCM decisions are recorded in the system LSAR and updated (by application of RCM logic analysis) as the design matures.

(3) Maintenance plan requirements including contract requirements based on RCM considerations are developed and incorporated into appropriate LSAs.

(4) RCM implementation is monitored by the RCM/ILS review team.

During this phase sufficient data are documented to support the development of firm R&M/logistics support objectives for inclusion in the subsequent requirement documents.

Full Scale Development

During this phase:

(1) RCM documentation is updated (by application of RCM logic analysis) at the beginning of this phase and thereafter as required.

(2) FMECAs (hardware) are performed to an indenture level one higher than the lowest level at which corrective and preventive maintenance are prescribed. An analysis of the failure modes is performed at the lowest level where corrective and preventive maintenance are prescribed. Also historical data from existing systems are reviewed to assure the adequacy of the data base prior to the subsequent RCM logic analysis.

(3) A complete RCM logic analysis is performed to define specific condition monitoring, on-condition and hard-time replacement maintenance tasks or to identify the need for design improvements.

(4) Maintenance tasks are specified for each maintenance significant component failure mode in accordance with the maintenance task(s) identified by the RCM logic analysis.

(5) Corrective maintenance analysis is performed to determine maintenance tasks that are required for each repairable item. This analysis takes into account the R&M characteristics of the equipment design as reflected in the MTBF and MTTR analyses.

(6) The adequacy of the overall maintenance plan, including the preventive maintenance checks and services (PMCS) and assigned maintenance levels, is evaluated during this phase in accordance with the appropriate test plans.

(7) RCM implementation is monitored by the RCM/ILS review team.

Production and Deployment

During this phase:

(1) Maintenance procedures are developed for maintenance significant items in accordance with the specified maintenance tasks derived from the RCM logic analysis.

(2) Maintenance requirements derived from RCM analyses are incorporated into the appropriate technical publications. This includes scheduling and preparing/procuring changes or revisions of the applicable technical publications. Also reviews of PMCS, technical publication, etc., for maintenance-significant fielded equipment utilizing RCM logic are conducted.

(3) Appropriate intervals are determined for each maintenance task. Also the time required for military personnel to perform scheduled maintenance is reviewed to determine if it is reasonable and is the minimum essential for the retention of safety and reliability that was designed into the system (i.e., a burdensome maintenance system cannot compensate for an inadequate design.).

(4) The maintenance concept/plan is fully demonstrated.

(5) A sustaining engineering program is instituted.

(6) Feedback (both field and engineering) data are assessed to determine the extent that the field is actually performing the scheduled maintenance services and to identify needed adjustments to the maintenance and reliability improvement programs.

2.7 Fielded Systems: RCM Application

This function implements RCM on fielded systems. It includes the following tasks:

(1) Performing a FMECA based on field experience data. This includes reviewing historical data from existing systems and assuring the adequacy of the RCM data base and available LSAR records.

(2) Performing RCM logic analysis in accordance with AMC Pamphlet No. 750-2.

(3) Developing PM task specifications and task intervals from the RCM logic analysis.

(4) Performing reviews of existing depot maintenance work requirements (DMWRs) and supplemental documentation and assuring that new DMWRs reflect the RCM philosophy and data requirements. This includes preparing schedules (AMC Form 2650-R) for DMWR reviews in accordance with AMC-R 750-9. The review schedules must include all DMWRs being revised based on the RCM philosophy as well as those being processed with RCM incorporated. It also includes preparing DMWR final reports showing the savings derived from the application of RCM logic. The final reports are dated and identified to DMWR number, national stock number, nomenclature, and model. Total cost (organic/inorganic) of the DMWR review is included. The following information is included: manhour savings, manhours cost savings, parts cost savings, materiel cost savings, and net cost savings. Any pertinent comments are also included in the DMWR final reports.

A key element of the DMWR review task is the incorporation of on-condition maintenance (OCM) through preshop analysis (PSA). PSA is performed on aircraft systems and components upon their induction into the depot. It is a logical inspection process with the inspection focusing on the reason(s) why the item was sent to the depot, the component operating times and the condition of the hardware. Based on condition the inspector specifies the extent of disassembly and repair needed to be performed. Criteria for further assessing the condition of aircraft components are continuously being developed by DERSO and included in revisions to the applicable DMWRs. The revised DMWRs require physical and functional inspection as part of the PSA process to determine the extent of repair, modification and part replacement required to return the item to serviceable status. As a result unnecessary overhaul is eliminated and maintenance performed only when the condition warrants it. The procedure for reviewing and revising applicable DMWRs to reflect RCM-OCM inspection and repair is given in Appendix B.

(5) Planning and implementing the airframe condition evaluation/aircraft analytical condition evaluation (ACE/AACE) program.

The ACE/AACE program involves an annual evaluation of the condition of an aircraft in accordance with a carefully designed profiling technique which can be easily applied by trained personnel. It uses a profiling techniques for evaluating aircraft condition and for identifying items most in need of depot maintenance. The program provides a meaningful and inexpensive method for ranking the aircraft within the fleet as candidates for depot level maintenance. ACE uses for its evaluation a representative list of indicators of structural condition selected for each aircraft type. Typical indicators include the condition of the main lift beam, the nose fuselage skin, and the upper bulkhead. Weights are then assigned to each of the indicators using ranking and distribution techniques. Each indicator is further defined by condition codes which depict the condition of the indicator, i.e., no defect, cracked, buckled, etc. AACE, a special corrosion structural examination, uses a representative list of indicators on corrosion only and has condition codes for the degree of severity. The basic aircraft structure is examined for corrosion defects together with an assessment of the external areas of components, both structural and dynamic, for deterioration caused by corrosion. AACE pertains principally to fuselage structural members that are replaceable at the depot, but also pertains to dynamic components and component structures.

(6) Supporting the bearing reclamation program. This includes establishing basic quality assurance and repair/replacement criteria for bearings with and without finite life requirements as listed in the applicable aircraft TM and the specific end-item DMWR.

(7) Performing age exploration analysis in accordance with AMC-P 750-2 on those items identified by the RCM logic analysis where a failure relationship between age and reliability must be established. In the early stages of an equipment life cycle, the age-reliability relationship may not be perfectly understood causing conservative estimates of the frequency of scheduled maintenance. As operating experiences are gained this information is used as the basis to perform age exploration analysis and ultimately used to adjust the time periods for scheduled maintenance as well as to validate the maintenance program.

2.8 RCM Data Bank

This function establishes and maintains AVSCOM's RCM data bank. The performance of RCM logic analyses as well as other RCM/ILS tasks requires the availability of an extensive and cumulative base of data and information. Consequently, AVSCOM compiles data for this purpose and maintains a complete, user-friendly on-going RCM data bank at CCAD. The data are continually refined and updated to include the most recent field experience information. Once validated, these data are used to update the part failure factors used as the basis for RCM/ILS analysis and to perform reliability-age exploration analysis as part of a sustaining engineering activity. Also key data output products as well as essential R&M numerics are derived from the RCM data bank including: Mean Time Between Failures (MTBF); Mean Time To Repair (MTTR); and Failure Mode, Effects and Criticality Analysis (FMECA) data and data for other statistical analyses.

MTBF numerics are derived from the field experience data in the RCM data bank and used to determine basic part replacement rates. They can also be directly inputted to logistics analyses and trade-off studies of alternative designs. Similarly, MTTR numerics are derived from the field data and used to determine (via the ILS process) the number of people required to maintain a given number of systems within a specified time period. Maintenance engineering data allow decisions to be made regarding difficulty of maintenance (which translates into personnel skill levels), tools and equipment required, consumable items used while performing maintenance, and facilities required.

2.9 RCM Cost Avoidance/Maintenance Reduction and Accomplishment Reports

This function:

(1) Prepares yearly cost avoidance reports involving savings from applications of RCM. Cost avoidance reports have calendar year and accumulative savings (since inception of program). Yearly cost avoidance reports are required by HQAMC, ATTN: AMCSM-PM by 1 March.

(2) Documents/assures contractor documentation of all reductions (in field effort) in maintenance actions, inspections, etc., made possible as a direct and specific result of the application of RCM logic.

(3) Submits an accomplishment report (AMC Form 2460-R) on all equipment publications reviewed using RCM logic that are scheduled in accordance with existing AMC guidance (see AMC-R 750-8, Appendix A).

3.0 OVERVIEW OF THE RCM PROGRAM PLAN

The purpose of the RCM program plan is to provide a framework for facilitating and enhancing the accomplishment of the RCM functions. The intent is to further implement the RCM process on Army aviation systems and components in order to:

A. Assure that current Army aviation maintenance tasks mitigate all prevalent failure modes.
B. Establish additional maintenance requirements, where necessary.
C. Help identify and/or analyze critical parts, including maintenance significant items (MSI) and structurally significant items.
D. Measure and evaluate failure rates and modes.
E. Identify items with potential for improved reliability.

Specific programs focus on:

(1) The development of improved, cost effective maintenance plans, methods, work requirements and material management techniques
(2) The application of the RCM decision logic to prioritized aircraft
(3) The collection, reduction and entry of expanded data into the AVSCOM RCM data bank
(4) The performance of more complete RCM data analysis and the preparation of comprehensive user reports
(5) The preparation of maintenance support guidelines and training material, the implementation of RCM training and the establishment of a more cost-effective RCM and integrated logistic support (ILS) interface.

The program plan, as well as many of the specific programs, is oriented toward enhancing the Directorate of Maintenance's capability to support HQ AVSCOM, Systems Managers and CCAD's projected workload for FY 1988-94. The depot work load requirements are defined in CCAD's modernization plan, 14 August 1986. Appendix C, adapted from this plan, provides a brief summary description of the new aircraft systems to be maintained at CCAD.

The application of the RCM program plan in the accomplishment of the RCM functions is illustrated in Figure 3-1.

Following is a list of specific programs by program area:

A. Maintenance Planning
   1. Army Aviation DMWR RCM Review
      - Change from "Complete" Overhaul to "On-Condition" Inspection and Repair
   2. T53-L-13B Engine Rebuild
B. Methodology
   1. Automated Failure Mode, Effects and Criticality Analysis
   2. Link FMECA/RCM Analysis to RCM Data Bank
   3. Update RCM Decision Logic

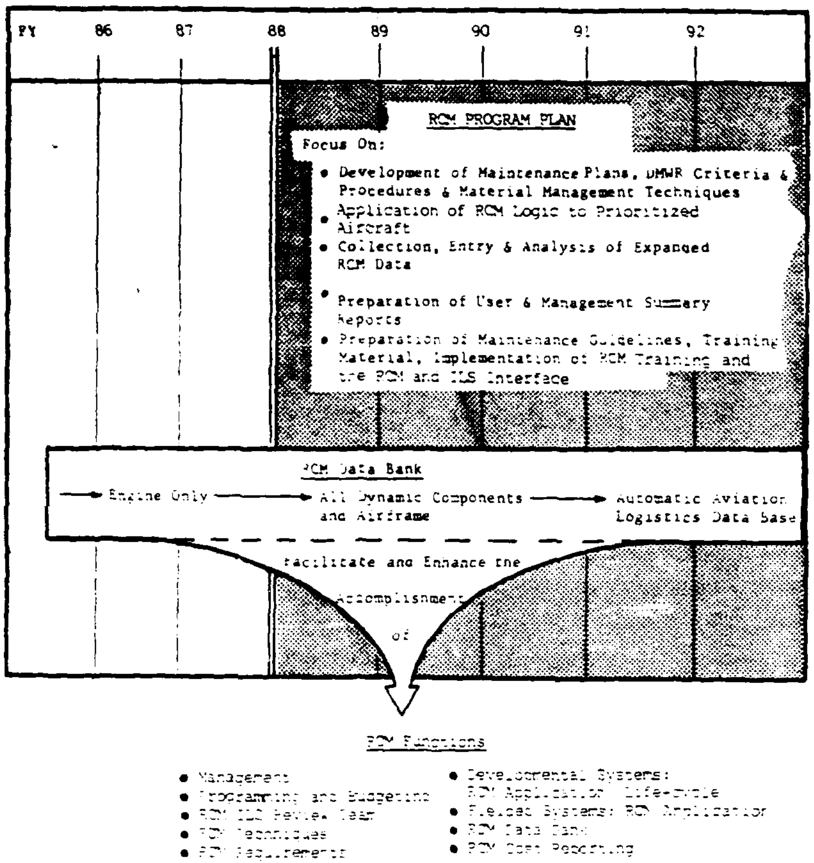


Figure 3-1 Application of the RCM Program Plan

4. ACE/AACE Improved Methodology and Inspection Equipment
5. Life Extension Prediction Methodology Development/Application
6. PAMS Improvements
7. AOAP Analysis

C. RCM Application
1. Apply RCM to AH-64
2. Apply RCM to UH-60
3. Apply RCM to CH-47D
4. Apply RCM to OH-58D
5. Apply RCM to LHX

D. Material Management
1. Corrosion Control: Program Support
2. Serialized Parts Life Tracking System
   • T700 Engine
   • All Flight Safety Parts

E. Maintenance Support Guides, Training and ILS Interface
1. Update Depot Maintenance Handbook
2. Update ACE/AACE Handbooks
3. Update ACE/AACE Pamphlets (750-1 and 2 series)

4. RCM Training
5. LSA Interface Requirements

F. Data Elements and Utilization
1. Expand Data
Include:
- Airframe PSA Data
- Transmissions
- Gear Boxes
- Other Components
- Airframe ACE/AACE Data

2. Expand Utilization
Include:
- Failure Rates by Component, Part, Geographical Area
- Failure Modes
- Transmission Reliability Reports
- Gear Box Reliability Reports
- Airframe Reliability Reports
- Other Reliability Reports
- Rejection of Serviceable Items
- Flight Safety Parts
- High Cost Items
- High Rejection Rate Items
- Critical Part/Component Shortage Items
- Early Return Components (reduced TBO)
- Critically Designated Readiness Parts (i.e., fuselage external stores, armament interface, etc.)
- Age Exploration
- Computer Aided Analysis Routines/Models

3. Management Summary Reports

These 24 programs have been established for the five year period starting FY 86. Each of these programs and their timeframes are depicted in Figure 3-2 and are identified to program area and number as above. The following sections (4.0 through 9.0) provide a description of each of the RCM programs and present timelines for their development and application. The individual program descriptions are keyed to the program areas and timeframes depicted in Figure 3-2.

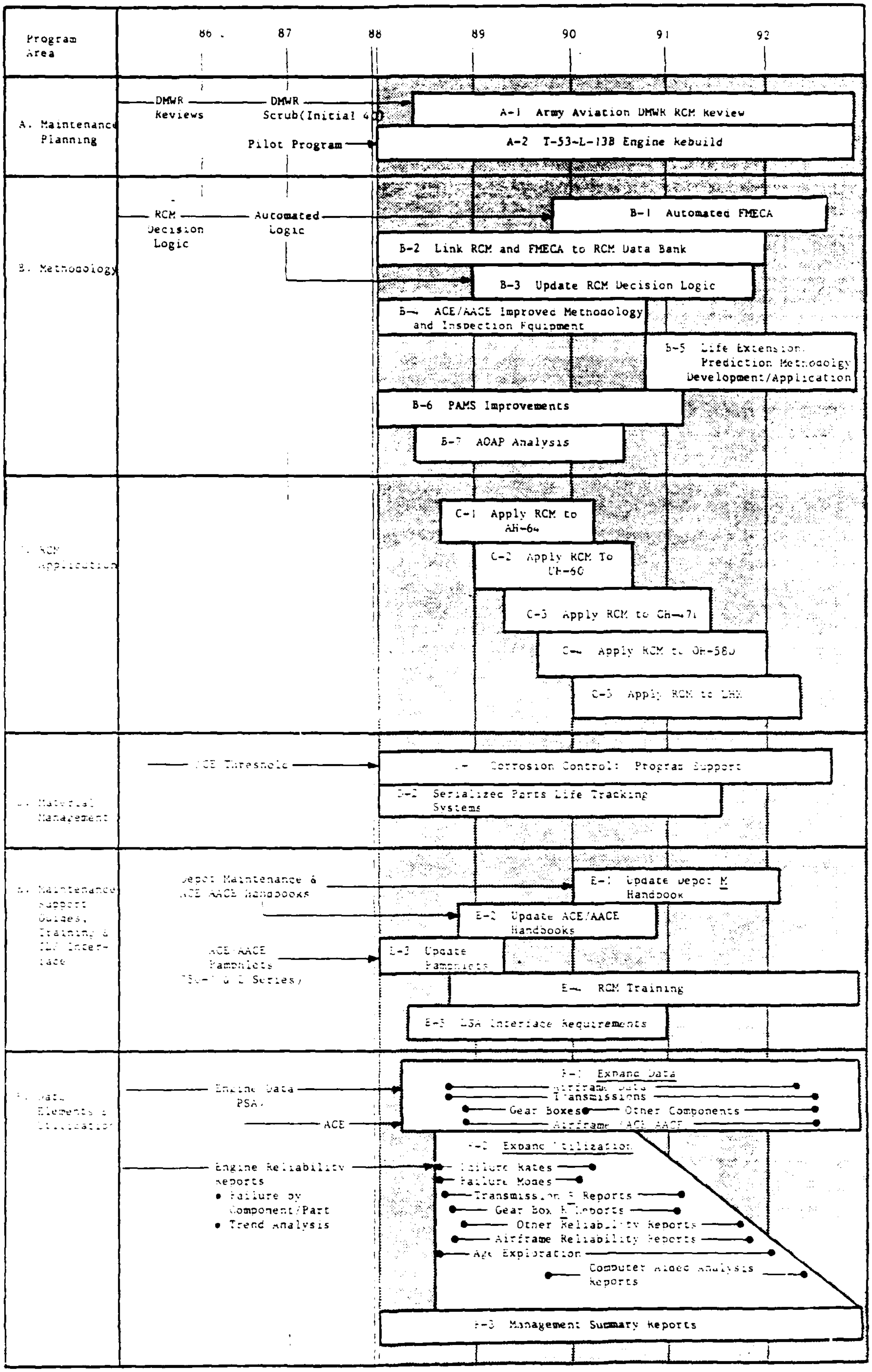


Figure 3-2 5 Yr RCM Program Plan

4.0 MAINTENANCE PLANNING

Program Area: Maintenance Planning

Program: A-1 Army Aviation DMWR RCM Review

Description: - To conduct an indepth review of depot maintenance work requirements (DMWRs) for RCM implementation and to develop specific requirements for applying RCM techniques to depot-level maintenance. This program is to assure that the basic RCM philosophy, in accordance with DARCOM -R750-9, is incorporated into the DMWRs managed by AVSCOM. The DMWRs are to be reviewed and revised, as necessary, to include pre-shop analysis (PSA) as an integral part of the maintenance process. Through PSA the condition of an item is determined prior to performing maintenance and used as the basis to determine only those repair or overhaul procedures which are essential to return the item to a satisfactory serviceable condition. A procedure is to be prepared for developing RCM/PSA requirements that assures that the inherent design reliability and safety of the repaired/overhauled items are achieved with the performance of the least amount of maintenance and that overhaul is accomplished on a rational basis. An initial 40 selected DMWRs are to be reviewed in accordance with this procedure and AEDS are to be generated. In addition, AEDs are to be prepared to implement mobilization requirements (i.e., to eliminate the minor repair criteria or to extend the operating hour ceiling) for these 40 DMWRs. A list of all DMWRs managed by AVSCOM is to be developed and maintained. The DMWRs are to be categorized as "on condition" or a "time change" item, and a schedule is to be prepared for implementation of RCM and mobilization guidelines. The DMWRs are then to be reviewed and AEDs prepared in accordance with the RCM DMWR review procedure at the time periods identified in the DMWR review implementation schedule.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Prepare RCM DMWR review procedure (see Appendix B)	▲				
• Apply procedure to initial 40 DMWRS - Review DMWRs - Develop PSA criteria/guidelines - Prepare AEDs - Prepare DMWR reports with cost analysis	▲				
• Implement mobilization requirements on the 40 DMWRs	▲				
• Develop/maintain DMWR control list/schedule	(1)			On-Going	
• Review "all" AVSCOM managed DMWRs for RCM				On-Going	
• Prepare AEDs for RCM/mobilization				On-Going	

Notes: (1) Initial list/schedule

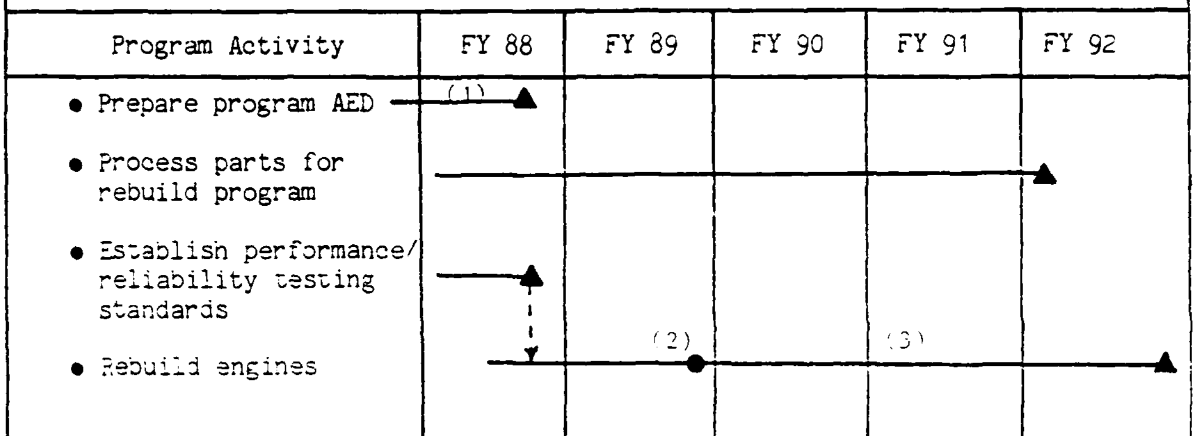
▲ Completion

Program Area: Maintenance Planning

Program: A-2 T53-L-13B Engine Rebuild

Description: - To plan and implement a program whereby selected engines coming in for depot level maintenance will be rebuilt to achieve like new performance. The rebuild program will use replacement parts now being processed for this program to meet original manufacturing tolerances and specifications. Performance testing standards will be established for the "overhauled" engines in order to improve field reliability, extend life and ultimately improve the field operating intervals. Through this program the reliability of the engine will be maintained at a high level, its useful life will be the same as a new engine and there will be a decrease in the cost of maintaining the engine because of an increase in time between depot returns. This engine rebuild program is oriented toward extending the life of the UH-1 helicopter fleet to the year 2010.

Time Line:



Notes: (1) Coordination/review
(2) Rebuild 200 Engines
(3) Continue rebuild program until all T53-L-13B engines have cycled through the depot

▲ Completion

5.0 METHODOLOGY

Program Area: Methodology

Program: B-1 Automated Failure Mode, Effects and Criticality Analysis

Description: - To prepare a computerized application procedure for identifying the likely modes of system failure, their effects on the aircraft and their criticality. This procedure will be developed to allow the FMECA to be conducted on-line using a remote microcomputer terminal(s). The process will be structured to have a flexible interface with the RCM data bank. A data base management system will be selected and tailored to meet AVSCOM's needs that offers complete record management, work processing, forms entry, data processing, report generation, conversion utilities, disk utilities, and a high-level programming language combined within a single architecture. Data resulting from application of the automated FMECA will be used as direct input to the RCM decision logic analysis to determine the optimum combination of maintenance tasks including hard-time, on-condition and condition monitoring or if redesign is needed in order to prevent a failure mode. An automated FMECA will allow current and future RCM application objectives (see programs C-1 through C-5) to be met quickly and efficiently.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Refine/engineer the FMECA process					
• Prepare computerized procedures and associate software					
• Demonstrate the computer-aided process on a selected aircraft system					
• Prepare user handbook			(1)		(2)

Notes: (1) Prepare draft handbook
(2) Review, revise as necessary

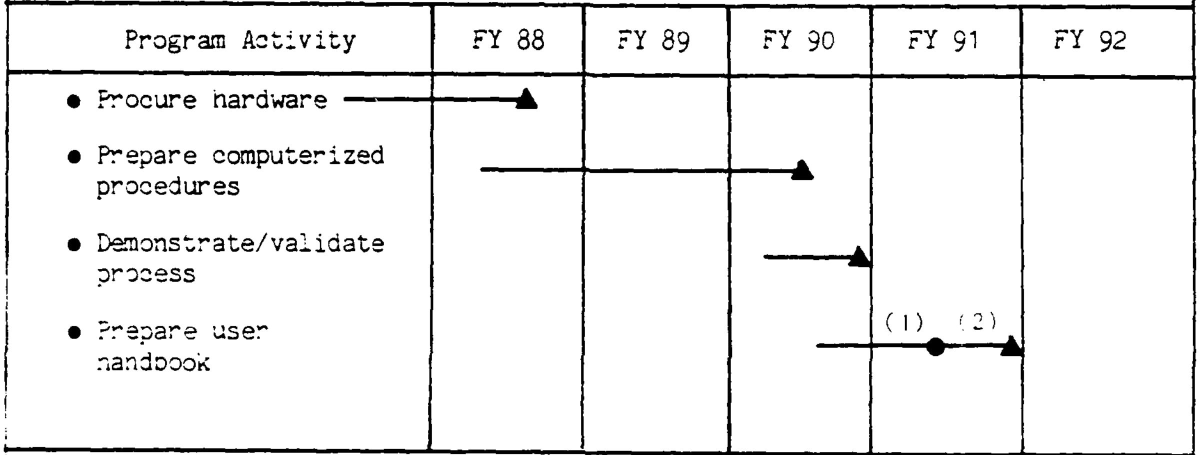
▲ Completion

Program Area: Methodology

Program: B-2 Link FMECA/RCM Analysis to RCM Data Bank

Description: - To structure the FMECA/RCM process to have a direct interface with the RCM data bank. This will provide AVSCOM with the means for the rapid development of a uniform and complete RCM-based maintenance program using data on-line from the RCM data bank. The long term objective is to develop the process such that ultimately it will include direct coupling into a yet to be developed fully computerized integrated logistics support (ILS) system. Direct linkage to the RCM data bank will speed up the process of performing FMECA and applying the RCM decision logic process to aircraft systems and components. It will reduce cost, enhance the uniformity of treatment and provide a well organized, readily accessible data and procedural audit trail.

Time Line:



Notes: (1) Prepare draft handbook
(2) Review, revise as necessary

▲ Completion

Program Area: Methodology

Program: B-3 Update RCM Decision Logic

Description: - To update AVSCOM's computer-aided RCM decision logic (see Appendix A) to reflect the decision logic questions, criteria and data requirements of AMC-P 750-2. This pamphlet covers the method and procedures for performing RCM and is to be used with MIL-STD-1388-2A for developmental systems or by itself for fielded systems. The logic process presented in the pamphlet is based upon the premise that maintenance cannot improve upon the safety or reliability inherent in the design of a hardware system. Good maintenance can only preserve these characteristics. It dictates that maintenance shall be performed on critical components when it will prevent a decrease in reliability and/or deterioration of safety to unacceptable levels or when it will reduce life-cycle cost; maintenance shall not be performed on noncritical components unless it will reduce life-cycle cost. The computer-aided RCM decision logic system will be demonstrated on a selected aircraft system and, if approved, applied to the selected/prioritized aircrafts under programs C-1 through C-5.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Review AMC-P 750-2	——▲				
• Prepare updated RCM computerized procedures and associated software	——	——▲			
• Demonstrate RCM on a selected aircraft system		——	——▲ (1)		
• Prepare updated user handbook			●—— (2)	●——▲ (3)	

Notes: (1) AVSCOM approval
(2) Prepare draft handbook
(3) Review, revise as necessary

▲ Completion

Program Area: Methodology

Program: B-4 ACE/AACE Improved Methodology and Inspection Equipment

Description: - To increase the efficiency, technology, and accuracy of the methodologies and inspection equipment used in the ACE/AACE programs. ACE/AACE as part of AVSCOM's OCM program (in accordance with AR 750-7) is performed annually on all first line/mission essential Army aircraft worldwide to identify those that are in the greatest need of depot maintenance. ACE encompasses the structural integrity of the aircraft in areas such as the main lift beam, the nose fuselage skin and the upper bulkhead; the AACE is an examination of the external areas of the aircraft and its components, both structural and dynamic, for deterioration caused by corrosion. Record keeping and the manipulation and analysis of data are accomplished by automated means. New portable automated bonded honeycomb structure inspection equipment are used by the ACE/AACE team to improve the efficiency and accuracy of the on-site evaluations.

This program places emphasis on data/trend analysis and improved feedback of deficiency information to the AVSCOM Directorate of Engineering and to the operating units to more readily identify maintenance problems for timely resolution and on using AACE data to correct corrosion problems at AVUM, AVIM and the depot. It includes development of an improved threshold methodology and mathematical/statistical formulae that combines the ACE/AACE indices into a single index based on application of experimental design and statistical process control (SPC) techniques. Also new or upgraded diagnostic equipment and on-site inspection techniques will be acquired or developed to further improve the efficiency and accuracy of the on-site evaluations. This includes upgrading the bond inspection equipment to improve its accuracy and safety and developing a device to measure the depth of corrosion.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Develop trend analysis and feedback method	———	▲			
• Develop improved ACC/AACE methodology	———▲				
• Develop/acquire improved inspection equipment	(1) ———●	(2) ———▲			

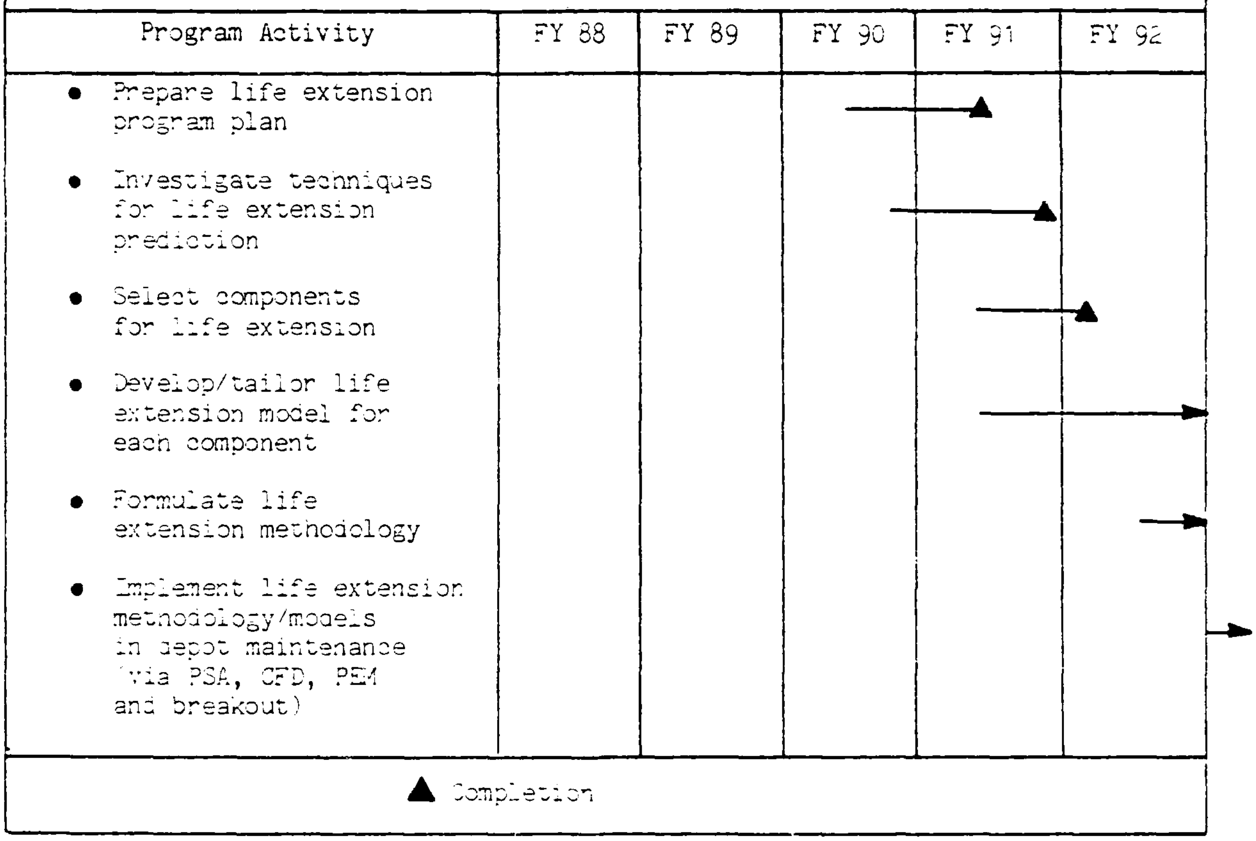
Notes: (1) Upgraded bond inspection equipment
(2) Corrosion measurement device
▲ Completion

Program Area: Methodology

Program: B-5 Life Extension/Prediction Methodology Development/Application

Description: - To develop experimental and analytical methods for predicting the remaining safe and useful life of aviation components. This includes evaluating the techniques used to measure the amount of degradation caused by various material degradation mechanisms, i.e., fatigue, creep, creep/fatigue, corrosion, stress corrosion, erosion, corrosion fatigue, and thermal embrittlement. It includes evaluating nondestructive and destructive measurement techniques including metallographic replication and testing of miniature specimens. It also includes evaluating analytical procedures used to model and estimate damage accumulation and remaining life which integrate the materials properties, component configurations, and operating parameters. Those techniques considered most applicable will be used as the basis to develop/tailor individual aviation component life extension models. The component life extension models will then be incorporated into a complete overall methodology that meets the needs of AVSCOM and reflects consideration of both the economic benefits and the safety concerns that impact replace or repair decisions. The methodology once approved will be implemented by DERSO to establish specific criteria for assessing remaining life. Applicable criteria will be incorporated into PSA, CFD, PEM and breakout programs.

Time Line:



Program Area: Methodology

Program: B-6 PAMS Improvements

Description: - To improve the predictive aircraft maintenance system (PAMS) ability to identify system performance degradation early enough to safely terminate flight and/or effect repairs. The overall objectives of the PAMS (as part of the RCM condition monitoring function) are to: (1) predict imminent failure in sufficient time to allow a safe landing, (2) predict impending failure in time to acquire parts and schedule repairs, (3) use expert systems to enhance troubleshooting, (4) make it operable at AVUM and (5) provide fleet wide component trend data, on-board fault annunciation & prioritization and automated logbooks/historical records.

This program includes developing a portable engine analyzer test set (PEATS). PEATS is an instrumentation package which can be installed on helicopters without permanent changes in the aircraft configuration. It provides referred engine performance diagnostic data for improving operational reliability through early problem identification and repair which reduces inflight problems and increase flight safety. The diagnostic data obtained on each aircraft prior to phase inspection will identify hidden problems for correction during scheduled down-time. Also, the discovery of hidden deterioration in its early stages allows repair before secondary damage occurs on other related parts which lowers the life-cycle cost of maintaining an aircraft.

Current plans also call for developing an improved on-board diagnostic, prognostics and flight data recorder system and better interface procedures and data transfer hardware for automated prediction, troubleshooting and data recording.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Develop PEATS	———	——▲			
• Develop improved flight data recorder system	———	———	——▲		
• Develop improved data recording and analysis methods		———	———	▲	

▲ Completion

Program Area: Methodology

Program: B-7 AOAP Analysis

Description: - To prepare plans, investigate and establish improved procedures and techniques and identify candidates for the Army oil analysis program (AOAP). This includes establishing procedures for implementing required ferrographic tests, investigating portable wear metal techniques and determining the feasibility of optimizing the oil sampling intervals.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Implement required ferrographic tests	———	———▲			
• Investigate portable wear metal techniques	———	———▲			
• Optimize sampling intervals	———	———	——▲		

▲ Completion

6.0 RCM APPLICATION

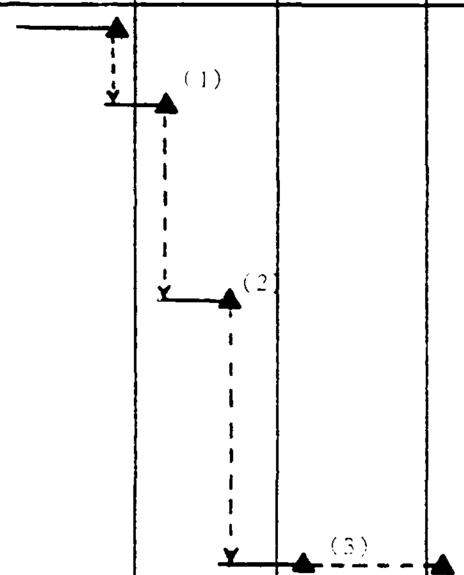
Program Area: RCM Application

Program: C-1 Apply RCM to AH-64

Description: - To develop maintenance and logistic requirements by applying the RCM process to the AH-64 aircraft using data from the RCM data bank. This includes reviewing and/or performing FMECA; applying the updated RCM decision logic (Program B-3) to determine the optimum maintenance tasks; implementing the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals; and preparing maintenance plans that integrates the RCM tasks and ILS requirements into a complete, cost-effective maintenance program. This involves applying the computer-aided process developed under program B-1 to identify safety critical parts and to develop part failure mode criticality data.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Perform FMECA					
• Apply RCM decision logic to identify: - Hardtime - On-condition - Condition Monitoring maintenance requirements					
• Implement RCM decisions by defining: - M task requirements - LSAR "B" Sheet data - Phase maintenance programs - Task frequencies/intervals					
• Prepare maintenance plans (integrating M tasks and support requirements into the ILS plan)					



Notes: (1) Review decision logic data and rationale, revise as applicable
(2) Review maintenance and LSAR data, revise as applicable
(3) Update maintenance plans using actual reliability-age experience data

▲ Completion

Program Area: RCM Application

Program: C-2 Apply RCM to UH-60

Description: - To develop maintenance and logistic requirements by applying the RCM process to the UH-60 aircraft using data from the RCM data bank. This includes reviewing and/or performing FMECA; applying the updated RCM decision logic (Program B-3) to determine the optimum maintenance tasks; implementing the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals; and preparing maintenance plans that integrates the RCM tasks and ILS requirements into a complete, cost-effective maintenance program. This involves applying the computer-aided process developed under program B-1 to identify safety critical parts and to develop part failure mode criticality data.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Perform FMECA	———	▲			
• Apply RCM decision logic to identify: - Hardtime - On-condition - Condition Monitoring maintenance requirements		▲ (1)			
• Implement RCM decisions by defining: - M task requirements - LSAR "B" Sheet data - Phase maintenance programs - Task frequencies/intervals			▲ (2)		
• Prepare maintenance plans (integrating M tasks and support requirements into the ILS plan)			——— ▲ (3)	- - - ▲	

Notes: (1) Review decision logic data and rationale, revise as applicable
(2) Review maintenance and LSAR data, revise as applicable
(3) Update maintenance plans using actual reliability-age experience data

▲ Completion

Program Area: RCM Application

Program: C-3 Apply RCM to CH-47D

Description: - To develop maintenance and logistic requirements by applying the RCM process to the CH-47D aircraft using data from the RCM data bank. This includes reviewing and/or performing FMECA; applying the updated RCM decision logic (Program B-3) to determine the optimum maintenance tasks; implementing the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals; and preparing maintenance plans that integrates the RCM tasks and ILS requirements into a complete, cost-effective maintenance program. This involves applying the computer-aided process developed under program B-1 to identify safety critical parts and to develop part failure mode criticality data.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Perform FMECA					
• Apply RCM decision logic to identify: - Hardtime - On-condition - Condition Monitoring maintenance requirements			(1)		
• Implement RCM decisions by defining: - M task requirements - LSAR "B" Sheet data - Phase maintenance programs - Task frequencies/intervals				(2)	
• Prepare maintenance plans (integrating M tasks and support requirements into the ILS plan)				(3)	

Notes:
(1) Review decision logic data and rationale, revise as applicable
(2) Review maintenance and LSAR data, revise as applicable
(3) Update maintenance plans using actual reliability-age experience data

▲ Completion

Program Area: RCM Application

Program: C-4 Apply RCM to OH-58D

Description: - To develop maintenance and logistic requirements by applying the RCM process to the OH-58D aircraft using data from the RCM data bank. This includes reviewing and/or performing FMECA; applying the updated RCM decision logic (Program B-3) to determine the optimum maintenance tasks; implementing the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals; and preparing maintenance plans that integrates the RCM tasks and ILS requirements into a complete, cost-effective maintenance program. This involves applying the computer-aided process developed under program B-1 to identify safety critical parts and to develop part failure mode criticality data.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Perform FMECA			▲		
• Apply RCM decision logic to identify: - Hardtime - On-condition - Condition Monitoring maintenance requirements				▲ (1)	
• Implement RCM decisions by defining: - M task requirements - LSAR "B" Sheet data - Phase maintenance programs - Task frequencies/intervals				▲ (2)	
• Prepare maintenance plans (integrating M tasks and support requirements into the ILS plan)				▲	(3) ▲

Notes: (1) Review decision logic data and rationale, revise as applicable
(2) Review maintenance and LSAR data, revise as applicable
(3) Update maintenance plans using actual reliability-age experience data

▲ Completion

Program Area: RCM Application

Program: C-5 Apply RCM to LHX

Description: - To develop maintenance and logistic requirements by applying the RCM process to the LHX aircraft using data from the RCM data bank. This includes reviewing and/or performing FMECA; applying the updated RCM decision logic (Program B-3) to determine the optimum maintenance tasks; implementing the RCM decisions by defining specific task requirements, developing logistics data, defining phase maintenance programs and identifying appropriate maintenance task frequencies/intervals; and preparing maintenance plans that integrates the RCM tasks and ILS requirements into a complete, cost-effective maintneance program. This involves applying the computer-aided process developed under program B-1 to identify safety critical parts and to develop part failure mode criticality data.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Perform FMECA			▲		
• Apply RCM decision logic to identify: - Hardtime - On-condition - Condition Monitoring maintenance requirements				▲ (1)	
• Implement RCM decisions by defining: - M task requirements - LSAR "B" Sheet data - Phase maintenance programs - Task frequencies/intervals				▲ (2)	
• Prepare maintenance plans (integrating M tasks and support requirements into the ILS plan)					▲ (3) ▲

Notes: (1) Review decision logic data and rationale, revise as applicable
(2) Review maintenance and LSAR data, revise as applicable
(3) Update maintenance plans using actual reliability-age experience data

▲ Completion

7.0 MATERIAL MANAGEMENT

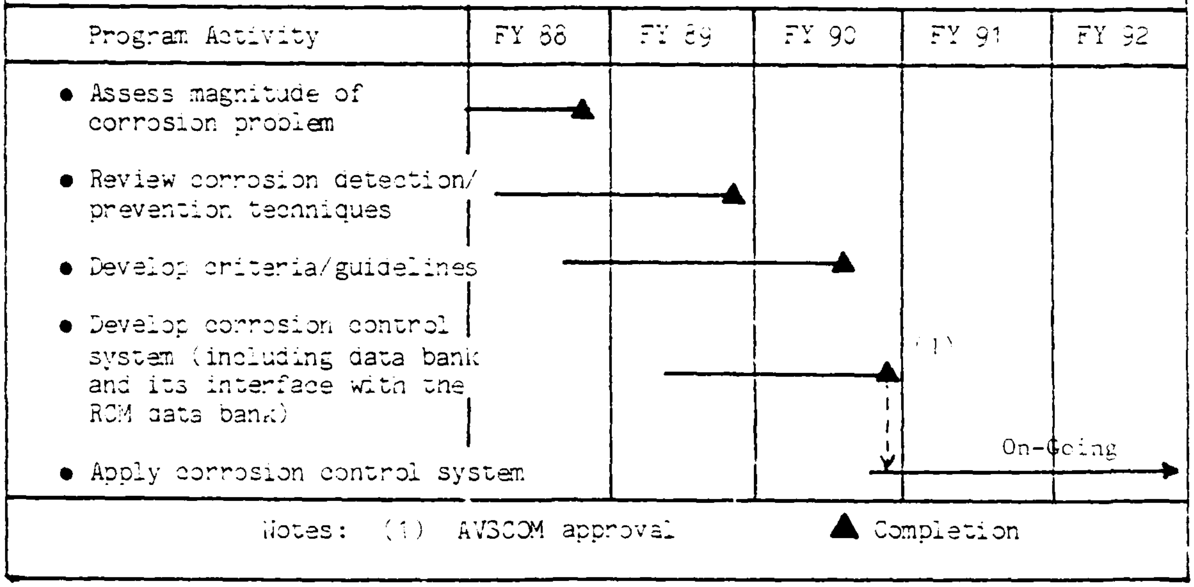
Program Area: Material Management

Program: D-1 Corrosion Control: Program Support

Description: - To prevent and control corrosion in Army aircraft. This includes assessing the extent of corrosion and its cost, investigating corrosion detection and prevention techniques, formulating specific recommendations to prevent or reduce corrosion in new and fielded Army aircraft, and establishing a life-cycle Army aircraft corrosion control system. It also includes preparing AVSCOM engineering directives (AEDs) and/or appropriate publication change forms for revising applicable technical manuals (TMs), depot maintenance work requirements (DMWRs) and other hardware requirement documentation to effect approved recommendations.

The corrosion control system is to emphasize early detection and correction as well as data/trend analysis and timely feedback of deficiency information. Prime data sources that are to be investigated during this effort and incorporated into the corrosion control system include component and airframe pre-shop analysis (PSA), airframe condition evaluation (ACE), aircraft analytical corrosion evaluation (AACE), AVSCOM engineering calls (AECs), equipment improvement recommendations (EIRs), quality deficiency reports (QDRs), and other pertinent experience data. A comprehensive evaluation process is to be developed and used to output the most recent corrosion critical items. The process is to take into account the type and stage of corrosion in an item in light of its structural function and criticality. The corrosion control system (and data bank) is to be applied on selected aircraft to identify the most significant corrosion problems and to develop special repair procedures, specify wear limits, prepare ECPs and PIPs and other actions to correct the problems. The system, once fully developed and validated during this effort, will be structured to interface with the RCM data bank and then applied on an on-going basis to the complete Army aircraft fleet.

Time Line:

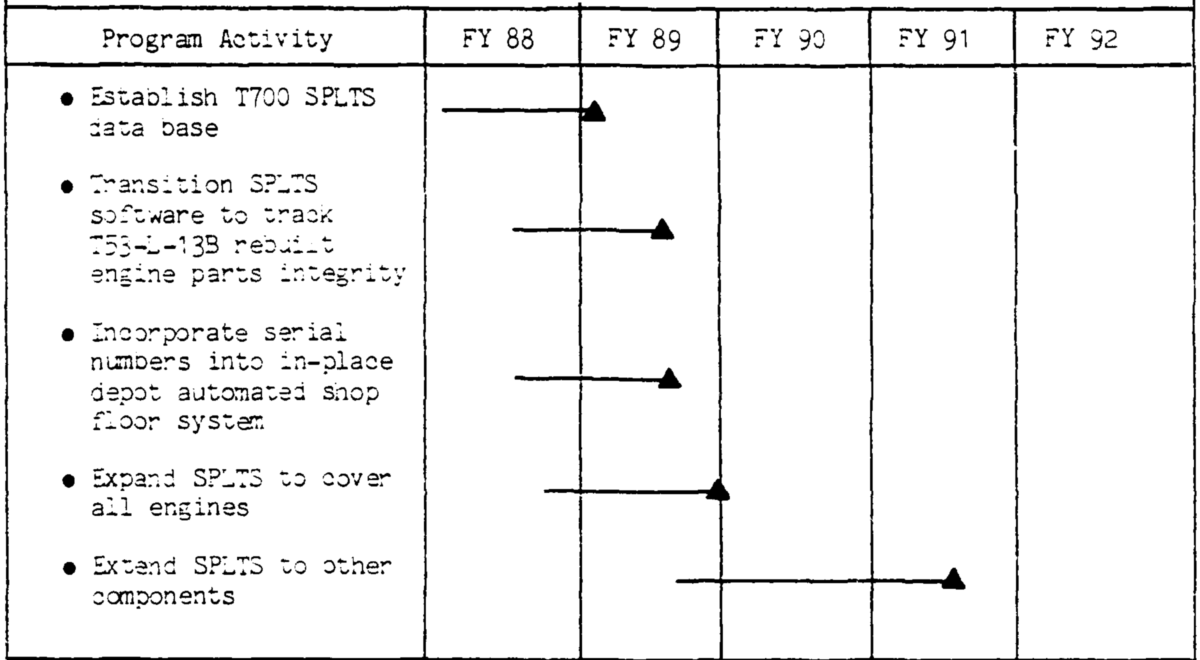


Program Area: Material Management

Program: D-2 Serialized Parts Life Tracking System (SPLTS)

Description: - To obtain serialized piece part traceability and analysis in the RCM data bank in combination with the depot automated shop floor system. SPLTS will determine exact operating times on parts at time of failure or reject. This information will be used along with the number (and causes) of failure to determine basic part failure rates (age exploration). These failure rates can be compared to the failure rates in the LSAR B sheets. Any discrepancy between the two rates can then be evaluated by further RCM analysis and the preventive maintenance program adjusted accordingly (i.e., change inspection intervals, add additional maintenance tasks, etc.). Also any failures not anticipated can be addressed and a preventive maintenance process established to prevent it. Initially SPLTS is being implemented to establish a data base for T700 engine cycle-limited and other parts. It will then be transitioned to track T53-L-13B rebuilt engine parts integrity, expanded to cover all engines, and eventually extended to parts of other components.

Time Line:



▲ Completion

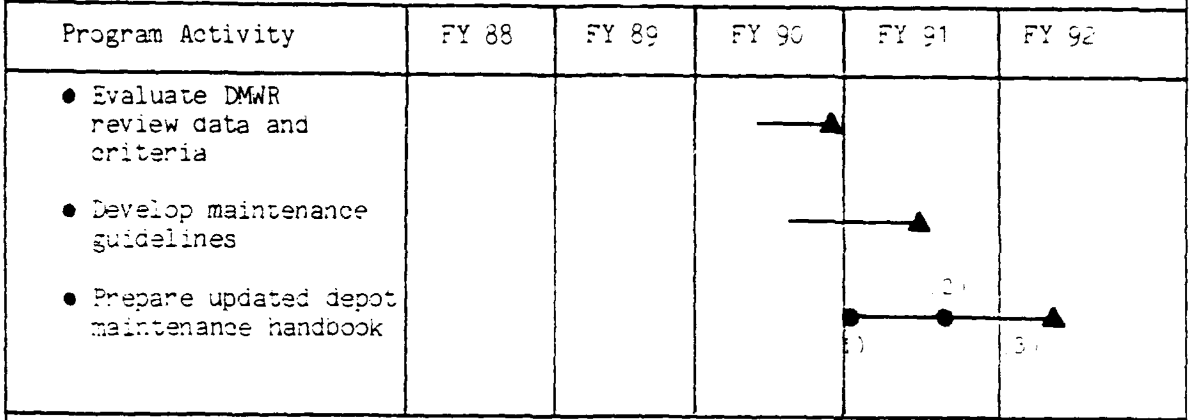
8.0 MAINTENANCE SUPPORT GUIDES, TRAINING AND ILS INTERFACE

Program Area: Maintenance Support Guides

Program: E-1 Update Depot Maintenance Handbook

Description: - To assure the adequacy of the criteria and guidelines currently incorporated in the depot maintenance handbook and to provide additional criteria and guidelines as necessary. The depot maintenance handbook will be updated to reflect data and criteria developed from the DMWR review on the forty (40) items conducted as part of program A-1, to include further details pertaining to the maintenance and overhaul operations at CCAD and to expand the guidelines on the repair of wear or damage, such as small cracks, cuts and other discrepancies, on gears, bearings, cables, hoses, valves, clamps, connectors and other common aircraft parts and on their restoration to "as new" condition.

Time Line:



Notes: (1) Prepare draft handbook
(2) AVSCOM approval
(3) Review, revise as necessary
▲ Completion

Program Area: Maintenance Support Guides

Program: E-2 Update ACE/AACE Handbook

Description: - To assure the adequacy of the criteria and guidelines currently incorporated in the existing ACE/AACE handbook series. The guidebook series will be reformatted and organized into a single, concise reference document incorporating the latest indicator descriptions, additional criteria and more detailed application guidelines. The ACE/AACE handbook will also be updated to reflect the latest inspection methods and analysis techniques and in particular the statistical procedure for determining candidates for overhaul when using a combined ACE/AACE profiling process.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Review improved ACE/AACE threshold methodology (developed under Program B-4)	———	——▲			
• Develop guidelines		———▲			
• Prepare updated handbook series		—— (1) ● (2)	—— (3) ▲		

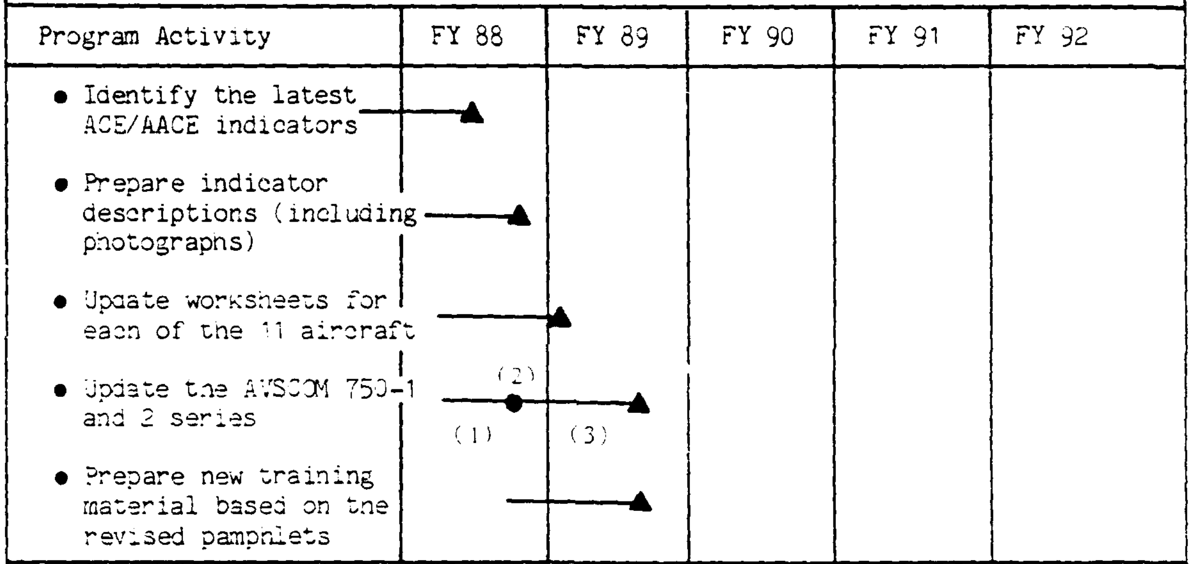
Notes: (1) Prepare draft handbook
(2) AVSCOM approval
(3) Review, revise as necessary
▲ Completion

Program Area: Maintenance Planning

Program: E-3 Update ACE/AACE Pamphlets

Description: - To update the ACE/AACE pamphlets (series 750-1 and 2) to include a description of the latest indicators identified by part number with detailed photographs and to update the worksheets for each aircraft. These pamphlets contain the information required to acceptably perform the data-collection phase of the ACE/AACE. This information covers: (1) general information including purpose and scope of the ACE/AACE program, applicable maintenance forms and records, etc.; (2) detailed technical requirements and in particular the specific indicators for each aircraft and the procedures for collecting the ACE/AACE data based on the indicators; and (3) reporting requirements. The computer codes used to facilitate the field data collection are included in the appendices.

Time Line:



Notes: (1) Draft pamphlet changes
(2) AVSCOM approval
(3) Review, revise as necessary
▲ Completion

Program Area: Maintenance Planning

Program: E-4 RCM Training

Description: - To develop, organize, and implement a comprehensive RCM training program. The training program is to provide the necessary engineering skills and knowledge required to plan and implement RCM for aircraft systems and components. The training program will cover FMECA, RCM decision logic analysis, maintenance task specification, age exploration and maintenance planning in accordance with the RCM/ILS process. In addition the program will include specific training for effective use of trends and patterns identification methods and other standardized procedures by pre-shop analysis (PSA) personnel.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Attend RCM training courses and seminars	———	——▲			
• Prepare RCM training materials/schedule - instructional materials - training devices/aids - instructor requirements - other specifics, i.e., number of courses, duration, size and scheduling	———	———	▲		
• Investigate and establish appropriate trends and patterns PSA identification techniques	———	—▲			
• Manage/implement overall training program - engineering - PSA	———	———	On-Going ———	———	——→

▲ Completion

Program Area: Maintenance Planning

Program: E-5 LSA Interface Requirements

Description: - To establish a more effective RCM and ILS interface. RCM analysis data are major inputs to the ILS process and appear on the LSAR "B" sheet along with reliability and maintainability (R&M) data. "B" sheet data provide the basis for preparing the other MIL-STD-1388 LSAR worksheets used to establish support resource requirements. The end result of the complete RCM/ILS process is the compilation of a Provisioning Master Record (PMR) from which procurement requirements of support items are derived. This program is to investigate this overall RCM/ILS process and to develop specific procedures to facilitate application of the RCM analyses within the process The procedures will reflect the complete RCM-driven ILS process as defined by AMC -P750-2 and MIL-STD-1388 and as implemented at AVSCOM. They will incorporate: (1) the use of R&M prediction and FMECA data during development as input to the RCM logic analysis and (2) the use of reliability-age experience data derived from the RCM data bank at CCAD as part of a sustaining engineering effort to optimize the process during deployment.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Review AMC-P750-2 and MIL-STD-1388 relative to Army aircraft needs					
• Develop RCM/ILS flowchart (and criteria) keyed to RCM functions, input/output data points, interface requirements and management decision points					
• Prepare RCM/ILS interface procedures in accordance with the flowchart and criteria		(1) (2)	(3)		

Notes: (1) Draft procedures
(2) AVSCOM approval
(3) Review, revise as necessary
▲ Completion

9.0 DATA ELEMENTS AND UTILIZATION

Program Area: F-1 Expand Data

Description: - To expand the RCM data bank by incorporating data from the serialized part life tracking system for the T700 engine and UH-60/AH-64 airframe, the automated airframe logbook, the upgraded RCM data base management system, the ACE/AACE, CFD, PEM, breakout and other programs as well as expanded component repair data, i.e., PSA data from the depot and depot level repair data from the field, commercial/contracted overhaul facilities and CONUS, OCONUS and AVCRADS overhaul facilities. Once these data have been validated, codified, and analyzed, they will be entered into the RCM data bank to generate reports, compute composite failure factors, support special projects, support determination of maintenance requirements for FSPs, determine component reliability-age characteristics and resulting scheduled maintenance changes and to provide direct data for spare part provisioning and/or to revise applicable LSA records as part of a sustaining engineering activity in accordance with AMC-P750-2. Automatic data readout and direct PSA data entry techniques will be investigated and developed/implemented, where applicable.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Begin transmission PSA data input	▲		On-Going		→
• Begin airframe PSA data input		▲	On-Going		→
• Begin gear box PSA data input		▲	On-Going		→
• Begin other component PSA data input			▲	On-Going	→
• Begin data input from other sources - programs (ACE/AACE, etc.) - field (depot level repair) - commerical overhaul facilities - CONUS, OCONUS, AVCRADS overhaul facilities		▲		On-Going	→
• Integrate SPLTS (and operating times)				▲	
• Develop/implement automated data readout/entry				▲	

▲ Completion (Initial Data)

Program Area: Data Elements and Utilization

Program: F-2 Expand Utilization

Description: - To expand the utilization of the RCM data elements from the RCM data bank. This includes developing procedures for failure data analysis (to components) based on the application of statistical analysis techniques and computerizing the data reduction and analysis process. Also as part of this program Tri-Service exchange of the outputs of the data bank will be established. Data output products will be designed and implemented to meet user needs including reliability analysis, variability analysis, PIP/ECP/MOD analysis, logistics analysis, depot activity support, exhibit tracking, RCM program effectivity analysis, reliability-age exploration, and FSP tracking and critical characteristic identification, control and feedback. Emphasis will be placed on providing part failure rates, FMECA and reliability-age exploration output data in support of the RCM/ILS process.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Establish improved data reduction and analysis procedures					
• Define/implement user oriented data output products (e.g., part failure rates, FMECA and reliability-age exploration data outputs for input to the RCM/ILS process)					
• Prepare computerized data output procedures and associated hardware					
• Demonstrate/validate data reduction/analysis process					
• Prepare user handbook				(1) (2)	(3)
• Establish Tri-Service Data Exchange				On-Going	

Notes: (1) Draft
(2) AVSCOM approval
(3) Final
▲ Completion

Program Area: Data Elements and Utilization

Program: F-3 Management Summary Reports

Description: - To publish analyzed RCM data summary reports at designated intervals to effect essential management visibility and control of the RCM program. Data and information provided in the data output products prepared under Program F-2 will be reduced, summarized and organized by aircraft and major components and submitted to system/program managers, AMC, AVSCOM directors, field units and depot organizations. Economic analyses will be performed to determine the cost effectiveness of major RCM program functions and resulting cost benefit data will be included in the summary reports.

Time Line:

Program Activity	FY 88	FY 89	FY 90	FY 91	FY 92
• Determine scope/ format				On-Going →	→
• Prepare report/review				On-Going →	→
• Prepare/submit reports at designated intervals				On-Going →	→

▲ Completion

APPENDIX A

THE ARMY AIRCRAFT COMPUTER-AIDED RCM DECISION LOGIC PROCESS

A.1 INTRODUCTION

This appendix describes a computer-aided decision logic process developed by AVSCOM to facilitate the rapid development of uniform, complete and cost effective RCM based maintenance program from standard, readily available input sources. In addition, this computer-aided process provides:

(1) A well organized, readily accessable document and procedural audit trail.

(2) Automated compilation of output data in real time.

(3) A compatible, computerized interface with logistic support analysis records (LSAR) for eventual overall integration within a computerized ILS sytem.

The system was developed based on the MSG-3 decision logic tailored for Army aircraft systems and components. It uses a standard, well supported microcomputer (IBM PC/XT) and an existing, mature, reliable and comprehensive database management system.

As experience is gained through application of the process, high quality maintenance plans will be developed in less time and at lower cost. A maintenance history will be provided for each aircraft system or component that can be correlated with specific parts and their failure modes and criticalities. The process will assure that all maintenance significant parts and their failure modes and criticality are considered in the development of maintenance requirements and that the level and content of the requirements are optimally specified.

The RCM process uses the METAFILE software development system. METAFILE offers record management, word processing, forms entry, data processing, report generation, conversion utilities, disk utilities, and a high level programming language combined within a single architecture. This wide scope allows the varied needs of the RCM process to be met quickly and efficiently.

The record management facilities allow complex data structures to be defined and implemented and external files to be created, updated, and sorted. Within the RCM process, these features are used extensively to store part numbers, criticality data, failure modes, and identification numbers, as well as to record the RCM path through the decision logic and produce the set of applicable maintenance tasks. Closely associated with the record management facilities are the word processing and data processing systems. The word processing system allows RCM logic data to be created, changed, formatted, and printed on paper. It also allows generation of RCM criticality graphs and system fault trees. The data processing system allows calculations to be made on-line and it supports the introduction of RCM data analysis including reliability-age exploration analysis for eventual integration into the RCM process.

The report generation and form entry features enhance program input and output by providing extensive visual text formatting facilities. The conversion and disk utilities interact with the microcomputer at the system level. It allows foreign files to be transferred to the microcomputer from a data storage system and converted to the RCM data base management format. The disk software provides system like features such as file transfer, file copy, and file erase. These facilities will become invaluable when the RCM logic process is linked to an external system and eventually to the RCM data bank.

The procedure development environment supports all essential features of a sequential programming language, as well as allows programmed access to other system utilities. Syntax for the IF, ELSE, FOR, WHILE, and WHERE clauses are supported. The RCM decision logic is implemented using this procedural language.

A.2 THE RCM DECISION LOGIC DIAGRAM

RCM is a proven technique for defining repair and maintenance actions for large and difficult to manage systems. Its primary function is to narrow the focus of the engineer by allowing effort to be concentrated on specific parts and failure modes within the context of an entire aircraft system or major component. All work specifications are made by the engineer and recorded in the program data base for future reference. Implementation of the process requires a working familiarity with the RCM process, the aircraft system or component and the Army's maintenance program.

The Army aircraft RCM logic diagram (see Figures A-1 thru A-5) is designed to lead, through the answering of a series of questions, to the most effective preventive maintenance task combinations. Simple "yes" or "no" answer the questions and are entered into the computer.

The decision logic is applied to critical failure modes for each maintenance significant item. Each identified failure mode is processed through the logic so that a judgment will be made as to the necessity of a task. The resultant tasks and intervals will form the total scheduled maintenance program.

The decision logic has two levels:

<u>The first level</u> (questions 1, 2, 3 and 4) requires evaluation of each FAILURE MODE for determination of the consequence category; i.e., safety (evident), economic (operational), economic (non-operational), safety (hidden) or non safety/economic.

<u>The second level</u> (questions 5 through 26) then takes the FAILURE CAUSES for each failure mode into account for selecting the specific type of task(s). Regardless of the answer to the questions regarding servicing, the next task selection question must be asked in all cases. When following the safety effects (hidden or evident) paths, all subsequent questions must be asked. In the other paths, subsequent to the first question, a "YES" answer will allow exiting the logic. At the user's option, advancement to subsequent questions after a "YES" answer is derived is allowable, but only until the cost of the task is equal to the cost of the failure prevented.

Default logic is reflected in paths outside the safety effects areas by the arrangement of the task selection logic. In the absence of adequate information to answer "YES" or"NO" to questions in the second level, default logic dictates that a "NO" answer be given and the subsequent question be asked. As "NO" answers are generated, the only choice available is the next question, which in most cases provides a more conservative, stringent and/or costly route.

The logic procedure requires consideration of the failures, failure causes, and the applicability/effectiveness of each task. Each identified failure processed through the first level logic will be directed into one of the five consequence categories. There are four first level questions.

Question 1: Can operating crew detect failures?

This question asks if the operating crew will be aware of the loss (failure) of the function during performance of their normal operating duties. The intent is to segregate the evident and hidden functional failures.

A "YES" answer indicates the failure is evident; proceed to question 2.

A "NO" answer indicates the failure is hidden; proceed to question 3.

Normal operating duties include:

a) Preflight check
b) Monitoring of cockpit and/or cabin instrumentation.
c) Recognition of potential failures through the use of normal physical senses (e.g., odor, noise, vibration, temperature, visual observation, changes in physical input force requirements, etc.).

For the failure to be evident by the operating crew the following criteria applies:

(1) Reduced resistance to failure must be detectable and the rate of reduction in failure resistance must be predictable. Indicators that annunciate failures at the time of occurrence are not applicable.
(2) For safety considerations the monitoring must be part of the normal duties of the operating crew and reduce the risk of failure to assure safe operation.
(3) For economic considerations the monitoring must be part of the normal duties of the operating crew.

Question 2: Does the failure (or secondary failure) cause a mission abort of flight safety incident?

For a "YES" answer the failure must have a direct adverse effect and the failure must achieve its effect by itself, not in combination with other functional failures (i.e., no redundancy exists and it is a primary item). Operation is defined as the time interval from the moment the aircraft first moves under its own power for the purpose of flight until the moment it comes to rest at the next point of landing.

A "YES" answer to this question indicates that maintenance tasks must be developed in accordance to the safety consequence category and that task development must proceed in accordance to questions 5 thru 10.

A "NO" answer indicates the effect is purely economic and question 4 must be asked.

Question 3: Does the hidden failure alone or the combination of a hidden failure and one additional failure of a system related or back-up function cause a mission abort or flight safety incident?

The question takes into account failures in which the loss of the one hidden function (whose failure is unknown to the operating crew) alone does not affect mission or flight safety; however, in combination with an additional functional failure (system related or intended to serve as a back-up) has an adverse effect on mission or flight safety.

IF a "YES" answer is determined, there is a safety consequence and task development must proceed in accordance with questions 16 through 21.

A "NO" answer indicates that there is an economic consequence which will be handled in accordance with questions 22 thru 26.

Question 4: Does the failure have a direct adverse effect on operating performance?

This question asks if the failure could have an adverse effect on operating capability such as:

a) requiring correction prior to further use;
b) compromising the mission flexibility; e.g., altitude restriction, non-icing restriction, weight restriction, etc.

If the answer to this question is "YES" or "NO", task selection will be handled in accordance with questions 11 thru 15.

Once the user has answered the applicable first level questions, he is directed via second level logic questions to one of the five consequence categories:

(1) Safety, Evident (Questions 5 thru 10)
This category must be approached with the understanding that preventive maintenance (PM) task(s) are required to assure safe operation. All questions (5-10) in this category must be asked. If no effective task(s) results from this category analysis, then redesign is mandatory.

(2) Economic, Operational (Questions 11-15)
For this category PM tasks(s) are desirable if the cost is less than the combined cost of the operational loss and the cost of repair. Analysis of the failure causes through the logic requires the first question (Servicing) to be answered. Either a "YES" or "NO" answer of question 11 still requires movement to the next level; from this point on, a "YES" answer will complete the analysis and the resultant task(s) will satisfy the requirements. If all answers are "NO", no task has been generated. If economic penalties are

severe, a redesign may be desirable.

(3) Economic, Non-Operational (Questions 11-15)
PM task(s) is desirable if the cost of the task is less than the cost of repair. Analysis of failure causes same as above.

(4) Safety Hidden (Questions 16-21)
The Hidden Function Safety Effect requires PM task(s) to assure the availability necessary to avoid the safety effects of multiple failures. All questions (16-21) must be asked. If there are no tasks found effective, then redesign is mandatory.

(5) Non-Safety Economic (Questions 22-26)
PM task(s) is desirable to assure the availability necessary to avoid the economic effects of multiple failures. Movement of the failure causes through the logic requires the first question (Servicing) to be answered. Either a "YES" or "NO" answer still requires movement to the next level; from this point on, a "YES" answer will complete the analysis and the resultant task(s) will satisfy the requirements. If all answers are "NO", no task has been generated. If economic penalties are severe, a redesign may be desirable.

Developing the most effective preventive maintenance task combination is handled in a similar manner for each of the five consequence categories. For task determination, it is necessary to apply the failure causes for the failure to the second level of the logic diagram. There are seven possible task resultant questions in the Effect categories as follows:

(1) Service Task (Questions 5, 11, 16 & 22)
Is a servicing task applicable and effective?

This task covers any act of servicing for the purpose of maintaining inherent design capabilities. It includes activities performed periodically to keep an item in proper operating condition, i.e., to clean (decontaminate), to preserve, to drain, to paint, or to replenish fuel, lubricants, hydraulic fluids, or compressed air supplies.

- Applicability Criteria:
  The replenishment of the consumable must reduce the rate of functional deterioration.
- Effectiveness Criteria - Safety:
  The task must reduce the risk of failure.
- Effectiveness Criteria - Economic

The task must be cost-effective.

(2) Crew Monitoring Task (Questions 6, 12 & 23)
Is a crew monitoring task applicable and effective?

This task consists of any monitoring of aircraft operation by the crew members during their normal duties. This includes monitoring of instrumentation and recognition of potential failures by the operating crew through the use of normal physical senses (e.g., odor, noise, vibration, temperature, visual observation, changes in physical input force requirements, etc.).

- Applicability Criteria:
  Reduced resistance to failure must be detectable and rate of reduction in failure resistance must be predictable. Indicators that annunciate failures at the time of occurrence are not applicable.
- Effectiveness Criteria - Safety:
  This task must be part of the normal duties of the operating crew and reduce the risk of failure to assure safe operation.
- Effectiveness Criteria - Economic:
  This task must be part of the normal duties of the operating crew.

(3) Verify Operation Task (Question 17)
Is a check to verify operation (or detect impending failure) applicable and effective?

This task is to verify qualitatively that an item is fulfilling its intended purpose.

- Applicability Criteria:
  Verification of operation must be possible.
- Effectiveness Criteria - Safety:
  The task must ensure adequate availability of the hidden function to reduce the risk of a multiple failure.
- Effectiveness Criteria - Economic:
  The task must ensure adequate availability of the hidden function in order to avoid economic effects of multiple failures and must be cost-effective.

(4) On Condition Task (Questions 7, 13, 18 & 24)
Is the ability to detect degradation of the function by on-aircraft or off-aircraft task(s) e.g., thru functional checkout, preflight inspection, ACE or thru PSA applicable and effective?
This task is to examine an item using a specific checklist or standard. It may include a functional check to determine if one or more functions of an item performs within specified limits.

- Applicability Criteria:
  Reduced resistance to failure must be detectable and rate of reduction in failure resistance must be predictable.
- Effectiveness Criteria - Safety:
  The task must reduce the risk of failure to assure safe operation.
- Effectiveness Criteria - Economic:
  The task must be cost-effective; i.e., the cost of the task must be less than the cost of the failure.

(5) Rework (or Restoration) Task (Questions 8, 14, 19 & 25)
Is a rework task to reduce failure rate applicable and effective?

This task includes repair, overhaul or rebuild. Repair is the application of maintenance services or other maintenance actions to restore serviceability to an item by correcting specific damage, fault, malfunctions or failure in a part, subassembly, module (component or assembly), end item, or system. Overhaul is that maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by the maintenance standard (i.e., DMWR) in the appropriate technical publication. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like-new condition. Rebuild consists of those services/actions necessary for the restoration of unserviceable equipment to a like-new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (i.e., hours) considered in classifying Army aircraft systems and components.
This task involves that work (on/off the aircraft) necessary to return the item to a specific standard. Since this task may vary from cleaning of single parts up to a complete overhaul or rebuild, the scope of each assigned restoration task has to be specified.

- Applicability Criteria:
  The item must show functional degradation characteristics at an identifiable age and a large proportion of units must survive to that age. It must be possible to restore the item to a specific standard of failure resistance.
- Effectiveness Criteria - Safety:
  The task must reduce the risk of failure to assure safe operation.
- Effectiveness Criteria - Economic:
  The task must be cost-effective; i.e., the cost of the task must be less than the cost of the failures prevented.

(6) Replacement Task (Question 9, 15, 20 & 26)
Is a replacement task to avoid failures or to reduce the failure rate applicable and effective?

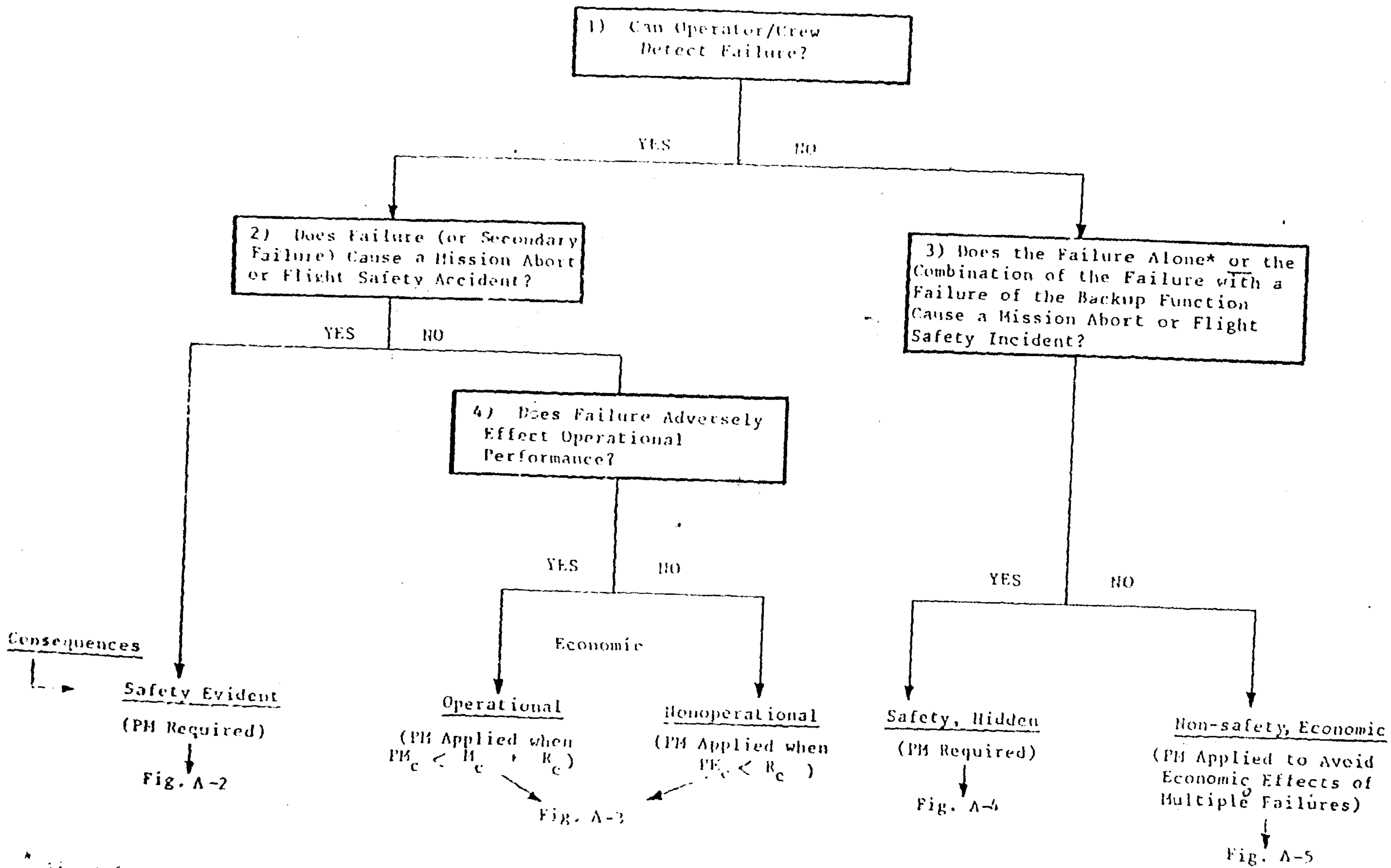
This task involves substituting a servicable like type part, subassembly or module (component or assembly) for an un-serviceable counterpart. It requires removal from service of an item at a specified life limit.
This task is normally applied to so-called single celled parts such as cylinders, engine disks, safe-life structural

members, etc.

- Applicability Criteria:
  The item must show functional degradation characteristics at an identifiable age and a large proportion of units must survive to that age.
- Effectiveness Criteria - Safety:
  A safe-life limit must reduce the risk of failure to assure safe operation.
- Effectiveness Criteria - Economic:
  An economic-life limit must be cost-effective; i.e., the cost of the task must be less than the cost of the failures prevented.

(7) Combination (Questions 10, 21)
Is there a task or combination of tasks which is applicable and effective?

Since this is a safety category question and a task is required, all possible avenues must be analyzed; to do this, a review of the task(s) that are applicable is necessary. From this review the most effective task(s) must be selected.
Once the maintenance task(s) have been selected, the next step is to set task *frequencies/intervals*. First determine whether real and applicable data are available which suggest an effective interval for task accomplishment. Prior knowledge from other aircraft systems may be used which shows that a scheduled maintenance task has offered substantial evidence of being effective and economically worthwhile.
If there is no prior knowledge from other aircraft systems or if there is insufficient similarity between the previous and current systems, the task frequency/interval can only be established initially by experienced engineering and maintenance personnel using good judgment and operating experience in concert with accurate reliability data.



* Aircraft should be designed such that a hidden failure alone will not cause a mission abort or flight safety incident

Figure A-1 Army Aircraft RCM Decision Logic: Consequence Categories

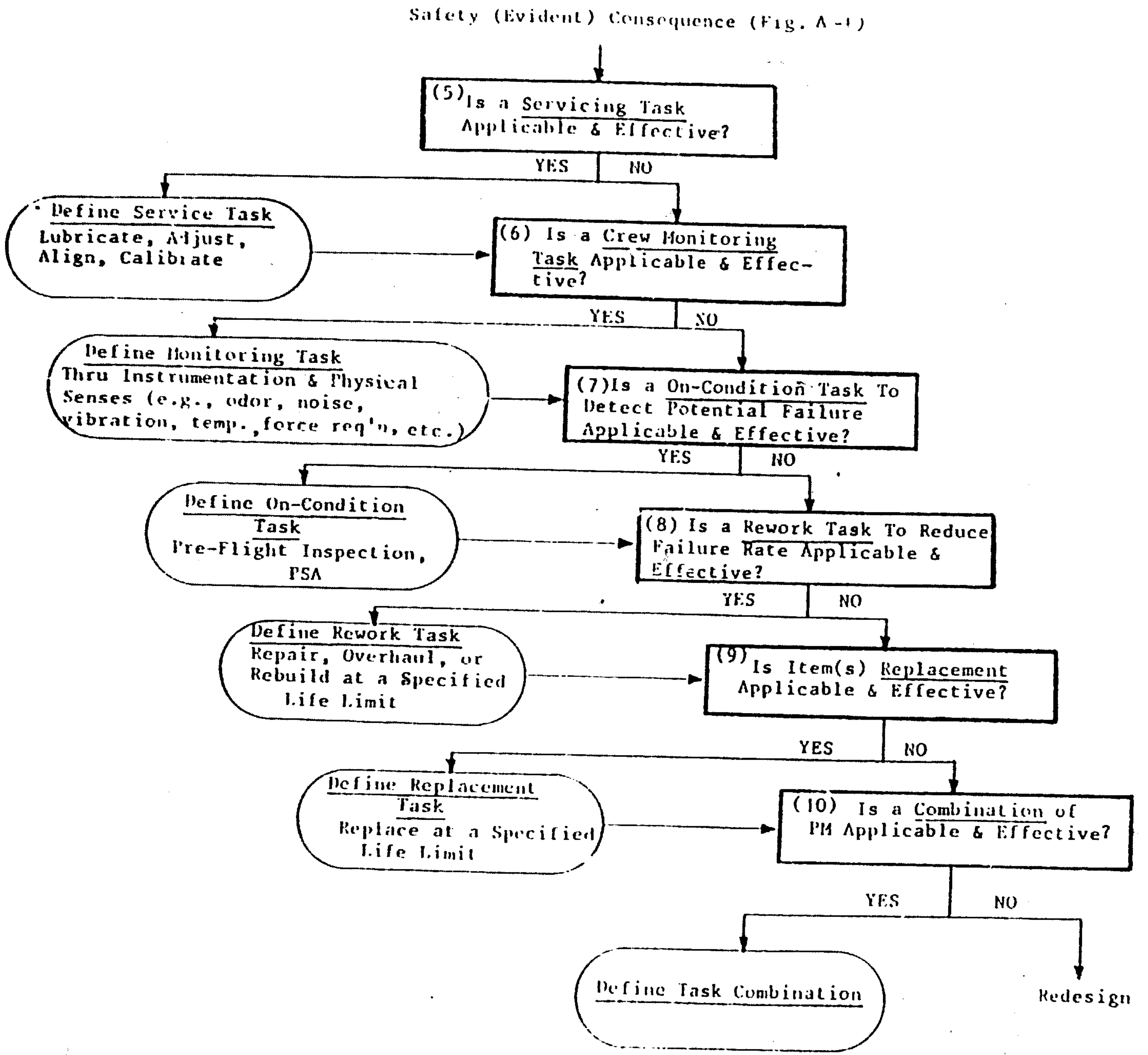


Figure A-2 Army Aircraft PM Decision Logic: Safety Evident

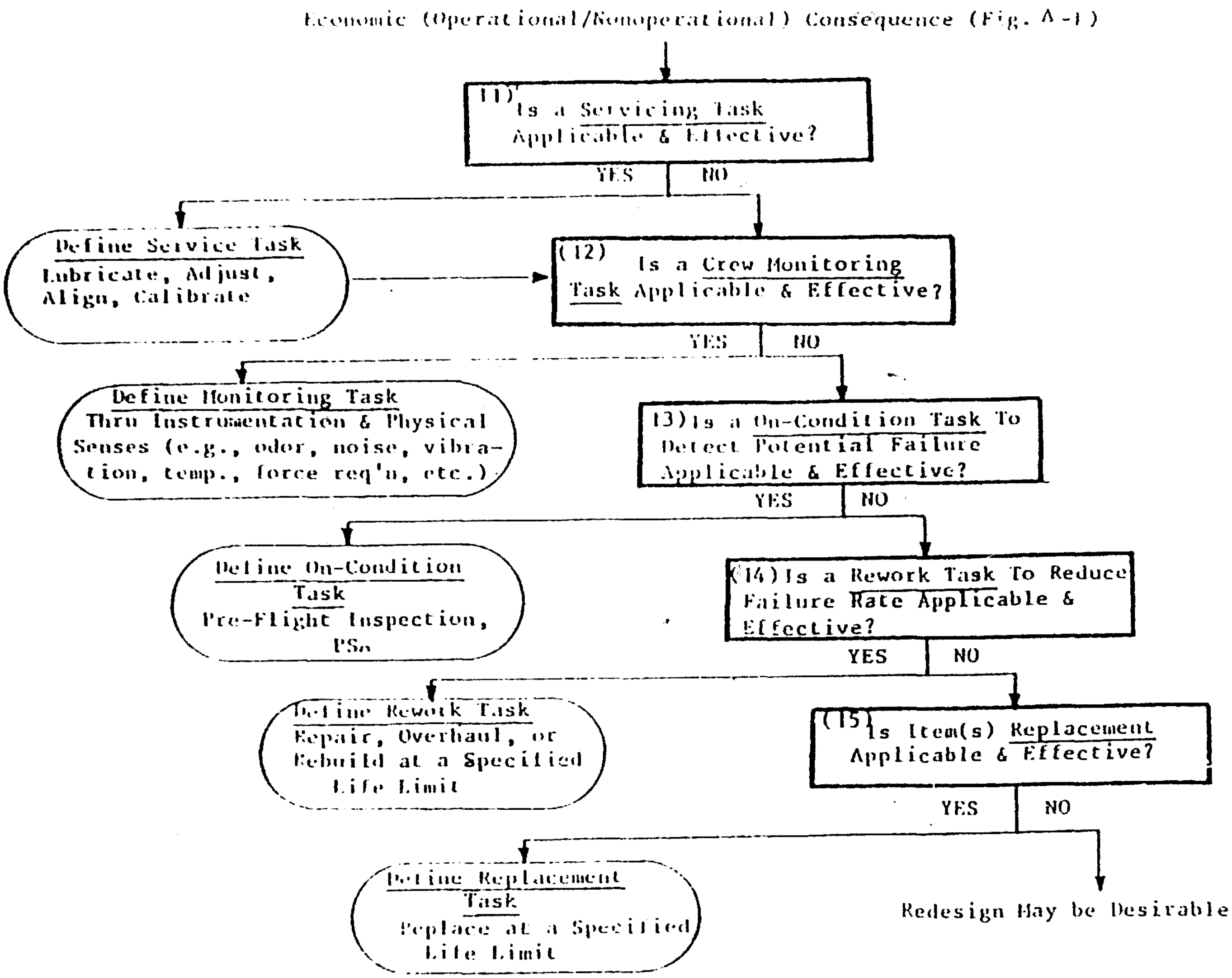


Figure A-3 Army Aircraft RCM Decision Logic: Economic Operational/Nonoperational

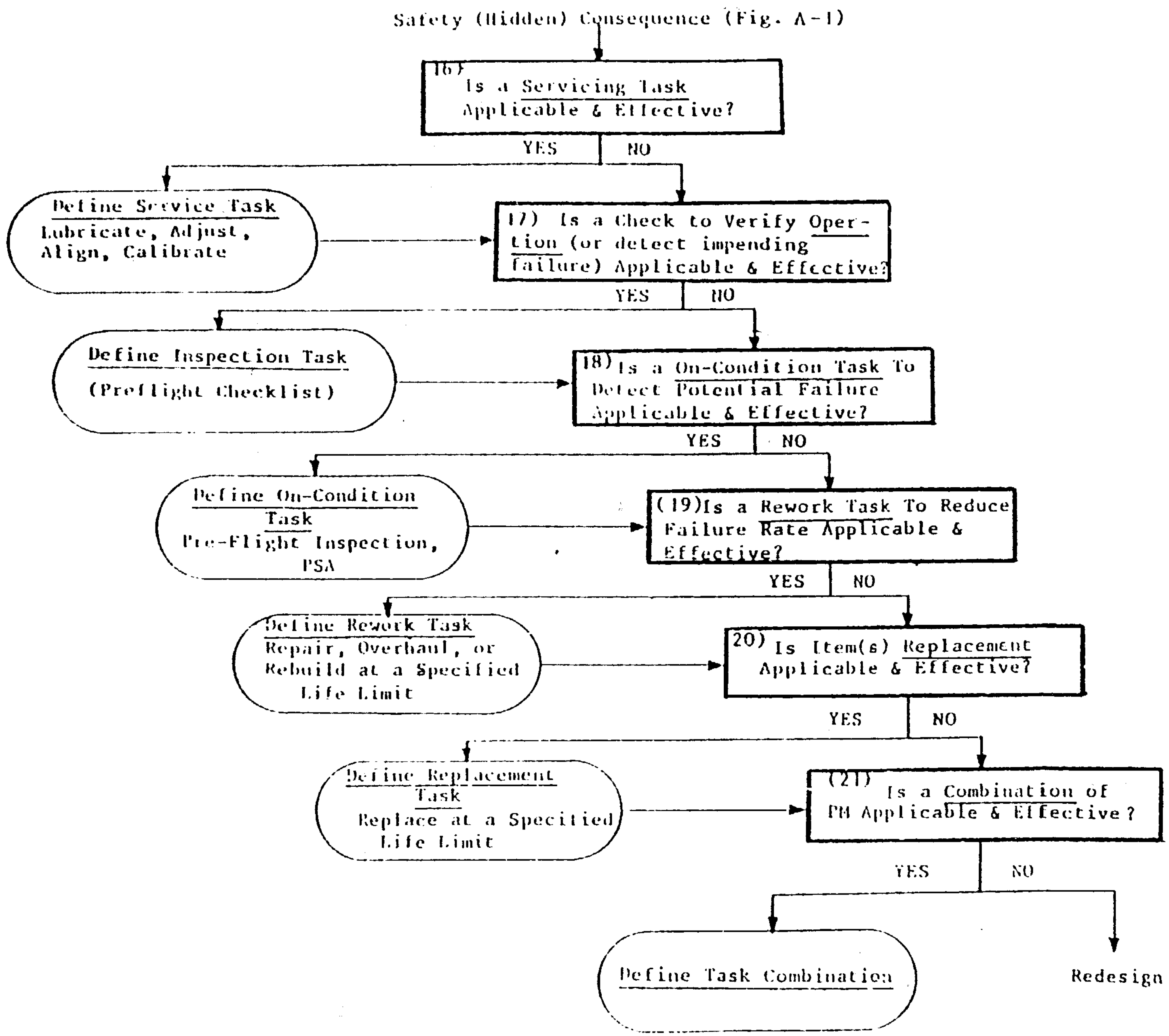


Figure A-4 Army Aircraft RCM Decision Logic: Safety Hidden

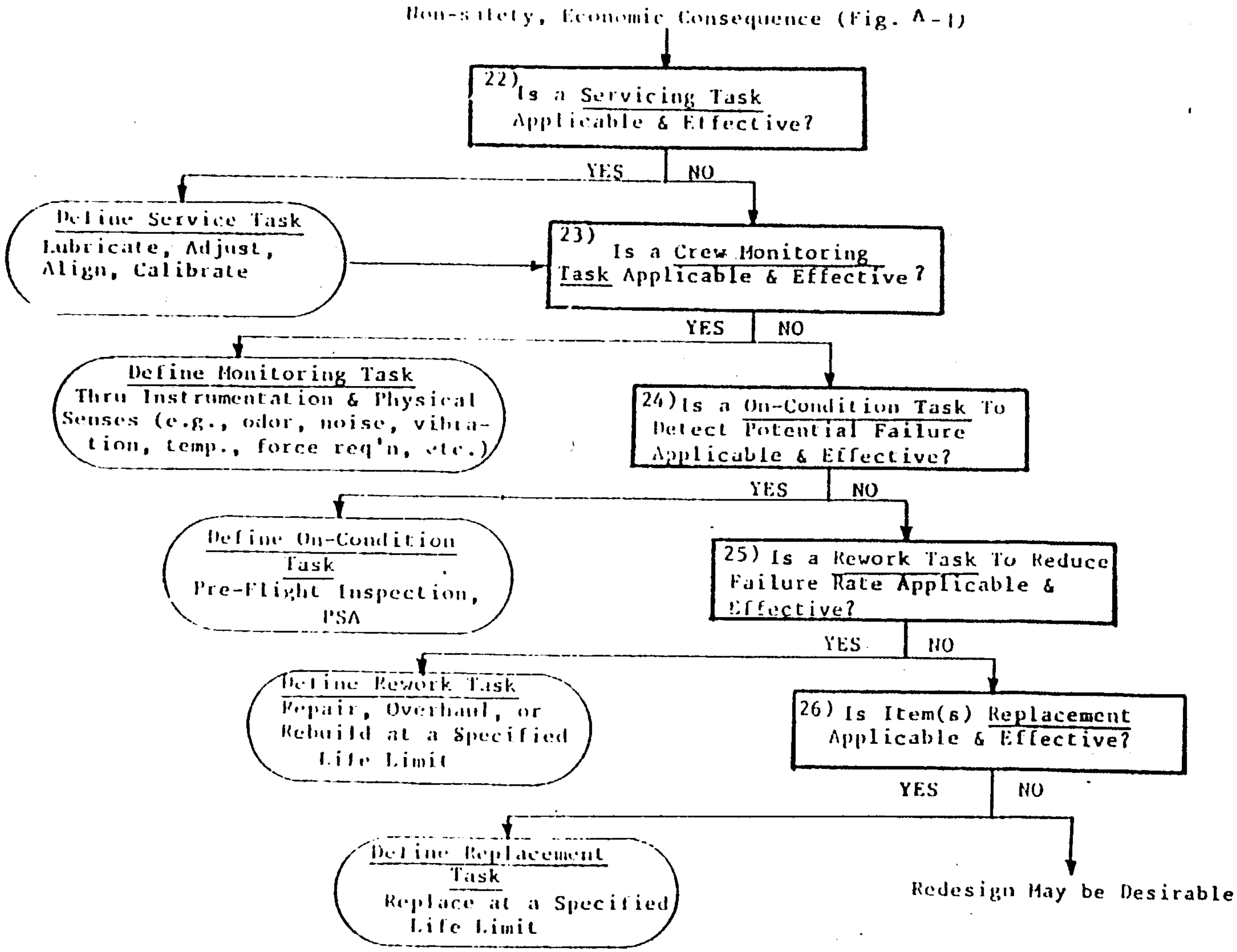


Figure A-5 Army Aircraft RCM Decision Logic: Non-safety Economic

APPENDIX B: THE DMWR RCM REVIEW PROCEDURE

The RCM process involves first identifying existent failure(s) through use of available data, test, and inspections. An evaluation of these elements is then conducted to determine the condition of an item prior to performing maintenance to return the item to a serviceable condition.

Tests, inspections, experience, and historical data are used to the extent practical for each unique item of equipment to determine depot maintenance procedures with the least extensive processes. Particular attention is paid to the following areas:

(1) The Army Oil Analysis Program (AOAP), as prescribed in AR 750-22, is used as applicable to identify maintenance requirements in subassemblies or components.

(2) Preshop analysis (PSA) is incorporated as a integral part of the entire maintenance process. Preshop analysis using inspection as well as diagnostic test is performed at the highest possible level of assembly to prevent unnecessary disassembly.

(3) Wear tolerances are reviewed to allow maximum use of parts within safety and reliability parameters. Tolerances that are primarily for manufacturing purposes are not required checks unless specifically required for reliability or safety.

(4) Diagnostic tests are reviewed for general application and for maximum allowable variation while retaining safety and reliability. Tests are used to determine the extent of depot maintenance, not to confirm design parameters.

(5) Economic considerations and trade-offs are balanced against reliability and safety requirements. If limited disassembly is required to determine condition and repairs required, any parts or assemblies easily accessible because of this disassembly are considered for repair or replacement based on condition, reliability, age-usage relationship and economics.

(6) Disassembly and replacement solely for cosmetic purposes are avoided.

(7) The benefits of refinishing end items and assemblies are weighed against the consequences of touch up only.

(8) Component repair or replacement is justified by statistically sound test or field data. Repair or replacement of an item is correlated closely between reliability and age or usage.

In order to integrate the RCM process fully into Army maintenance, maintenance requirements derived from the RCM process must be incorporated into the appropriate technical publications. As an example of how this incorporation of RCM into technical publications should be carried out, this appendix describes the method used to review, and to revise or rewrite as necessary, existing depot maintenance work requirements (DMWRs) to reflect the RCM process.

Depot maintenance is performed in accordance with the flow chart given in Figure B-1. As shown, all aviation equipment items are grouped into the following three (3) categories upon induction into a depot:

(1) Category I: Aircraft - This category encompasses the total aircraft; for example, the airframe, electrical wiring, seats, transparencies, push-pull systems and doors.

(2) Category II: Large Components - This category encompasses large components and major assemblies; for example, engines and

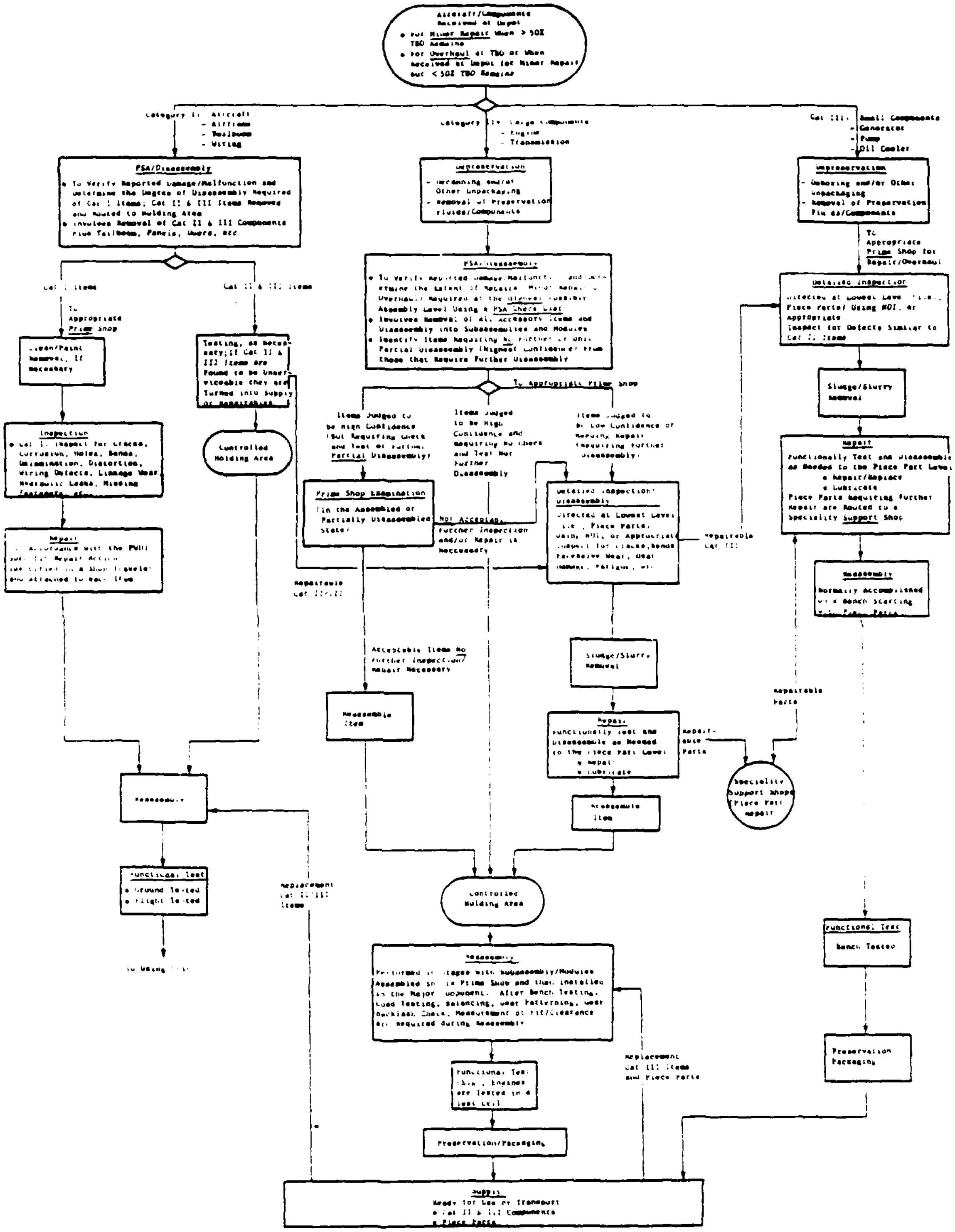


Figure B-1 The Depot Maintenance Process transmissions.

(3) Category III: Small Components - This category encompasses small components and accessories; for example, generators, hydraulic pumps and oil coolers.

A DMWR contains complete instructions and acceptance criteria for an overhaul of an aircraft or component based on the process shown in Figure B-1. The DMWR identifies minimum acceptable standards and (where applicable) provides preshop analysis (PSA) guidelines for determining the extent of repair required. It is normally provided as the "Statement of Work" for each item contracted or programmed for depot level maintenance. It is a "how to do" type of document which provides the necessary instructions for the complete overhaul of an item, including conversion/modification criteria (parts, subassemblies, and assemblies required to convert to latest item configuration as specified in depot program notices and the modification of parts, subassemblies, and assemblies required by engineering change proposals) and piece-part reclamation procedures for the worse case condition of applicable parts.

The DMWR is the result of an intensive effort to determine the processes required to achieve maintenance standards and incorporate those processes into a usable document as described in MIL-M-63041. The DMWR is constructed in a manner which will enable it to be utilized by those elements responsible for producing a quality product that meets serviceability requirements. An effective DMWR will result in minimizing resource and materiel expenditures required to restore and retain the reliability and safety of the equipment.

DMWRs are supplemented at the depot by AVSCOM Engineering Directives (AEDs). AEDs address specific problems in a DMWR and serve as an aid in updating the DMWR. AEDs are also used to formulate technical data packages for piece part repair and contracts and to provide alternate procedures to the depot because of unique capabilities or restrictions. AEDs of this latter type are referred to as "program" AEDs since they will not be picked up in a DMWR.

PSA, an integral part of the entire depot maintenance process, is a logical inspection procedure that is done to determine the condition of an item sent to the depot. The condition of an item, along with the reason(s) why the item was sent to the depot and the component operating times, will dictate the minimum amount of depot maintenance needed to restore the item to inherent design safety and reliability levels. PSA identifies the extent of disassembly and repair required at the appropriate prime shop(s) and also determines if component "short routing" can occur, i.e. if components can be sent directly to the control holding area or assembly lines. PSA utilizes visual inspection, diagnostic testing, nondestructive testing, dimensional inspection, and other methods as determined appropriate in conjunction with experience and historical data in the evaluation process. PSA using inspections as well as diagnostic test is performed at the highest possible level of assembly to prevent unnecessary disassembly. Defined weak spots within a component must be accessed to inspect for specified historically common deficiencies and to determine repair required to restore item design requirements reliability and safety.

The PSA section of a DMWR provides the "what-to-do" guidelines necessary for determining when and where to apply the DMWR's procedures. Although overhaul is the major part of the work performed at a depot, not all of the items processed at a depot receive a complete overhaul. When a complex unit becomes defective in the field, and is beyond field repair capability, it is often more cost effective to minor repair rather than overhaul when received at the depot. A minor repair consists of the minimum maintenance necessary to correct the specific discrepancy that caused the item to be returned to the depot along with other applicable tasks associated with reassembly, testing, and preservation. The minor repair changes the status of the unit from repairable to serviceable but does not increase its potential longevity. The determination to minor repair or overhaul is made after the item is inducted into the depot and undergoes a PSA.

Figure B-2 illustrates a longevity curve which depicts wear/degradation behavior with respect to time. The slope of the curve during wear-in and wear-out varies from item to item as does the length and slope of the stable wear life part of the curve. A descrepancy changes an item's status from serviceable to repairable and acts as a roadblock in preventing the item from progressing down its longevity curve. When the discrepancy arises, usually either overhaul or minor repair is performed. Overhaul is performed to recover used-up wear life in items with time-between-overhaul (TBO) limits; the longevity of an overhauled item approximates that of a new item. A minor repair removes the roadblock and allows the unit to progress; it does not recoup any of the used up wear life and therefore does not change the item's position on the longevity curve. For simple OCM items without TBOs minor repair is the only alternative.

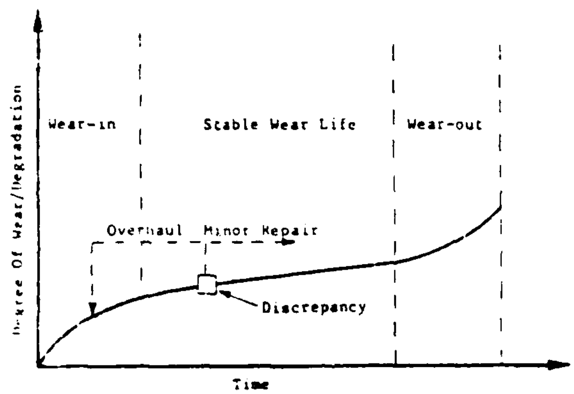


Figure B-2 Impact of Repair on Potential Longevity

The PSA section of the DMWR are to include guidelines for determining the minimum extent of maintenance needed to ensure restoration and preservation of the item's inherent design reliability and safety. Figure B-3 provides general guidelines to aid in the review of a DMWR and to prepare practical PSA guidelines for each of the three categories of equipment.

A key aspect of evaluating and/or preparing the PSA section for a given hardware item is to determine if the item can be restored by minor repair (i.e., inspection and repair) or if overhaul is necessary. A decision logic to determine if minor repair is feasible is given in Figure B-4. Time since new or last overhaul is not changed after minor repair.

To eliminate unnecessary maintenance tasks while restoring inherent system reliability and safety requirements, one initiative (where applicable) is to only partially disassemble the item during the overhaul process. This initiative is viable on complex items, such as engines and transmissions,

I. AIRCRAFT:

A. Preshop Analysis (PSA): If a PSA exists, it will be evaluated; if it doesn't exist, it will be developed. The DMWR PSA which results will provide guidelines to the depot for examining the basic airframe and identifying the extent of maintenance required. Initiatives will include:

1. Determining which panels and other structure require arbitrary removal from the airframe and which are removed only for cause.
2. Identifying specific structural weak points that must be addressed at every overhaul.
3. Determining which aircraft require aligment check at every overhaul and, if not, when an airframe aligment fixture is required.
4. Reviewing the depot maintenance process to determine what other tasks can be eliminated, streamlined, or accomplished only on condition.
5. Determining the extent of repair for the tailboom.
6. Providing guidance for using visual examination in lieu of nondestructive testing (NDT) (where possible) for detecting cracks in piece parts.

B. The accessories/components which require functional test or special inspection will be determined.

C. The aircraft's characteristic weaknesses which must be addressed at each depot maintenance (convenience maintenance) will be identified.

II. MAJOR COMPONENTS (ENGINES, TRANSMISSIONS, ETC.):

A. Preshop Analysis (PSA): The PSA will establish a limited disassembly concept which will feature:

1. Short routing of the high confidence assemblies by establishing hard time between complete disassemblies for each major assembly or subassembly.
2. Identifying inherent weaknesses which must be addressed at each depot maintenance (convenience maintenance).
3. Identifying bearings which require disassembly and inspection in clean room environment.

B. Guidance for using visual examination in lieu of NDT (where possible) for detecting cracks in piece parts will be provided.

C. Piece parts which should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together will be identified.

D. The DMWR will provide for check and test of the major component's accessories and the performance of minor repair as necessary.

E. The depot maintenance process will be reviewed to determine what other tasks can be eliminated, streamlined, or accomplished only on condition.

III. SMALL COMPONENTS:

Since these components are disassembled, on a workbench, directly into their integral piece parts, there are usually not subassemblies, or subassemblies are bonded together and further disassembly is impractical. Although limited disassembly is not a viable initiative on small components, a PSA will be developed to address:

A. Inherent weaknesses of the component which require emphasis at each depot maintenance.
B. Guidance in determining when and which parts require NDT.
C. Which parts should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together.
D. Which bearings require disassembly/inspection in a clean room environment.

Figure B-3 RCM DMWR Review Tasks

where an item is extensively evaluated during PSA to determine if its condition requires complete disassembly. After a limited disassembly overhaul, the item's records are adjusted to reflect zero time since overhaul. In evaluating the item to determine if limited disassembly is a viable option the following questions are asked:

(1) Does the item have subassemblies, modules, accessories, etc.? If so, do some subassemblies have considerably more longevity than others?
(2) What are the item's inherent design weaknesses?
(3) What are the most common causes for depot return?
(4) Are there some maintenance tasks that are not necessary under certain situations?

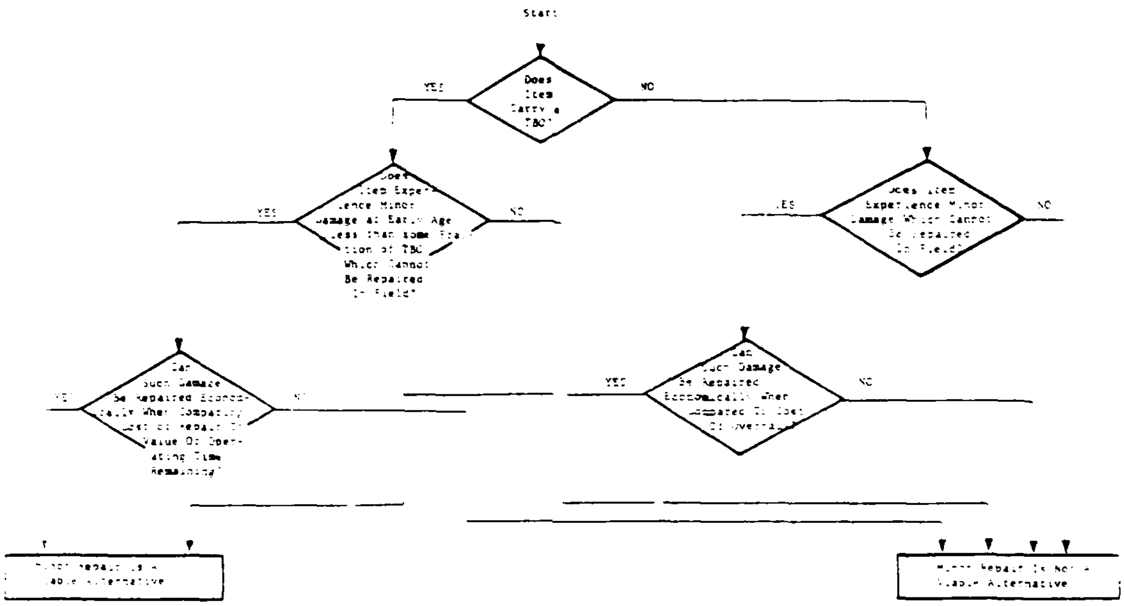


Figure B-4 Minor Repair Feasibility Decision Logic

The specific procedure to review, and revise or rewrite as necessary a DMWR to include the RCM philosophy is illustrated in Figure B-5. There are six (6) steps as follows:

Step 1: Compile Data

This includes compiling and reviewing the following data items:

(a) AMC Regulation No. 750-9, RCM Application to DMWRs, dated 31 August 1983 -- This defines the basic philosophy of RCM as it relates to depot-level maintenance and directs that new DMWRs be developed in terms of RCM philosophy and that existing DMWRs be reviewed and revised or rewritten as necessary to incorporate the RCM philosophy.

(b) The current DMWR for the particular item being reviewed -- This forms, of course, the baseline for the evaluation/development of the PSA

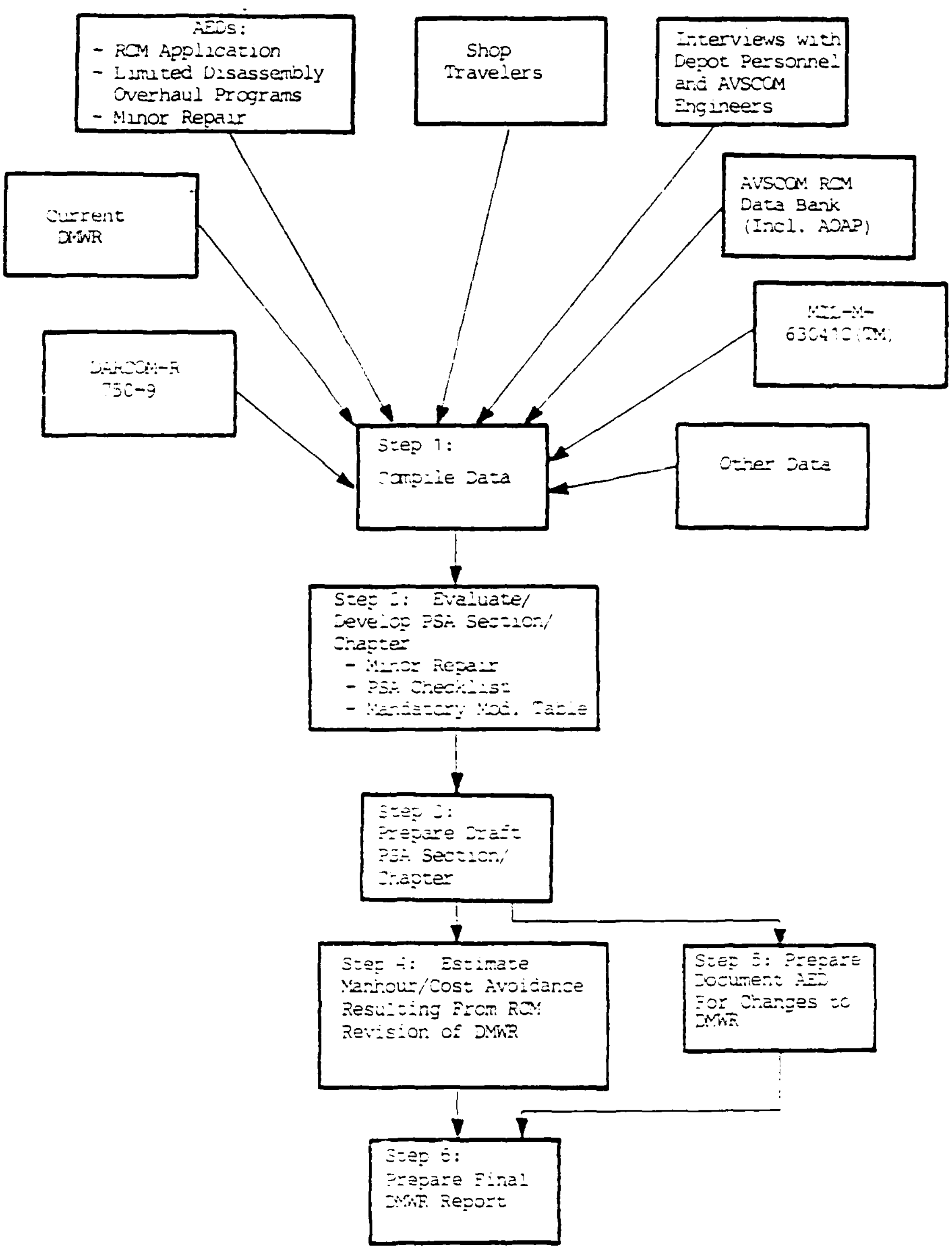


Figure B-5 RCM DMWR Review Procedure

section/chapter carried out in step 2.

(c) Certain program AEDs (that deal with concepts and procedures for processing and managing particular equipment through the depot process) -- These include AEDs on RCM application to T53 engines, on limited disassembly overhaul of engines, on minor repair of engines, and on RCM/minor repair of transmissions and gear boxes. They serve as background material for the evaluation/development of the PSA section/chapter.

(d) Shop travelers -- These are depot work order documents that provide authorized prescribed sequential shop routing and technical processing instructions for assemblies, accessories, components, end items, and/or parts. They are developed utilizing applicable DMWRS, document AEDs, program AEDs, and/or field maintenance technical manuals. They provide information on how the item being reviewed is currently processed through the depot and can be used as background material for the evaluation/development of the PSA section/chapter.

(e) Experience information -- This is information compiled for the item being reviewed from the depot process beginning with PSA if applicable, and proceeding to the prime shops. At each shop the depot personnel directly involved with the equipment are interviewed to determine weaknesses and problems with the equipment, how these weaknesses/problems can be addressed, and the high confidence items which can be short routed.

(f) RCM turbine engine data -- DERSO collects, reduces and analyzes data from all available sources relative to the operation and maintenance of turbine engines. From this data engine reliability, maintenance significant items, and failure modes can be measured and evaluated; engine component or parts with potential for improved reliability can be identified; and future engine requirements can be decided. For an engine, then, this data bank is used to assure that current maintenance tasks in the DMWR, program AEDs, and shop travelers mitigate all prevalent failure modes and, if not, to establish additional maintenance requirements in the PSA section/chapter developed in step 2.

(g) MIL-M-63041, Preparation of DMWRS — This specification contains the detail requirements on the general format and content of the DMWRs.

(h) Other data -- This includes AVSCOM memoranda on problems with certain equipment and material from previous RCM applications.

Step 2: Evaluate/Develop PSA Section/Chapter

Evaluate or develop the PSA section/chapter based on the data compiled in step 1. Major considerations in the evaluation/development of a PSA section/chapter are as follows:

(1) If minor repair is feasible, the PSA section/chapter should contain minor repair criteria as well as overhaul criteria. The PSA section/chapter should make it clear that the procuring activity will establish separate programs for minor repair and overhaul. The minor repair portion of the PSA section/chapter should address the cause for depot return and also include (where applicable) convenience maintenance where convenience maintenance involves inspection, repairs, or other preventive maintenance that is determined to be cost effective and/or significantly improves longevity, reliability and/or safety and thus is done while the item is in the depot.

(2) If minor repair is not feasible and overhaul is the only viable alternative, the PSA section/chapter should stipulate

that "minor repair is not economically feasible for this item".

(3) If limited disassembly is a viable initative during overhaul. This includes studying the primary weaknesses and strengths of the item. The strengths can provide justification for a limited disassembly approach. Any weaknesses can be addressed by convenience maintenance during minor repair or limited disassembly overhaul.

(4) A PSA checklist shall be included as a handy, streamlined list of the issues addressed in depth in the PSA section/chapter. The checklist shall not repeat any of the inspection tables that are contained in the maintenance instruction sections/chapters of the DMWR.

(5) A mandatory modification table shall be included as a handy list of the modifications that can be accomplished on the item. All of the modifications are required at overhaul; safety-driven and/or cost-effective modifications should be required at minor repair.

Step 3: Prepare Draft PSA Section/Chapter

A draft PSA section/chapter is prepared, based on the considerations evaluated and the criteria, checklist and other documentation developed during Step 2, in accordance with the format and content data requirements of MIL-M-63041. The section/chapter is tailored to the particular DMWR/Army aviation equipment item being reviewed. However, two portions, of each PSA section/chapter prepared are fairly well standardized:

(1) A purpose statement very similar to that given in MIL-M-63041 is provided as the first paragraph in the section/chapter.

(2) The PSA checklist format is standardized based on that given in MIL-M-63041.

Step 4: Estimate Man-hour/Cost Avoidance

Once the PSA section/chapter is approved by AVSCOM, estimation of the man-hour/cost avoidance resulting from RCM revision of the DMWR through the PSA section/chapter can begin. If RCM has already been applied previously, through program AED and/or shop traveler, to the fielded Army aviation equipment covered by the DMWR revised, complete data on man-hours, man-hour costs, and parts costs required for depot-level maintenance before and after RCM application probably exist and can be obtained from depot program production planning and control managers for the equipment involved. If complete data do not exist, at least data for maintenance before RCM application (i.e., complete disassembly and overhaul) are available from these managers; then, with assistance from depot production engineering personnel, the cost avoidance resulting from application of RCM can be estimated.

Step 5: Prepare Document AED

A document-type AED is prepared in accordance with Procedure No. DESG-009C as the vehicle for revising or rewriting the DMWR to incorporate the approved PSA section/chapter for release to the depot maintenance facility for implementation and to AVSCOM, St. Louis, along with a DA Form 2028 for publication change.

Step 6: Prepare Final DMWR Report

A final DMWR report on the DMWR revised using RCM principles is prepared in accordance with DARCOM-R 750-9 and submitted to the U.S. Army Materiel Command Materiel Readiness Support Activity.

APPENDIX C: DEPOT WORKLOAD REQUIREMENTS

CCAD presently performs repair, overhaul, modification, and retrofit of airframes, aircraft components, systems, subsystems and related items for the UH-1, AH-1, OH-6, OH-58 and CH-47 rotary aircraft. Future weapon systems to be supported by CCAD include the CH-47D, AH-64, OH-58D, and UH-60 rotary aircraft, selected parts of the AGT 1500 turbine shaft engine, and the landing craft, air cushion (LCAC) TF40B Marine gas turbine engine. Brief summary descriptions of these future weapon systems are given in the following paragraphs. Full plans for supporting this increase in workload at CCAD are given in the Corpus Christi Army Depot modernization plan dated 14 August 86. Table C-1 provides projected dates for the induction of the new aircraft systems at CCAD.

Table C-1 Projected Aircraft Workload Overview

AIRCRAFT ITEM			
AIRCRAFT	AIRFRAME	ENGINE	COMPONENTS
CH-47D	OCT 87 (FY 88)	OCT 83	OCT 87 (Partial) AUG 89 (Complete)
OH-58D	DEC 88 (FY 89)	DEC 88	DEC 88
UH-60A	OCT 86 (FY 87)	OCT 84	OCT 86
AH-64A	FY 90	FY 88	FY 88 (Partial) FY 90 (Complete)

<u>CH-47D Chinook Helicopter</u>: The present CH-47 fleet of A, B, and C models is being modernized to one standard configuration (CH-47D) which will facilitate logistical support and simplify maintenance support. The CH-47D Chinook, with twin-turbine T55-L-712 engines, is a tandem rotor helicopter designed for internal and external cargo transport during visual and instrument, day and night operations. Design improvements have resulted in improved reliability, availability, maintainability, and survivability. The CH-47D will provide the Army with the necessary medium lift helicopter (MLH) that can accomplish missions throughout the range of temperature/altitude combinations where United States forces can reasonably be expected to operate.

<u>OH-58D Kiowa Observation Helicopter</u>: The CH-058D uses the basic airframe of the OH-58 A-C helicopter modifications. The OH-58's include a mast-mounted sight (MMS) sub-system designed as an aerial surveillance system for day/night acquisition of enemy targets. The OH-58D performs day and night close aero-scout and field artillery aerial observer missions world-wide under a variety of environmental and threat conditions. The OH-58D will be assigned as an aero-scout helicopter for attack helicopter companies and air cavalry troops and as a field artillery aerial observation helicopter.

<u>UH-60A Black Hawk Helicopter</u>: The Black Hawk is a twin-turbine, medium speed, single main rotor configured helicopter capable of transporting cargo, 11 combat troops, and weapons during day, night, visual and instrument

conditions. The main and tail rotors are both four-bladed, with a capability of manual main rotor blade folding, tail rotor blade scissoring, and tail pylon folding. The aircraft is powered by two T700 General Electric 1543 SHP turbine engines and has a flight endurance time of 2.3 hours at 4,000 feet altitude and 95 degrees Fahrenheit. The Black Hawk will replace the UH-1 in air assault, air cavalry, and aeromedical evacuation missions. The Black Hawk was designed to transport troops and equipment into combat, resupply these troops while in combat, and perform associated functions of aeromedical evacuation, repositioning of reserves, and other combat support missions.

AH-64A Apache Helicopter: The AH-64A is a twin engine attack helicopter designed as a stable, manned aerial weapons system to deliver aerial point and area and rocket target firepower. Developed to be the most lethal and survivable helicopter in aviation history, the AH-64 will augment the combined arms team with improved folding fin 2.75 aerial rockets, 30mm cannon, and the anti-armor HELLFIRE missile. The AH-64A will perform its assigned missions by providing direct aerial fire support under day, night, and marginal weather conditions. Typical AH-64A combat missions include anti armor, air cavalry operations, and escort and fire support for airmobile operations.

Selected Parts of the AGT 1500 Turbine Shaft Engines: The M-1 Abrams tank is powered by an AGT 1500 SHP turbine engine. The depot will support the reclamation of selective parts that require special equipment and processes that are not available at other depots. The list of parts and special equipment and processes that the depot has available to support the reclamation is shown below in Table 2-2.

Table C-2 Selected Engine Parts To Be Repaired By The Depot

PART	PROCESS REQUIRED
STATOR VANE (5 low & 4 high pressure)	Electric Discharge Machining Vacuum Brazing
TURBINE WHEELS (1st thru 4th)	Plasma Spray Precision Balancing
TURBINE NOZZLES (1st, 2nd, & 4th)	Electric Discharge Machining Vacuum Brazing Plasma Spray
TURBINE SHAFT	Electron Beam Weld
BEARING HOUSINGS	Electron Beam Weld
TURBINE CYLINDER	Plasma Spray
SHROUD ASSEMBLY	Plasma Spray
BEARINGS (ALL)	Complete Bearing Rework
POWER TURBINE HOUSING ASSEMBLY	Electric Discharge Machining Vacuum Brazing Plasma Spray

Landing Craft, Air Cushion (LCAC) TF40B Marine Gas Turbine Engine: The TF40B engine, a derivative of the T55 AVCO Lycoming engine of the CH-47, powers the Naval Sea System Command's newest assault craft. The LCAC is a high-speed, over-the-beach, ship-to-shore hovercraft with capability to lift all equipment organic to the ground elements of a Marine Amphibious Force. Each LCAC is powered by four TF40B gas turbine engines. Projected fleet size by 1994 is 90 hovercraft with a total population of 360 TF40B engines plus 10% spares. The pilot overhaul program is scheduled to begin in Jun 87 with full organic depot support beginning in Jan 88.

The large increase in workload due to the new systems described above results in the need to modernize and expand the existing shops and to construct new facilities. The Black Hawk and Apache are both larger in size than the present systems being overhauled. The manufacturing shops must be able to accommodate not only the increased workload but larger airframes, engines, transmissions, rotor heads, and many other components. Increased shop space is not the only requirement for the support of these sophisticated new weapon systems. State-of-the-art equipment is required to work on the new materials used and to test the technologically advanced systems in these aircraft. It is imperative that these new systems are provisioned for in terms of depot maintenance. The airframe, engine, power train, mechanical and hydraulic components of these aircraft differ widely from the UH/AH/OH aircraft common to the CCAD depot workload. CCAD will continue to provide depot level support to its existing assigned aircraft while integrating the new systems into the depot for support.

Accordingly, DERSO must also modernize to effectively support this increased workload and to provide the required RCM data base, to analyze equipment failure modes and trends, to develop equipment preventative and corrective maintenance plans, to develop equipment overhaul and repair procedures, to evaluate modified and new equipment, to qualify new vendors, to scrub DMWRs, to evaluate airframe condition requirements and to analyze aircraft corrosion.

PROCEDURE FOR REVIEW OF ARMY AVIATION DMWRs FOR RCM PHILOSOPHY

Procedure
for
Review of Army
Aviation DMWRs
for RCM Philosophy

Prepared for
Depot Engineering and RCM Support Office, AMSAV-7
U.S. Army Aviation Systems Command
Corpus Christi Army Depot
Corpus Christi, Texas 78419-6195

Prepared by
Reliability Technology Associates
700 Ravinia place
Orland Park, IL 60462

As a Special Task under the auspices of the
Nondestructive Testing Information Analysis Center (NTIAC)
Southwest Research Institute
Post Office Drawer 28510
6220 Culebra Road
San Antonio, Texas 78284
Government Contract No. DLA900-84-C-0910

May 1986

FOREWORD

The procedure described herein was developed by Reliability Technology Associates (RTA) for the U.S. Army Aviation Systems Command (AVSCOM), Depot Engineering and RCM Support Office, as a Special Task under the auspices of the Nondestructive Testing Information Analysis Center (NTIAC) at Southwest Research Institute (SwRI), Contract No. DLA900-84-C-0910. The work involved comprises Task 1 of a multitask effort to review, and revise or rewrite as necessary, Army aviation depot maintenance work requirements (DMWRs) for reliability centered maintenance (RCM) philosophy.

At RTA Mr. Ronald T. Anderson and Dr. C. D. Henry compiled and organized the technical material and developed the procedure. At NTIAC the task was performed under the direction of Dr. George A. Matzkanin.

On the part of AVSCOM, the task was under the technical management of Mr. Lewis Neri, Chief, Depot Engineering and RCM Support Office. Mr. Robert Ladner, Chief of the Depot Engineering Support Division, guided the development of the procedure and provided the necessary Army documents and other information used as input to the procedure.

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1.0 OBJECTIVE

The objective of this document is to describe a procedure for reviewing, and revising or rewriting as necessary, existing U.S. Army aviation depot maintenance work requirements (DMWRs) in order to assure that the basic reliability centered maintenance (RCM) philosophy is incorporated into the DMWRs. This involves insuring, through the procedure, that the inherent design reliability and safety of Army aviation items are achieved with the performance of the least amount of maintenance and that overhaul is accomplished on a rational basis. The DMWRs reviewed, and revised or rewritten, by the procedure will: (1) eliminate unnecessary tasks during depot maintenance and (2) eliminate arbitrary remanufacture through the development of extended wear limits and reclamation procedures for piece parts. Following the process described in this procedure selected DMWRs will be reviewed and AVSCOM Engineering Directives (AEDs) for their revision will be prepared.

2.0 BACKGROUND

2.1 Reliability Centered Maintenance (RCM)

Reliability centered maintenance (RCM) is a precept which uses an analytical methodology or logic for influencing design maintainability and reliability and for establishing specific maintenance tasks for material systems or equipment.

RCM is based on the premise that more efficient and cost-effective life-time maintenance programs can be developed using a well disciplined decision logic which focuses on the consequences of failure. A computer-aided decision logic question sequence is applied to those parts that are maintenance and structurally significant in a particular end item, i.e., engine, transmission, rotor system, control system, airframe, etc. Each significant component failure mode is evaluated to identify maintenance tasks. The logic process forces maintenance tasks to be classified into three areas: (1) Hard Time Maintenance for those failure modes that require scheduled maintenance at predetermined fixed intervals of age or usage; (2) On-Condition Maintenance (OCM) for those failure modes that require scheduled inspections or tests designed to measure deterioration of an item so that, based on the deterioration of the item, either corrective maintenance can be performed or the item can remain in service; and (3) Condition Monitoring for those failure modes that require unscheduled tests or inspection on components where failure can be tolerated during operation of the system or where impending failure can be detected through routine monitoring during normal operations.

Further information on RCM is given in a report prepared by Reliability Technology Associates for AVSCOM: "Automated Army Aircraft RCM Analysis", September 1984.

2.2 The Depot Maintenance Process

Figure 2-1 illustrates the depot maintenance process as performed at the Corpus Christi Army Depot (CCAD) and, in general, for Army aviation equipment. As shown in the figure, all aviation equipment items are grouped into three main categories upon induction into a depot:

(1) Category I: Aircraft - This category encompasses the total aircraft; for example, the airframe, electrical wiring, seats, transparencies, push-pull systems and doors.

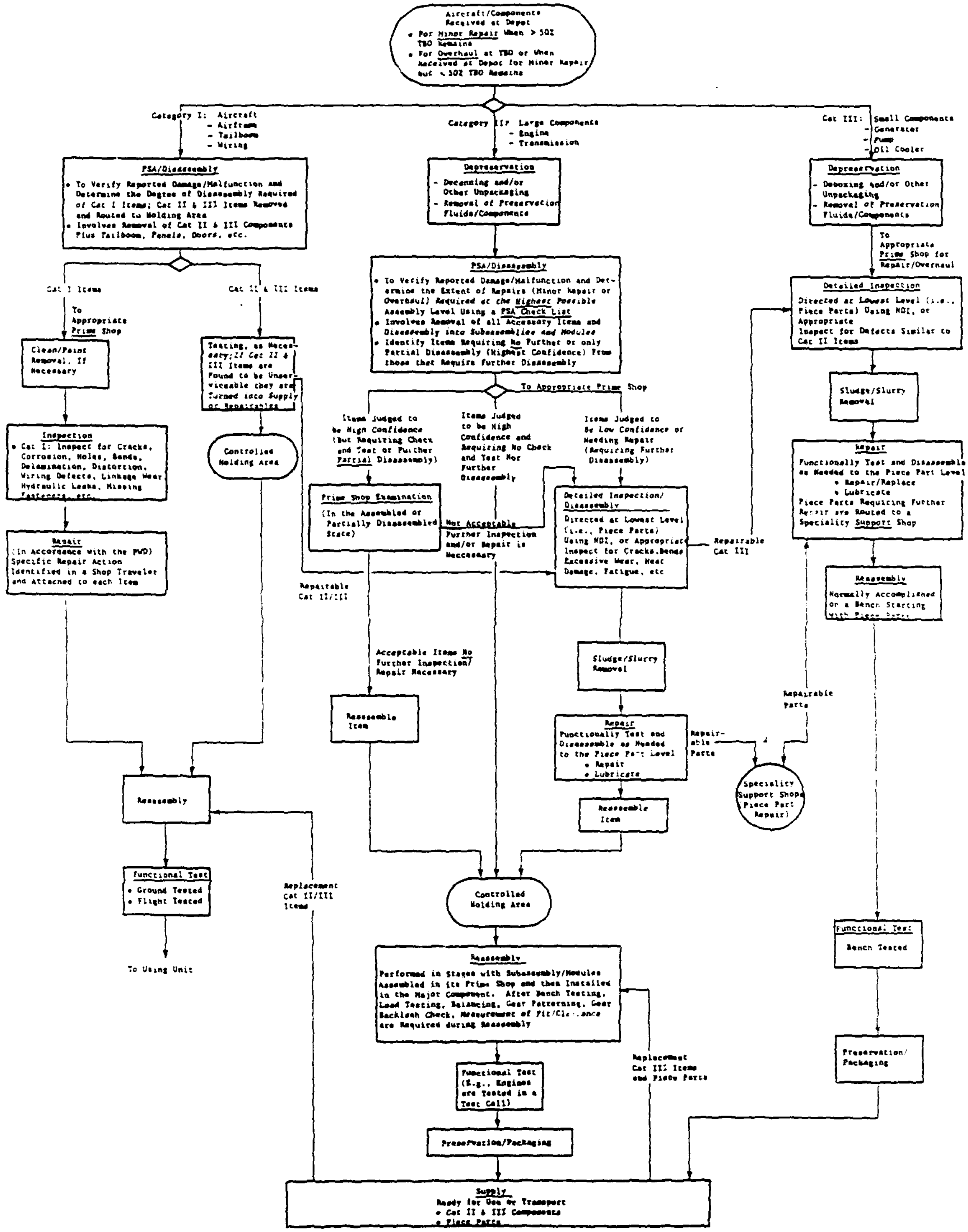


Figure 2-1 Depot Maintenance Process

(2) Category II: Large Components - This category encompasses large components and major assemblies; for example, engines and transmissions.

(3) Category III: Small Components - This category encompasses small components and accessories; for example, generators, hydraulic pumps and oil coolers.

2.2.1 Scope of Work

Although overhaul is the major part of the rework performed at the depot, not all of the items processed at the depot receive a complete overhaul. An aircraft sent to the depot for a paint job, a transmission sent to the depot to replace an unreliable bearing or gear, and an engine sent to the depot to correct a seal leak are examples of cases where the project work directive, or contract, will stipulate the scope of work and identify the appropriate depot maintenance work requirement (DMWR) as the technical data source to perform the repair task(s).

An aircraft sent to the depot for repair normally contains serviceable components (for example, engine, transmission, and gearbox) which are removed only to allow access for repair of the basic airframe and are subsequently reinstalled. If a discrepant component is discovered during assembly or functional testing and the discrepancy cannot be corrected with field level repairs, the component is turned into supply and a serviceable component issued.

Engines returned to depot for overhaul normally contain serviceable accessories (for example, fuel control, overspeed governor, and igniter unit) which are functionally tested (bench tested) and are subsequently reinstalled on the engines. Accessories which do not meet the functional test requirements and cannot be corrected by minor repairs are either turned into supply as "repairables" or inducted into a component repair/overhaul program. Some components require upgrading to a later configuration and are automatically inducted for repair. The engine DMWR normally provides the functional test criteria along with adjustment or trim criteria (where applicable). For minor repair, overhaul, or modification, the component DMWR is consulted.

When a complex unit becomes defective in the field, and is beyond field repair capability, it is often more cost effective to minor repair rather than overhaul the item when received in the depot. A minor repair consists of the minimum maintenance necessary to correct the specific discrepancy that caused the item to be returned to the depot along with other applicable tasks associated with reassembly, testing, and preservation. The minor repair changes the status of the unit from repairable to serviceable but does not increase its potential longevity. The determination to minor repair or overhaul is made after the item is inducted into the maintenance shops and undergoes a preshop analysis (PSA). The decision logic for making such a determination is based on fleet readiness and cost effectiveness.

Figure 2-2 illustrates a longevity curve which depicts wear/degradation behavior with respect to time. The slope of the curve during wear-in and wear-out varies from item to item as does the length and slope of the stable wear life part of the curve. A discrepancy changes an item's status from serviceable to repairable and acts as a roadblock in preventing the item from progressing down its longevity curve. When the discrepancy arises, usually either overhaul or minor repair is performed. Overhaul is performed to recover used-up wear life; the longevity of an overhauled item approximates that of a new item. A minor repair removes the roadblock and allows the unit to progress; it does not recoup any of the used up wear life and therefore does not change the item's position on the longevity curve. If rebuild is performed, the item is new and is returned to the starting point of the longevity curve.

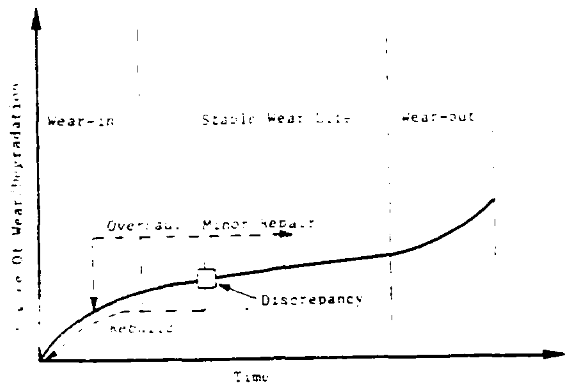


Figure 2-2 Impact Of Repair On Potential Longevity

2.2.1.1 Depot Maintenance Work Requirement (DMWR)

A DMWR is a comprehensive document which defines the minimum procedures and standards required to process a component or end item through the depot. It is normally provided as the "Statement of Work" for each item contracted or programmed for depot level maintenance. It is a "how to do" type of document which provides the necessary instructions for the complete overhaul of the item, including conversion/modification criteria and piece-part reclamation procedures for the worse case condition of applicable parts.

The DMWR is the result of an intensive effort to determine the maintenance processes required to achieve serviceability standards and incorporate those processes into a usable document. That resultant document should be constructed in a manner which will enable it to be utilized by those elements responsible for producing a quality product that meets the serviceability requirements. The effectiveness of the DMWR will result in minimizing resource and materiel expenditures required to restore and retain reliability and safety of the equipment.

DMWRs are supplemented in the depot by AVSCOM Engineering Directives (AEDs) where an AED addresses a specific problem in a DMWR and can also be used to support depot programs independent of DMWRs. AEDs also serve as an aid in updating DMWRs.

2.2.1.2 Shop Traveler

To make use of a DMWR in a practical manner, a specific item repair task to be performed during the depot process is converted into a "shop traveler." The shop traveler is attached to the item and delineates the steps taken to perform the repair action (as stated per the applicable DMWR).

2.2.2 Depreservation

Depreservation is the initial task to be performed in the depot process.

Basically, the task is to remove the item from its incoming packaged state.

- Category I - Aircraft that are flown in do not require any depreservation. Aircraft within the continental United State (CONUS) are usually transported to the depot by truck and only Category II items may require decanning or deboxing. Items such as a tail boom or the basic airframe (i.e. the aircraft without any Category II or III items) require deboxing. Aircraft transported to the depot via ship may require removal of preservation compounds.

- Category II - Requires decanning and/or other unpackaging. Any preservation fluids/compounds also need to be removed (for example, oil and grease).

- Category III - Requires deboxing and/or other unpackaging. Any preservation fluids/compounds also need to be removed (for example, oil and grease).

2.2.3 Preshop Analysis/Disassembly

Preshop analysis (PSA) is a logical inspection process that is done in conjunction with equipment disassembly. Components are disassembled to the subassembly level with a PSA team focusing on the reason(s) why the item was sent to the depot and on component operating times. PSA specifies the extent of further disassembly and repair needed to be performed at the appropriate prime shop(s) and determines if component "short routing" can occur, i.e. if components can be sent directly to the control holding area or assembly lines. Defined weak spots within a component must be accessed to inspect for specified historically common deficiencies.

- Category I - PSA is conducted to determine the degree of disassembly required. This includes removal of all Category II and III items, tailboom, appropriate panels, and doors. After the aircraft is disassembled and PSA is completed, the airframe and airframe components (for example, tailboom, skids, panels, and doors) are routed to their appropriate prime shop. The Category II and III items are not repaired; these items are routed into a holding area or subjected to preservation and storage. If Category II and/or III items are found to be unserviceable during aircraft reassembly, they are turned into supply as repairables. These Category II and III items identified as repairables are then scheduled by for maintenance.

- Category II - PSA is conducted while removing all accessory items and disassembling the basic component into subassemblies/modules. PSA identifies the high confidence subassemblies/modules that can complete processing without further disassembly or with only partial disassembly.
The accessory items are forwarded to their respective prime shop for check and test. Only minor repairs are allowed to address deficiencies; otherwise the assemblies are turned into supply as repairables and scheduled for maintenance.
The subassemblies/modules of the basic component are forwarded to their respective prime shops for disassembly and processing. The high confidence subassemblies/modules

receive a more thorough examination in the assembled or partially disassembled state in the prime shop. Based on findings, the prime shop can override the PSA judgment and completely disassemble the subassembly/module for further inspection and/or repair.

- Category III - There is no advantage to a PSA since, in any case, complete disassembly is required. These components are normally inducted into their respective prime shops where they are completely repaired/overhauled. Only those piece-parts requiring further repair (for example, machining, plating, or welding) are routed from the prime shop to a specialty shop.

2.2.4 Cleaning/Paint Removal

Cleaning and paint removal tasks are performed only if necessary to facilitate inspection and/or repair.

- Category I - Normally the most needful of paint removal. This is performed using paint remover (Federal Specification TT-R0246), vapor blasting (for example, glass bead, light abrasive, or plastic media), or hot-alkali soak.

- Category II - Requires the removal of sludge and/or slurry. This is performed by masking all component openings to prevent clogging by deposits and then utilizing one of the following processes: solvent immersion, dry-cleaning solvent, vapor blasting (care must be taken to prevent wearing away of metal), hot-alkali soak, or periodic-reverse cleaning.

- Category III - Addressed the same as Category II components.

2.2.5 Inspection

Detailed inspection of components is performed at the prime shop. Inspection is directed at piece parts and utilizes nondestructive inspection (NDI) techniques, as appropriate.

- Category I - Inspection for cracks, corrosion, holes, bends, delamination, distortion, wiring defects, linkage wear, hydraulic leaks, missing fasteners, etc.

- Category II - Inspection for cracks, bends, excessive wear, heat damage, fatique, etc. An engine, for example, requires turbine blade inspection for deterioration and balancing flaws.

- Category III - Inspection for defects similar to Category II items. A fuel control, for example, requires control linkage inspection for excessive wear and damage.

2.2.6 Repair Task

The basic repair task for Category I, II, and III items is performed at the applicable prime shop. Items received at the prime shop are usually in the form of accessory or module/subassembly items. The project work directive identifies the repair needed and identifies the applicable DMWR to be used. Normally, the specific repair action needed is identified in the form of a "shop traveler" and attached to the item.

The prime shop functionally tests the item and then performs disassembly, as needed, to the piece-part level. At this point a piece-part may be sent to a support shop for a specific specialized repair action.

2.2.7 Reassembly

Reassembly of components is performed relative to instructions provided within the applicable DMWR. At this point, smaller components are functionally tested.

- Category I - The airframe is riveted together and painted. All Category II and III components, including transparencies, seats, doors, and wiring, are installed.

- Category II - Final assembly is normally performed in stages with each subassembly/module being assembled in its respective prime shop and then installed in the basic component. Subassemblies/modules often require bench testing, load testing, balancing, gear patterning, gear backlash check, measurement of fit/clearance/alignment, etc., upon assembly and/or during installation into basic component final assembly.

- Category III - Final assembly is normally accomplished on a given bench, starting with piece-parts.

2.2.8 Functional Test

A functional test is applicable to not only the aircraft's systems, but to almost all aircraft components and component accessories. This consists of subjecting the item in question to a series of tests to verify conformity to required operational specifications.

- Category I - Upon complete assemblement, the aircraft is subjected to ground testing and any needed adjustments are made. The aircraft is then flight tested.

- Category II - Engines, transmissions, gearboxes, etc., are functionally tested in a test cell. Aside from the various parameters that are measured during instrumentation testing, the test operator is sensitive to noticeable oil leaks, air leaks, abnormal sounds, etc. Some transmissions and gear boxes require partial disassembly to check pinion gear tooth patterns before completing the functional test. Some accessory items, such as engine fuel controls, are adjusted to achieve compatability with the engine during engine testing.

- Category III - Components are bench tested and adjusted to achieve performance requirements.

2.2.9 Preservation/Packaging

Preservation and packaging tasks complete the depot repair process. Preservation prepares the item to withstand effects of decomposition caused primarily by moisture and is especially applicable to items remaining at the depot under storage conditions. Decomposition does not occur in a clean atmosphere when moisture is not permitted to reach the item's surface. Packaging prepares the item for travel as well as to inhibit decomposition effects. The selection of packaging techniques depends on such factors as: susceptibility of the item to damage, normal hazards to which the item will be exposed, the length of time the item must remain in the package, and the promotional role of the package.

- Category I - Aircraft that are to be flown from the depot to the using unit require no preservation. Aircraft that are to be airlifted outside the continental United States (CCONUS) via C-141 or C-5A are palletized. For example, for the UH-1 and AH-1 this involves removal of the main rotor blades, the rotor head and mast, and the tailboom. The main rotor blades, along with the UH-1 rotor head and mast, are installed in a holding fixture and attached to a pallet beneath the aircraft. The rotor head and mast for the AH-1 are fixtured to a pallet and placed inside the UH-1. The tailboom is installed in a fixture (vertical fin down) and attached to the side of the aircraft.

- Category II - Some components and component accessories require special preservation that can be accomplished immediately after functional test. For example, after checking pinion gear tooth pattern on a gear box, MIL-L-8188 corrosion resistant oil is used in the gearbox for the remainder (i.e., a short time period) of the functional testing. Also, the T-53 engine fuel control is drained of fuel at the end of functional testing and is filled with 10 weight oil.
  Basic components, such as an engine or gearbox, are installed in reusable metal transport/storage containers. Most of these containers are sealed air tight and contain bags of desiccant which absorb moisture from enclosed air. For example, the T-53 engine is enclosed in an air tight ziplock bag, with desiccant located inside the bag, and then placed in vented metal transport/storage containers.

- Category III - Components are preserved with an oil film and/or other compounds, possibly bagged, and boxed for transport.

3.0 RCM DMWR REVIEW PROCEDURE

The RCM DMWR review procedure is shown in Figure 3-1.

3.1 Step 1: Compile Data

3.1.1 Current DMWRs

The DMWRs to which the procedure is to be applied are listed in Table 3-1

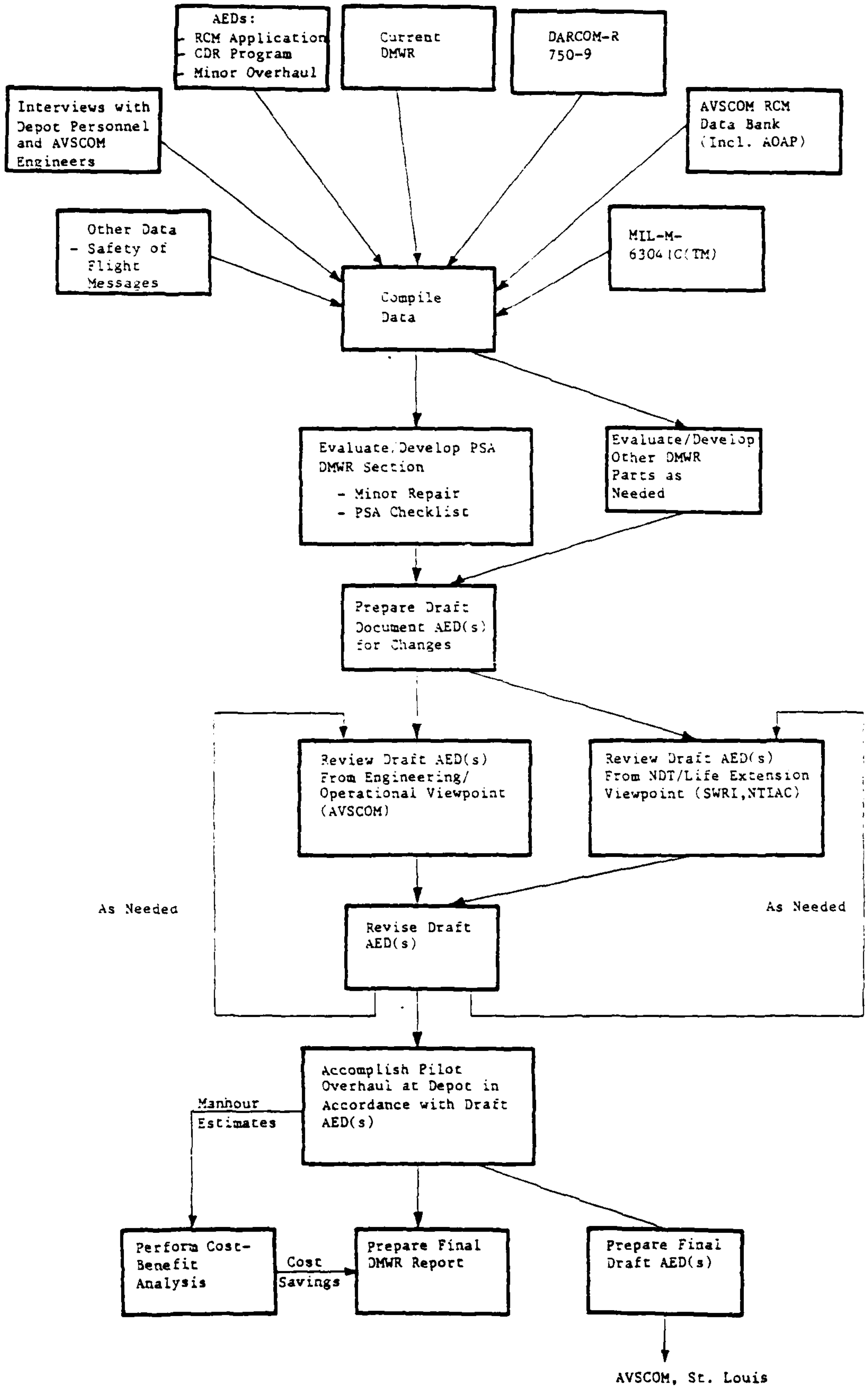


Figure 3-1 RCM DMWR Review Procedure

Table 3-1

DMWRs To Be Reviewed

1. T53-L-13B/T53-L-703/T53-L-701A Engines (DMWR 55-2840-113)
2. T55-L-712 Engine (DMWR 55-2840-254)
3. T63-A-700 Engine (DMWR 55-2840-231)
4. T63-A-720 Engine (DMWR 55-2840-242)
5. Power Turbine Governor Model AL-L3 (DMWR 55-2915-149)
6. UH-1/AH-1G Main Transmission (DMWR 55-1615-156)
7. AH-1S Main Transmission (DMWR 55-1615-275)
8. OH-58 A/C Main Transmission (DMWR 55-1560-157)
9. CH-47C Forward Transmission (DMWR 55-1615-117)
10. CH-47 Aft Transmission (DMWR 55-1615-116)
11. CH-47 Combining Transmission (DMWR 55-1615-152)
12. CH-47 Engine Transmission (DMWR 55-1615-153)
13. UH-1 Ninety Degree Gear Box (DMWR 55-1560-127)
14. AH-1S Ninety Degree Gear Box (DMWR 55-1615-277)
15. AH-1G 90 Degree Gear Box (DMWR 55-1615-125)
16. OH-58 A/C Tail Rotor Gearbox (DMWR 55-1615-159)
17. UH-1 Main Rotor Hub (DMWR 55-1615-102)
18. OH-58 Main Rotor Hub (DMWR 55-1615-158)
19. CH-47 Rotary-wing Head Assembly (DMWR 55-1615-112)
20. AH-1 Main Rotor Hub (DMWR 55-1560-196)
21. CH-47 Controllable Swashplate (DMWR 55-1615-114)
22. OH-58 Tail Rotor Blade/Tail Rotor Hub (DMWR 55-1615-162)
23. CH-47 Aft Rotary-wing Drive Shaft (DMWR 55-1615-113)
24. AH-1S Servo Cylinder (DMWR 55-1650-322)
25. CH-47 Electromechanical Linear Actuator (DMWR 55-1680-289)
26. CH-47 Electromechanical Linear Actuator (DMWR 55-1680-266)
27. OH-58A Gas Turbine Fuel Control (DMWR 55-2915-148)
28. UH-1 Centrifugal Fuel Booster Pump (DMWR 55-2915-284)
29. U-21 Propeller Governor (DMWR 55-1610-222)
30. OV-1 Pressure Demand Oxygen Regulator (DMWR 55-1660-113)
31. UH-1 Valve Assembly (DMWR 55-1615-150)
32. OH-58A Fuel Pump and Filter (DMWR 55-2915-147)
33. CH-47 Flight Hydro System (DMWR 55-1650-291)
34. CH-47 Hydraulic Starter (DMWR 55-2995-107)
35. AH-1 C/S Electro-hydraulic Servo-actuator (DMWR 55-1650-160)
36. OH-58 DC Starter-Generator (DMWR 55-2925-245)
37. Army Model OH-58A Helicopter (DMWR 55-1520-228)
38. AH-1S Helicopter (Modified) (DMWR 55-1520-234)
39. U-21 Propeller (DMWR 55-1610-219)
40. T74 CP700 Engine (DMWR 55-2840-120)

in the order in which they are to be done. In each case the latest changed version of the DMWR will be used as the baseline for the review.

3.1.2 Military Specification MIL-M-63041: Preparation of Depot Maintenance Work Requirements

This specification contains the detail requirements for preparing DMWRs. The version MIL-M-63041C(TM), dated 1 October 1984, is used.

3.1.3 DARCOM Regulation No. 750-9: Reliability Centered Maintenance - Application to Depot Maintenance Work Requirements

This regulation defines the basic philosophy of RCM as it relates to depot-level maintenance and directs that DMWRs be developed in terms of RCM philosophy and that DMWRs be reviewed and revised or rewritten as necessary to incorporate the RCM philosophy.

3.1.4 Interviews

The equipment to which the DMWRs to be reviewed apply will be followed through the depot process by experienced RTA engineers, starting with preshop analysis, if applicable, and proceeding to the prime shops. At each step the depot personnel directly involved with the equipment will be interviewed to determine weaknesses and problems with the equipment, how these weaknesses/problems can be addressed, and the high confidence items which can be short routed. This will involve, as a minimum, witnessing the disassembly of the equipment.

In addition the cognizant engineers in the AVSCOM Depot Engineering and RCM Office for each piece of equipment will be interviewed to obtain their expertise.

3.1.5 AVSCOM Engineering Directives (AEDs)

Certain AEDs deal with concepts and procedures for processing and managing equipment through the depot process. These include AEDs on RCM application to T53 engines and to transmissions and gearboxes, AEDs on complete depot repair (CDR) programs for engines, and AEDs for the minor repair of engines. These will serve as background material for the PSA sections of the DMWRs reviewed.

3.1.6 AVSCOM RCM Data Bank

The AVSCOM Technical Analysis Branch collects, reduces and analyzes data from all available sources relative to the operation and maintenance of turbine engines. From this data U.S. Army turbine engine reliability, maintenance significant items, and failure modes can be measured and evaluated; engine components or parts with potential for improved reliability can be identified; and future engine requirements can be decided. For engine DMWRs, then, this data bank can be used to assure that current maintenance tasks in the DMWR mitigate all prevalent failure modes and, if not, to establish additional corrective maintenance requirements in subassemblies or components of engines.

3.1.7 Other Data

Other data for the RCM DMWR review include AVSCOM memoranda on problems with certain equipment and corrective actions from safety of flight messages.

3.2 Step 2: Evaluate/Develop PSA Section/Other DMWR Parts

The main objective of the RCM DMWR review program is to incorporate preshop analysis (PSA) as an integral part of the entire maintenance process to identify existent failure(s) through the use of available data, test, and inspection. Through PSA an evaluation of these elements is conducted to determine the condition of an item prior to performing corrective maintenance to return the item to a serveable condition. Tests, inspections, experience, and historical data, then, are used to determine overhaul procedures with the least maintenance processes.

PSA is applied at the subassembly or component level to facilitate the maintenance process and maintain the reliability of the item. Preshop analysis utilizes visual inspection, diagnostic testing, nondestructive testing, dimensional inspection, and other methods in conjunction with experience and historical data in the evaluation process. Preshop analysis using inspections as well as diagnostic test is performed at the highest possible level of assembly to prevent unnecessary disassembly.

With use of the data compiled in Step 1, then, each DMWR will be reviewed, and revised or rewritten as necessary, through accomplishment of the tasks listed in Figure 3-2 for the three categories of equipment.

The PSA DMWR section will, in general, comprise Chapter 3 of the DMWR and will have the general format and content shown in Figure 3-3.

3.3 Step 3: Prepare Draft Document AED(s)

Document-type AVSCOM Engineering Directives (AEDs) will be the vehicles for revising or rewriting a DMWR to incorporate the PSA section, and other DMWR parts, developed in Step 2. These will be prepared in accordance with Procedure No. DESS-009C.

3.4 Step 4: Review Draft AED(s)

The draft AED(s) will be submitted to the AVSCOM Depot Engineering and RCM Support Office for review from an engineering and operational viewpoint. They will be submitted to the Nondestructive Testing Information Analysis Center at Southwest Research Institute for review from the standpoint of (1) optimizing the utilization of visual inspection, diagnostic testing, nondestructive testing, dimensional inspection, and other methods, particularly as they would apply to preshop analysis, and (2) analysis and evaluation of remaining life and life extension criteria and methodology.

The draft AED(s) will be revised and reviewed as necessary.

3.5 Step 5: Accomplish Pilot Overhaul

Action will be initiated to accomplish a pilot overhaul in accordance with the draft AED(s). The pilot overhaul will be monitored, problems will be resolved, and changes will be authorized during the pilot overhaul as appropriate.

3.6 Step 6: Prepare Final Draft AED(s) and Final DMWR Report

The AED(s) will be revised, as necessary, based on results of the pilot overhaul, and submitted to AVSCOM for the updating of the DMWR.

A final summary report for each DMWR, identified to DMWR number, NSN,

I. AIRCRAFT:

A. Preshop Analysis (PSA): If a PSA exists, it will be evaluated; if it doesn't exist, it will be developed. The DMWR PSA which results will provide guidelines to the depot for examining the basic airframe and identifying the extent of repairs required. Initiatives will include:

1. Determining which panels and other structure require arbitrary removal from the airframe and which are removed only for cause.
2. Identifying specific structural weak points that must be addressed at every overhaul.
3. Determining which aircraft require alignment check at every overhaul and, if not, when an airframe alignment fixture is required.
4. Reviewing the overhaul process to determine what other tasks can be eliminated, streamlined, or accomplished only for cause.
5. Determining the extent of repair for the tailboom.
6. Providing guidance for using visual examination in lieu of NDT (where possible) for detecting cracks in piece parts.

B. The accessories/components which require functional test or special inspection will be determined.

C. The aircraft's characteristics weaknesses which must be addressed at overhaul (convenience maintenance) will be identified.

II. MAJOR COMPONENTS (ENGINES, TRANSMISSIONS, ETC.):

A. Preshop Analysis (PSA): The PSA will establish a limited disassembly concept which will feature:

1. Short routing of the high confidence assemblies by establishing hard time between complete disassemblies for each major assembly or subassembly.
2. Identifying inherent weaknesses which must be addressed at each overhaul (convenience maintenance).
3. Identifying bearings which require disassembly and inspection in clean room environment.

B. Guidance for using visual examination in lieu of NDT (where possible) for detecting cracks in piece parts will be provided.

C. Piece parts which should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together will be identified.

D. The DMWR will provide for check and test of the major component's accessories and the performance of minor repair as necessary.

E. The overhaul process will be reviewed to determine what other tasks can be eliminated, streamlined, or accomplished only for cause.

III. SMALL COMPONENTS:

Since these components are disassembled, on a workbench, directly into their integral piece parts, there are usually not subassemblies, or subassemblies are bonded together and further disassembly is impractical. Although limited disassembly is <u>not</u> a viable initiative on small components, a PSA will be developed to address:

A. Inherent weaknesess of the component which requires emphasis at each overhaul.

B. Guidance in determining when and which parts require NDT.

C. Which parts should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together.

D. Which bearings requiring disassembled/inspected in a clean room environment.

Figure 3-2 RCM DMWR Review Tasks

CHAPTER 3 - PRESHOP ANALYSIS

3.1 Section I - Purpose, Test and Analysis Standards

3.1.1 Purpose. This paragraph will state something similar to the following: "The purpose of preshop analysis is to determine, at the highest assembly level possible, the work required to return the item to a serviceable condition as specified herein. If inspection at the highest level of assembly is precluded by missing, damaged or diagnosed defective assemblies, consideration will be given to techniques that would allow continued inspection at that level. If this is not possible, inspection will proceed at the next lower level. A preshop analysis checklist (see 3.2) will be used to record the results of the analysis and any required maintenance."

3.1.2 General Instruction. General instructions for inspection of forms, removal of end item, assembly, subassembly or component from shipping container, external inspection, cleaning, temporary preservation, special handling or decontamination procedures, modifications, and testing will be contained in the following paragraphs:

3.1.2.1 Inspection of Forms. Instructions to check all tags and forms attached to the end item, assembly, subassembly or component to determine the reason for removal from service, other discrepancies, and accumulated operating time will be covered. This will include instructions not to remove the tags and forms. If any tags or forms are missing, instructions for obtaining the information they contain will be placed here.

3.1.2.2 Removal of End Item, Assembly, Subassembly or Component from Shipping Container, Package or Storage. Instruction for removal from shipping container, package or storage and electrostatic discharge control measures will be covered.

3.1.2.3 External Inspection. Instructions for external inspection of the end item, assembly, subassembly or component will be included to determine completeness of end item, assembly, subassembly or component, evidence of damage, and remaining life.

3.1.2.4 Cleaning. Instructions for cleaning of the end item, assembly, subassembly or component for inspection will be covered.

3.1.2.5 Test. This paragraph will contain instructions for preshop analysis tests which include verifying tests to confirm damage/malfunction report/historical record/remaining life/data (unless damage malfunction is obvious), nondestructive or operational check/performance functional tests and troubleshooting/fault isolation procedures to support testing.

3.1.2.6 Temporary Preservation/Protection. Instructions for temporary preservation/protection of the end item, assembly, subassembly, or component pending performance of maintenance required will be contained or referenced herein.

3.1.2.7 Special Handling or Condemnation Procedures. Instructions for special handling or condemnation procedures for such reasons as precious metal content, high dollar value, critical or hazardous material will be covered. Any pertinent available documents on handling or condemnation will be referenced.

3.1.2.8 Analysis Maintenance Actions. This paragraph will contain general standards for analysis to determine maintenance actions which are based on results of the preshop analysis. This paragraph may be combined with the test Paragraph 3.1.2.5.

3.2 Section II - Preshop Analysis Checklist (see Figure 3-4.)

A preshop analysis checklist will be prepared, in working sequence, and contain visual external inspections, tests and analysis maintenance actions required of the end item/assembly/subassembly or component at the highest level of assembly. The checklist will be used to evaluate the end item, assembly, subassembly or component to determine the extent of overhaul operations required to make the end item, assembly, subassembly or component completely serviceable as specified in the DMWR. Complex end items may require removal of assemblies (powerplant/engine and transmission, etc.) for preshop analysis in accordance with the applicable publication which will be listed under the recommended maintenance action column of the PSA checklist. Detailed test procedures or reference to the final test procedures, which include verifying test to confirm damage/malfunction, report/historical record/data (unless damage/malfunction is obvious), nondestructive or operational/flight test/performance test (with AOAP sampling and troubleshooting/fault isolation), will be listed on the PSA checklist.

Figure 3-3 PSA DMWR Section Format and Content

Table 3-1. Preshop Analysis Checklist - Engine

Inspection/Test	Para Ref	Condition/Dimensions Found	Recommended Maintenance Action	Signature and Date of Person Performing Analysis
<-(Typed in by preparing--> activity)		<--(Written in by person performing --> analysis)		
Review of records and data	3-14	Oil is contaminated	Change oil per para 4-13	John Doe 4/18/84

Sheet___ of ___

Figure 3-4 Sample Preshop Analysis Checklist nomenclature, and model, will be submitted giving background information; program objectives; number of additions/deletions to the DMWR; pertinent assumptions and methods used to make the change, including a summary of depot personnel/AVSCOM engineer interview data and, for engines, AVSCOM RCM data; pertinent comments; discussion; and conclusions, as well as the total cost of the review/revision/change for that DMWR, including technical reviews, editorial reviews, and other required efforts. Also included will be information on manhour savings, manhour cost savings, material cost savings, and the net cost savings, all per unit, as a result of the RCM revision of the DMWR.

APPLICATION OF RELIABILITY CENTERED MAINTENANCE TO DEPOT MAINTENANCE WORK REQUIREMENTS

APPLICATION
OF
RELIABILITY CENTERED MAINTENANCE
TO
DEPOT MAINTENANCE WORK REQUIREMENTS

Background, Assumptions, and Methods
for Application to Army Aviation DMWRs

Submitted to
U.S. Army Materiel Command
Materiel Readiness Support Activity

Submitted by
U.S. Army Aviation Systems Command
Depot Engineering and RCM Support Office
Depot Engineering Support Division

September 1987

1.0 OBJECTIVE

The objective of this document is to describe the background, assumptions, and methods used to review, and to revise or rewrite as necessary, existing U.S. Army aviation depot maintenance work requirements (DMWRs) in order to assure that basic reliability centered maintenance (RCM) philosophy is incorporated into the DMWRs. This effort was carried out in accordance with the direction given in Army Materiel Command (AMC) Regulation No. 750-9 dated 31 August 1983 and is part of the response of the U.S. Army Aviation Systems Command (AVSCOM) to the Department of the Army mandate to implement RCM concepts and principles on weapon systems.

2.0 BACKGROUND

2.1 Reliability Centered Maintenance (RCM)

Reliability centered maintenance (RCM) is a systematic, disciplined methodology used to identify maintenance needed to ensure restoration and preservation of the inherent design reliability, safety, and mission accomplishment of equipment at a minimum expenditure of resources and to prevent indiscriminate maintenance which is not cost effective.

The overall objective of RCM for a materiel system is to arrive at that precise amount of maintenance which is essential for restoring and preserving inherent system reliability, meeting safety standards, and minimizing the likelihood of mission abort.

RCM is based upon the premise that maintenance cannot improve upon the safety or reliability inherent in the design of the hardware. Good maintenance can only preserve these characteristics. The RCM concept evaluates maintenance based on equipment functions and failure modes.

RCM divides the total maintenance spectrum into three categories of maintenance:

(1) Hard Time Limit Maintenance consists of that maintenance that is performed at a predetermined, fixed interval because of age or usage such as operating time or flying hours.

(2) On-Condition Maintenance (OCM) is performed, or an item is replaced, based upon an inspection and evaluation of the item. On-condition evaluation and inspection are performed for either of two reasons:
   - (a) To anticipate failure by detection of deterioration and thereby attempt to prevent the occurrence of failure during operation, or
   - (b) To determine the occurrence of hidden failures; i.e., failures that are not detectable by the operator/crew during normal operation

(3) Condition Monitoring of equipment is carried out during normal operation or startup procedures without detracting from actual operation. The operator/crew is directed to monitor for specific abnormal conditions. The condition monitored item may normally be corrected by the operator/crew or be operated for the duration of the mission without any adverse effects. It is performed for either of two reasons:
   - (a) To observe a deteriorated condition which will lead to failure if uncorrected, or
   - (b) To observe the occurrence of failure during operation.

RCM does the following:

(1) Identifies (using data from system safety and reliability programs) components in a system which are critical in terms of mission accomplishment and operating safety,
(2) Determines the feasibility and desirability of maintenance,
(3) Highlights maintenance problem areas for consideration, and
(4) Provides supporting justification for maintenance.

The RCM philosophy dictates that maintenance should be performed on critical components only when it will prevent a decrease in reliability and/or deterioration of safety to unacceptable levels or when it will reduce the life- cycle cost of ownership of the system or equipment. Maintenance should be performed on noncritical components only when it will reduce the life-cycle cost of ownership of the system or equipment.

As it relates to depot-level maintenance, RCM provides a methodology so that depot maintenance is accomplished on a rational basis. An RCM process at the depot level first identifies existent failure(s) through use of available data, test, and inspections. An evaluation of these elements is conducted to determine the condition of an item prior to performing maintenance to return the item to a serviceable condition.

Tests, inspections, experience, and historical data are used to the extent practical for each unique item of equipment to determine depot maintenance procedures with the least processes. Particular attention is paid to the following areas:

(1) The Army Oil Analysis Program (AOAP), as prescribed in AR 750-22, is used as applicable to identify maintenance requirements in subassemblies or components.
(2) Preshop analysis (PSA) is incorporated as a integral part of the entire maintenance process. Preshop analysis using inspection as well as diagnostic test is performed at the highest possible level of assembly to prevent unnecessary disassembly.
(3) Wear tolerances are reviewed to allow maximum use of parts within safety and reliability parameters. Tolerances that are primarily for manufacturing purposes are not required checks unless specifically required for reliability or safety.
(4) Dignostic tests are reviewed for general application and for maximum allowable variation while retaining safety and reliability. Tests are used to determine the extent of depot maintenance, not to confirm design parameters.
(5) Economic considerations and trade-offs are balanced against reliability and safety requirements. If limited disassembly is required to determine condition and repairs required, any parts or assemblies easily accessible because of this disassembly are considered for repair or replacement based on condition, reliability, age-usage relationship and economics.
(6) Disassembly and replacement solely for cosmetic purposes are avoided.
(7) The benefits of refinishing end items and assemblies are weighed against the consequences of touch up only.
(8) Component repair or replacement is justified by statistically sound test or field data. Repair or replacement of an item is correlated closely between reliability and age or usage.

2.2 The Depot Maintenance Process

Figure 2-1 illustrates the depot maintenance process as performed at Corpus Christi Army Depot (CCAD) and, in general, for Army aviation equipment. As shown in the figure, all aviation equipment items are grouped into three categories upon induction into a depot:

(1) Category I: Aircraft - This category encompasses the total aircraft; for example, the airframe, electrical wiring, seats, transparencies, push-pull systems and doors.

(2) Category II: Large Components - This category encompasses large components and major assemblies; for example, engines and transmissions.

(3) Category III: Small Components - This category encompasses small components and accessories; for example, generators, hydraulic pumps and oil coolers.

2.2.1 Depot Maintenance Work Requirement (DMWR)

A DMWR is a comprehensive document which contains complete overhaul criteria, identifies minimum acceptable standards and (where applicable) provides preshop analysis guidelines for determining the extent of repair required. It is normally provided as the "Statement of Work" for each item contracted or programmed for depot level maintenance. It is a "how to do" type of document which provides the necessary instructions for the complete overhaul of the item, including modification of parts, subassemblies, and assemblies and/or parts, subassemblies, and assemblies required to convert to latest item configuration as specified in depot program notices.

The DMWR is the result of an intensive effort to determine the processes required to achieve maintenance standards and incorporate those processes into a usable document as described in MIL-M-63041. That resultant document should be constructed in a manner which will enable it to be utilized by those elements responsible for producing a quality product that meets the serviceability requirements. The effectiveness of the DMWR will result in minimizing resource and materiel expenditures required to restore and retain reliability and safety of the equipment.

DMWRs are supplemented in the depot by AVSCOM Engineering Directives (AEDs). AEDs address specific problems in a DMWR and serve as an aid in updating the DMWR. AEDs are also used to formulate technical data packages for piece part repair, contracts and provide alternate procedures to the depot because of unique capabilities or restrictions. AEDs of this latter type are referred to as "program" AEDs by AVSCOM DERSO since they will not be picked up in a DMWR.

2.2.2 Preshop Analysis

Preshop analysis (PSA), an integral part of the entire depot maintenance process, is a logical inspection procedure that is done to determine the condition of an item sent to the depot. The condition of an item, along with the reason(s) why the item was sent to the depot and the component operating times, will dictate the minimum amount of depot maintenance needed to restore the item to inherent design safety and reliability levels. PSA identifies the extent of disassembly and repair required at the appropriate prime shop(s) and also determines if component "short routing" can occur, i.e. if components can be sent directly to the control holding area or assembly lines. Preshop analysis utilizes visual inspection, diagnostic testing, nondestructive testing, dimensional inspection, and other methods as determined appropriate

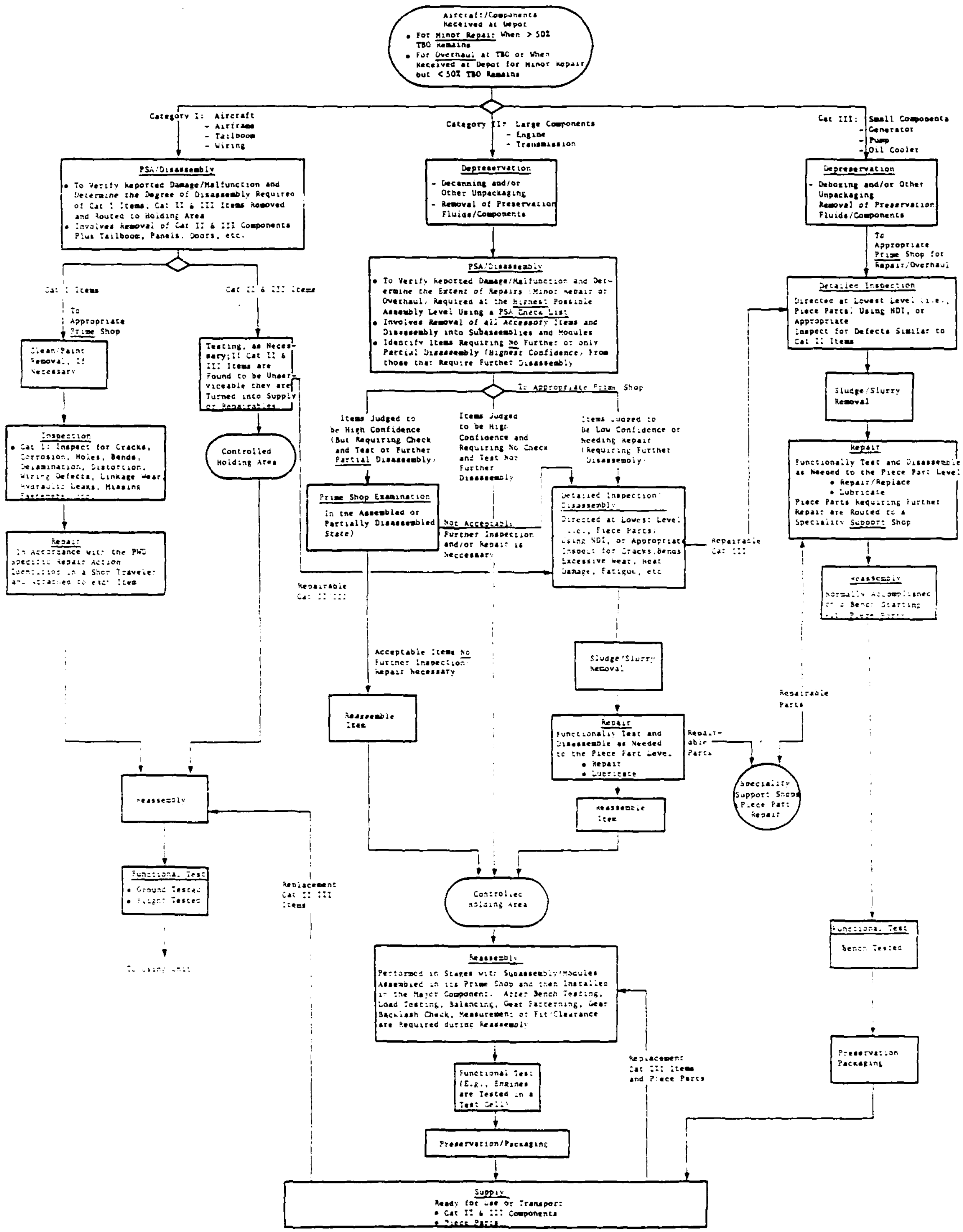


Figure 2-1 Depot Maintenance Process

in conjunction with experience and historical data in the evaluation process. Preshop analysis using inspections as well as diagnostic test is performed at the highest possible level of assembly to prevent unnecessary disassembly. Defined weak spots within a component must be accessed to inspect for specified historically common deficiencies and to determine repair required to restore item design requirements reliability and safety.

The PSA section of a DMWR provides the "what-to-do" guidelines necessary for determining when and where to apply the DMWR's procedures.

2.2.3 Minor Repair

Although overhaul is the major part of the work performed at a depot, not all of the items processed at a depot receive a complete overhaul. When a complex unit becomes defective in the field, and is beyond field repair capability, it is often more cost effective to minor repair rather than overhaul when received in the depot. A minor repair consists of the minimum maintenance necessary to correct the specific discrepancy that caused the item to be returned to the depot along with other applicable tasks associated with reassembly, testing, and preservation. The minor repair changes the status of the unit from a repairable item to a serviceable item retaining reliability and safety design level requirements, but it does not, in general, increase the unit's potential longevity. The determination to minor repair or overhaul is made after the item is inducted into the depot and undergoes a preshop analysis (PSA).

Figure 2-2 illustrates a longevity curve which depicts wear/degradation behavior with respect to time. The slope of the curve during wear-in and wear-out varies from item to item as does the length and slope of the stable wear life part of the curve. A descrepancy changes an item's status from serviceable to repairable and acts as a roadblock in preventing the item from progressing down its longevity curve. When the discrepancy arises, usually either overhaul or minor repair is performed. Overhaul is performed to recover used-up wear life in items with time-between-overhaul (TBO) limits; the longevity of an overhauled item approximates that of a new item. A minor repair removes the roadblock and allows the unit to progress; it does not recoup any of the used up wear life and therefore does not change the item's position on the longevity curve. For simple OCM items without TBOs minor repair is the only alternative.

Figure 2-2 Impact of Repair on Potential Longevity

3.0 RCM DMWR REVIEW ASSUMPTIONS AND METHODS

3.1 Initial Considerations

The method used to apply RCM to Army aviation DMWRs was to develop PSA sections/chapters for the DMWRs which will provide guidelines necessary for determining the minimum extent of maintenance needed to ensure restoration and preservation of the inherent design reliability, safety, and mission accomplishment of the equipment covered by the DMWR. Tasks to accomplish this are listed in Figure 3-1 for the three categories of equipment.

"Extent of maintenance" can be broken down into "minor repair (inspection and repair)" and "overhaul". A decision logic to determine if minor repair (inspection and repair) is feasible for a given item is given in Figure 3-2. Engine time since new or last overhaul is not changed after minor repair.

To eliminate unnecessary maintenance tasks while restoring inherent system reliability and safety requirements, one initiative (where applicable) is only to partially disassemble the item during the overhaul process. This initiative is viable on complex items, such as engines and transmissions, where an item is extensively evaluated during PSA to determine if its condition requires complete disassembly. AVSCOM DERSO distinguishes the processing of an item that requires complete disassembly by referring to "complete disassembly and overhaul"; processing of items that require only partial disassembly is referred to as "limited disassembly overhaul". The item's records reflect zero time since overhaul after a limited disassembly overhaul. The following questions should be asked in studying the item to determine if limited disassembly is a viable option:

(1) Does the item have subassemblies, modules, accessories, etc.? If so, do some subassemblies have considerably more longevity than others?
(2) What are the item's inherent design weaknesses?
(3) What are the most common causes for depot return?
(4) Are there some maintenance tasks that are not necessary under certain situations?

The considerations in this section, then, provide an initial general framework for development of a PSA section/chapter.

3.2 RCM DMWR Review Procedure

The procedure developed to review, and revise or rewrite as necessary, Army aviation DMWRs for RCM philosophy is illustrated in Figure 3-3.

3.2.1 Step 1: Compile Data

3.2.1.1 DARCOM-R 750-9

U.S. Army Materiel Command (AMC) Regulation No. 750-9, Reliability Centered Maintenance - Application to Depot Maintenance Work Requirements, dated 31 August 1983, defines the basic philosophy of RCM as it relates to depot-level maintenance and directs that new DMWRs be developed in terms of RCM philosophy and that existing DMWRs be reviewed and revised or rewritten as necessary to incorporate RCM philosophy. This regulation then provides the direction in accordance with which the procedure outlined in Figure 3-3 is carried out.

3.2.1.2 Current DMWR

The current DMWR for the particular fielded Army aviation equipment being

I. AIRCRAFT:

A. Preshop Analysis (PSA): If a PSA exists, it will be evaluated; if it doesn't exist, it will be developed. The DMWR PSA which results will provide guidelines to the depot for examining the basic airframe and identifying the extent of maintenance required. Initiatives will include:

1. Determining which panels and other structure require arbitrary removal from the airframe and which are removed only for cause.
2. Identifying specific structural weak points that must be addressed at every overhaul.
3. Determining which aircraft require alignment check at every overhaul and, if not, when an airframe alignment fixture is required.
4. Reviewing the depot maintenance process to determine what other tasks can be eliminated, streamlined, or accomplished only on condition.
5. Determining the extent of repair for the tailboom.
6. Providing guidance for using visual examination in lieu of nondestructive testing (NDT) (where possible) for detecting cracks in piece parts.

B. The accessories/components which require functional test or special inspection will be determined.

C. The aircraft's characteristic weaknesses which must be addressed at each depot maintenance (convenience maintenance) will be identified.

II. MAJOR COMPONENTS (ENGINES, TRANSMISSIONS, ETC.):

A. Preshop Analysis (PSA): The PSA will establish a limited disassembly concept which will feature:

1. Short routing of the high confidence assemblies by establishing hard time between complete disassemblies for each major assembly or subassembly.
2. Identifying inherent weaknesses which must be addressed at each depot maintenance (convenience maintenance).
3. Identifying bearings which require disassembly and inspection in clean room environment.

B. Guidance for using visual examination in lieu of NDT (where possible) for detecting cracks in piece parts will be provided.

C. Piece parts which should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together will be identified.

D. The DMWR will provide for check and test of the major component's accessories and the performance of minor repair as necessary.

E. The depot maintenance process will be reviewed to determine what other tasks can be eliminated, streamlined, or accomplished only on condition.

III. SMALL COMPONENTS:

Since these components are disassembled, on a workbench, directly into their integral piece parts, there are usually not subassemblies, or subassemblies are bonded together and further disassembly is impractical. Although limited disassembly is <u>not</u> a viable initiative on small components, a PSA will be developed to address:

A. Inherent weaknesses of the component which require emphasis at each depot maintenance.

B. Guidance in determining when and which parts require NDT.

C. Which parts should remain together for reassembly (where practical) and desired alternatives when such parts do not remain together.

D. Which bearings require disassembly/inspection in a clean room environment.

Figure 3-1 RCM DMWR Review Tasks

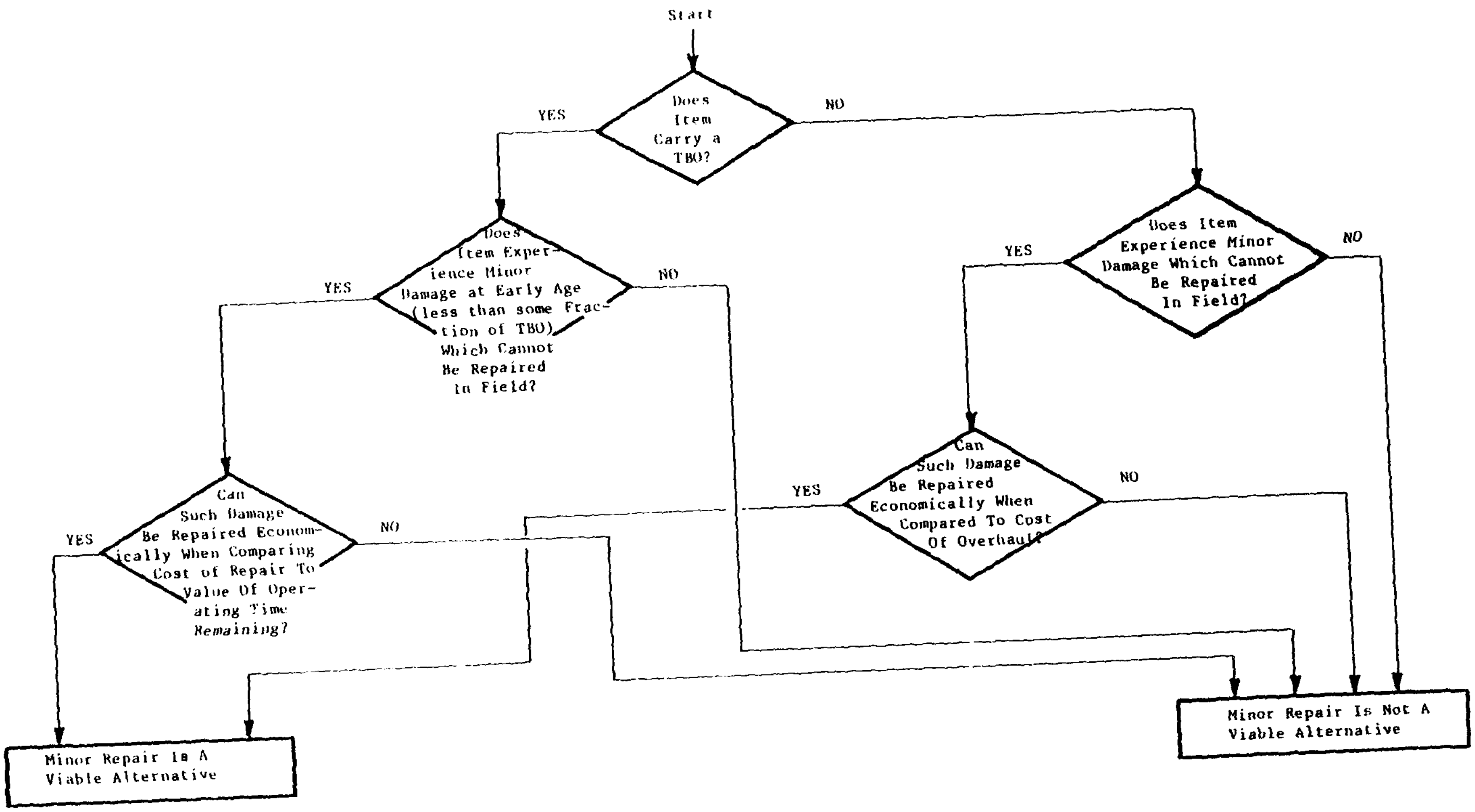


Figure 3-2 Minor Repair (Inspection and Repair) Feasibility Decision Logic

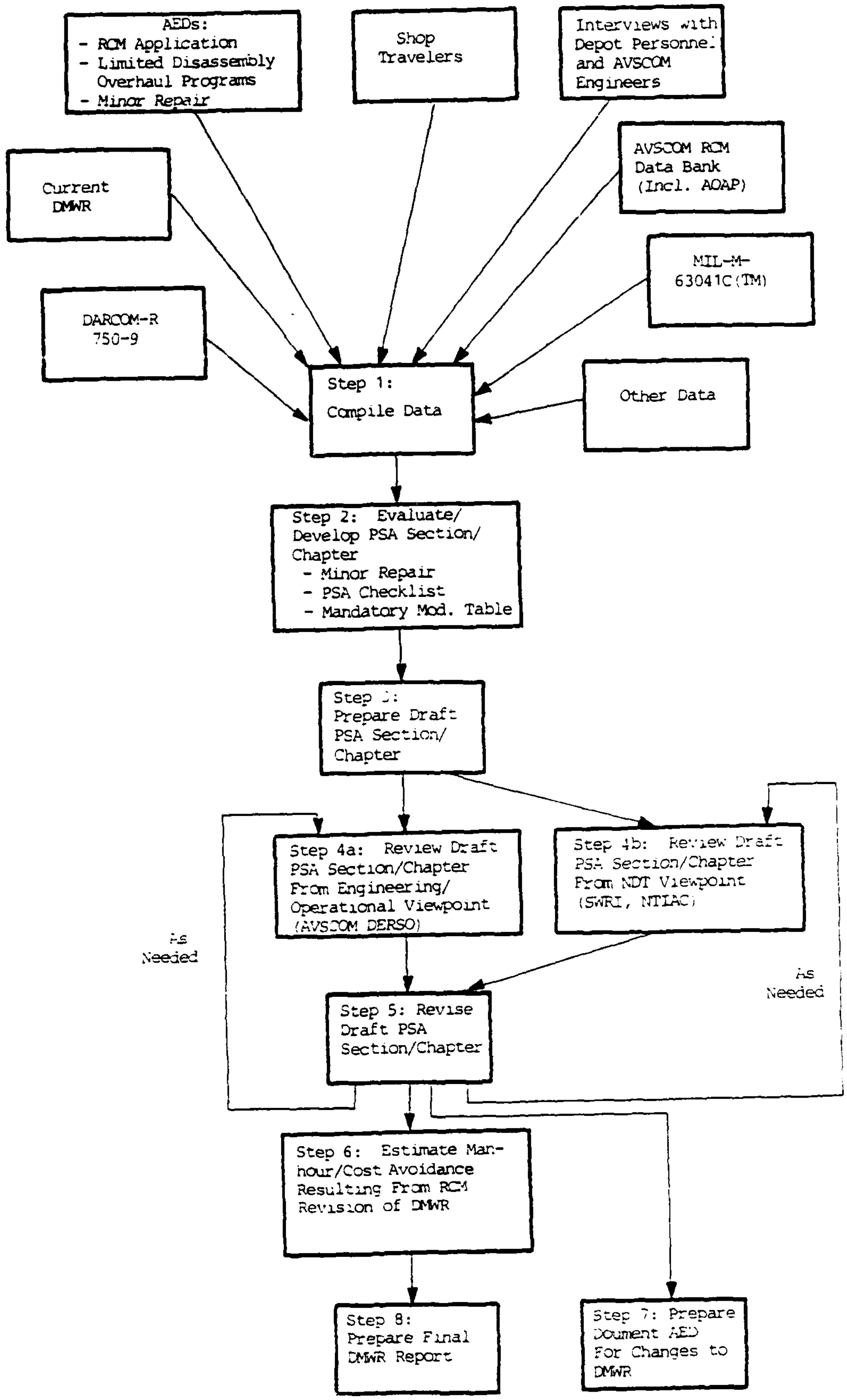


Figure 3-3 RCM DMWR Review Procedure

reviewed for RCM application forms, or course, the baseline for the evaluation/development of the PSA section/chapter carried out in step 2.

3.2.1.3 AVSCOM Engineering Directives (AEDs)

Certain program AEDs deal with concepts and procedures for processing and managing particular equipment through the depot process. These include AEDs on RCM application to T53 engines, on limited disassembly overhaul of engines, on minor repair of engines, and on RCM/minor repair of transmissions and gear boxes. These serve as background material for the evaluation/development of the PSA section/chapter.

3.2.1.4 Shop Travelers

Shop travelers are depot work order documents that provide authorized prescribed sequential shop routing and technical processing instructions for assemblies, accessories, components, end items, and/or parts. They are developed utilizing applicable DMWRS, document AEDs, program AEDs, and/or field maintenance technical manuals. They provide information on how the particular fielded Army aviation equipment being reviewed for RCM application is currently processed through the depot and can be used as background material for the evaluation/development of the PSA section/chapter.

3.2.1.5 Interviews

The fielded Army aviation equipment being reviewed for RCM application is followed through the depot process by experienced engineers, beginning with preshop analysis, if applicable, and proceeding to the prime shops. At each shop the depot personnel directly involved with the equipment are interviewed to determine weaknesses and problems with the equipment, how these weaknesses/problems can be addressed, and the high confidence items which can be short routed.

In addition the cognizant engineer(s) in the AVSCOM Depot Engineering and RCM Support Office (DERSO) for the equipment are interviewed to obtain their expertise.

The information obtained from the interviews is used to supplement and/or confirm information from the current DMWR, AEDs, and shop travelers.

3.2.1.6 AVSCOM RCM Data Bank

AVSCOM DERSO's Technical Analysis Branch collects, reduces and analyzes data from all available sources relative to the operation and maintenance of turbine engines. From this data U.S. Army turbine engine reliability, maintenance significant items, and failure modes can be measured and evaluated; engine component or parts with potential for improved reliability can be identified; and future engine requirements can be decided. For an engine, then, this data bank can be used to assure that current maintenance tasks in the DMWR, program AEDs, and shop travelers mitigate all prevalent failure modes and, if not, to establish additional maintenance requirements in the PSA section/chapter developed in step 2.

3.2.1.7 MIL-M-63041C(TM)

Military specification MIL-M-63041, Preparation of Depot Maintenance Work Requirements, contains the detail requirements for preparing DMWRs. MIL-M-63041 requirements for PSA chapters/sections are used in determining the format and content of the PSA sections/chapters prepared in step 3. The version MIL-M-63041C(TM), dated 31 October 1984, is used.

3.2.1.8 Other Data

Other data for the RCM DMWR review include AVSCOM memoranda on problems with certain equipment and material from previous RCM application to the equipment.

3.2.2 Step 2: Evaluate/Develop PSA Section/Chapter

With use of the data compiled in step 1: if a PSA section/chapter exists for the DMWR being reviewed, it is evaluated; if it doesn't exist, it is developed. Major considerations in the evaluation/development of a PSA section/chapter are as follows:

(1) If minor repair is feasible for the item covered by the DMWR being reviewed (see Section 3-1 and Figure 3-2), the PSA section/chapter should contain minor repair criteria and overhaul criteria. The PSA section/chapter should make clear that the procuring activity will establish separate programs for minor repair and overhaul. The minor repair portion of the PSA section/chapter should address the cause for depot return and also include (where applicable) convenience maintenance where convenience maintenance involves inspection, repairs, or other preventive maintenance that is determined to be cost effective and/or significantly improves longevity, reliability and/or safety and thus is done while the item is in the depot.

(2) If minor repair is not feasible per Section 3-1 and Figure 3-2 and overhaul is the only viable alternative, the PSA section/chapter should stipulate that "minor repair is not economically feasible for this item".

(3) The questions given in Section 3-1 should be asked to determine if limited disassembly is a viable intiative during overhaul of this item.

(4) The primary weaknesses and strengths of the item should be studied in detail. The strengths provide justification for a limited disassembly approach. The weaknesses should be addressed by convenience maintenance during minor repair or limited disassembly overhaul.

(5) A PSA checklist should be included as a handy, streamlined list of the issues addressed in depth in the PSA section/chapter, i.e., it should be totally redundant. It should not repeat any of the inspection tables that are contained in the maintenance (how-to-do) sections/chapters of the DMWR.

(6) A mandatory modification table should be included as a handy list of the modifications that can be accomplished on the item. All of the modifications are required at overhaul; safety-driven and/or cost-effective modifications should be required at minor repair.

3.2.3 Step 3: Prepare Draft PSA Section/Chapter

A draft PSA section/chapter is prepared, incorporating the considerations and evaluation/development in step 2, in accordance with the format and content data requirements of MIL-M-63041. The section/chapter is tailored to the particular DMWR/Army aviation equipment item being reviewed. However, two portions, of each PSA section/chapter prepared are fairly well standardized:

(1) A purpose statement very similar to that given in MIL-M-63041 is provided as the first paragraph in the section/chapter.

(2) The PSA checklist format has been standardized to that shown in Figure 3-4. This format is adapted from that given in MIL-M-63041.

3.2.4 Step 4: Review Draft PSA Section/Chapter

The draft PSA section/chapter is submitted to AVSCOM DERSO for review from an engineering and operational viewpoint. It is submitted to the Nondestructive Testing Information Analysis Center at Southwest Research Institute for review from the standpoint of optimizing the utilization of visual inspection, diagnostic testing, nondestructive testing, dimensional inspection, and other methods as they apply to preshop analysis.

3.2.5 Step 5: Revise Draft PSA Section/Chapter

The draft PSA section/chapter is revised until approved by AVSCOM DERSO.

3.2.6 Step 6: Estimate Man-hour/Cost Avoidance

Once the PSA section/chapter is approved by AVSCOM DERSO, estimation of the man-hour/cost avoidance resulting from RCM revision of the DMWR through the PSA section/chapter can begin. If RCM has already been applied previously, through program AED and/or shop traveler, to the fielded Army aviation equipment covered by the DMWR revised, complete data on man-hours, man-hour costs, and parts costs required for depot-level maintenance before and after RCM application probably exist and can be obtained from depot program production planning and control managers for the equipment involved. If complete data do not exist, at least data for maintenance before RCM application (i.e., complete disassembly and overhaul) are available from these managers; then, with assistance from depot production engineering personnel, the cost avoidance resulting from application of RCM can be estimated.

For small, Category III components which are maintained on a "on-condition" basis (i.e., they do not carry a TBO) at a small cost per unit (approximately $1000 or less), there is no advantage to distinguishing "before RCM" from "after RCM". Therefore, cost avoidance estimates are not done for these components.

3.2.7 Step 7: Prepare Document AED

A document-type AED is prepared in accordance with Procedure No. DESS-009C as the vehicle for revising or rewriting the DMWR to incorporate the approved PSA section/chapter for release to the depot maintenance facility for implementation and to AVSCOM, St. Louis, along with a DA Form 2028 for publication change.

3.2.8 Step 8: Prepare Final DMWR Report

A final DMWR report on the DMWR revised using RCM principles is prepared in accordance with DARCOM-R 750-9 and submitted to the U.S. Army Materiel Command Materiel Readiness Support Activity.

Preshop Analysis Checklist.

INSPECTION POINT	CONDITION	ACTION	REMARKS	DONE

Figure 3-4. Standard PSA Checklist Format

APPENDIX A

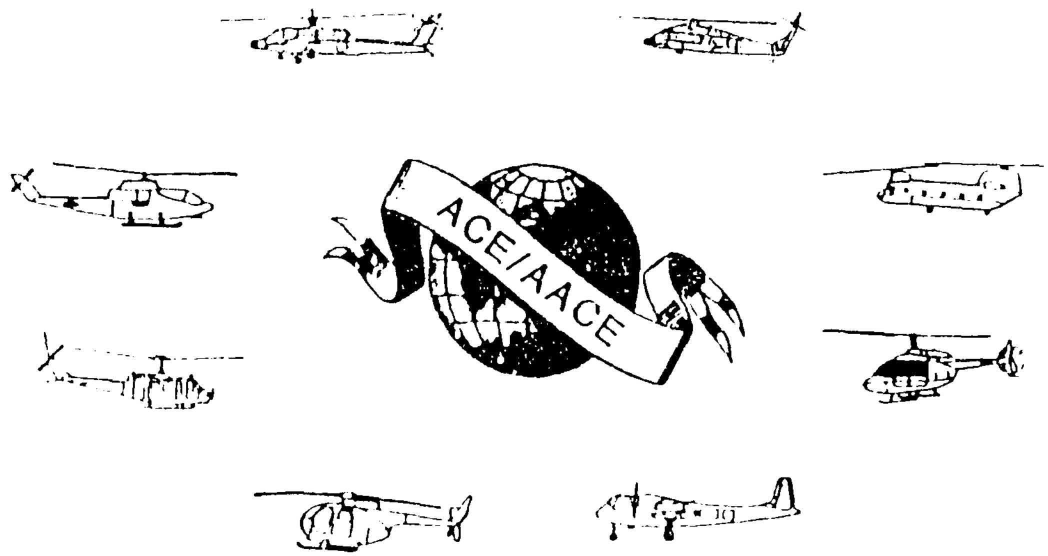
GLOSSARY

Minor Repair (Inspection and Repair) - That maintenance performed to address the cause for depot return of an item, to restore the item to serviceable condition through correction of specific failure or unserviceable conditions and to address an item's inherent weaknesses by carrying out convenience maintenance-inspections, repairs, and other preventive maintenance that are determined to be cost effective and/or significantly improves longevity, reliability, and/or safety, given that the item is in the depot. For items with TBOs the only alternative to minor repair is overhaul. For OCM items minor repair is distinguished from major repair simply by the depth of effort required. Major repair includes a greater degree of convenience maintenance. Minor repair does not "zero" the "time since new" or "time since overhaul" of the item.

Limited Disassembly Overhaul - An approach to overhauling an item in depot in which the item is restored to a serviceable condition through partial disassembly, inspection, replacement, or repair of parts as specified in applicable technical manuals or DMWR. High confidence assemblies are short routed by establishing hard time between complete disassemblies for each major assembly or subassembly. Inherent weaknesses are identified which must be addressed at each depot maintenance. Refer to paragraph 3-1 for details. This action "zeroes" the "time since overhaul" of the item.

ACE/AACE VIEWGRAPHS

U.S. ARMY AVIATION SYSTEMS COMMAND



DEPOT ENGINEERING
AND RCM SUPPORT
OFFICE

AGENDA

- ACE/AACE PROGRAM OVERVIEW
- ACE/AACE ACHIEVEMENTS
- ACE/AACE FUTURE INITIATIVES

BACKGROUND

- OLD SYSTEM (CALENDAR MONTHS OR FLYING HOURS)
- ENGINEERING STUDY DURING 1967 THROUGH 1972 ON AIRCRAFT MAINTENANCE
- ON-CONDITION MAINTENANCE (OCM) SYSTEM

ON-CONDITION MAINTENANCE PROGRAM (OCM)

SIGNIFICANT PROGRAM ELEMENTS:

- AIRFRAME CONDITION EVALUATION/ AIRCRAFT ANALYTICAL CORROSION EVALUATION (ACE/AACE)
- PRE-SHOP ANALYSIS
- DEPOT MAINTENANCE WORK REQUIREMENTS
- OIL ANALYSIS (AOAP)
- PROGRESSIVE PHASE MAINTENANCE

ACE/AACE PROGRAM

- DETERMINE CONDITION OF ARMY AIRCRAFT
  - FOR DEPOT RETURN
  - RANKS AIRCRAFT IN ORDER OF DEPOT REPAIR NEED
  - MANAGEMENT DECISION TOOL
  - ANNUAL EVALUATION

ACE/AACE GUIDANCE

AVSCOM PAMPHLETS 750-1 AND 750-2

- TECHNICAL DESCRIPTION FOR
  - EXECUTING THE EVALUATION
  - REPORTING REQUIREMENTS

ACE/AACE KEY FEATURES

- SIMULTANEOUS EVALUATION
- REQUIRES 2 EVALUATORS PER TEAM
- TAKES APPROXIMATELY 45 MINUTES PER AIRCRAFT
- DATA COMPUTER PROCESSED

ACE/AACE METHODOLOGY

ELEVEN STEPS AS FOLLOWS:

STEP 1: SELECT INDICATORS

STEP 2: DETERMINE CONDITION CODES

STEP 3: RANK INDICATORS

STEP 4: ESTABLISH DISTRIBUTION CURVE (PARETO)

STEP 5: DEVELOP INDICATOR WEIGHTS

STEP 6: ASSIGN WEIGHTS TO INDICATORS

STEP 7: INSPECT AIRCRAFT (ACE/AACE TEAM)

STEP 8: COMPUTE PROFILE INDEX FOR EACH AIRCRAFT

STEP 9: DEVELOP PI DISTRIBUTION

STEP 10: ESTABLISH THRESHOLD

- QUALITATIVE ANALYSIS - ESTIMATE
- AIRCRAFT MAINTENANCE AUDIT - SET

STEP 11: IDENTIFY CANDIDATE AIRCRAFT

ACE/AACE INDICATORS

- AIRCRAFT ARE EVALUATED BASED ON SELECTED INDICATORS

- EXAMPLES

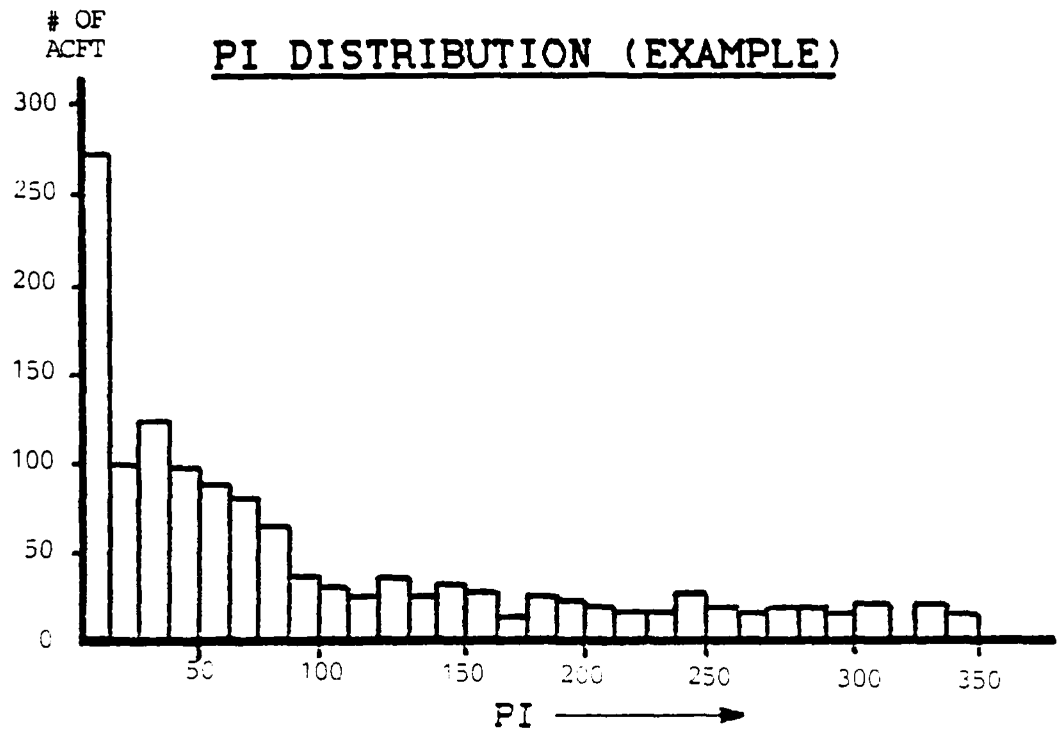
  - ACE
    - CARGO DOOR TRACKS
    - AFT FUSELAGE SKIN
    - TAILBOOM SKIN

  - AACE
    - BATTERY COMPARTMENT
    - DOORFRAME AREA
    - NOSE SECTION

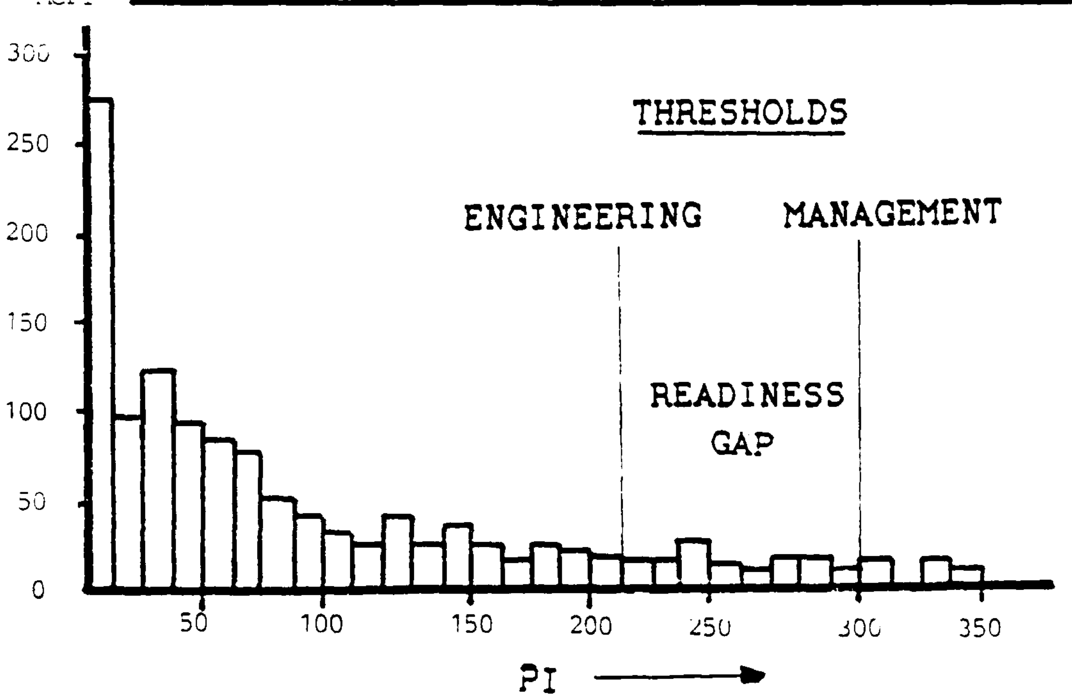
RESULTS OF ACE/AACE EVALUATION

- AIRCRAFT PROFILE INDEX (PI)
  - A <u>SINGLE</u> NUMERICAL VALUE FOR EACH AIRCRAFT
- PI DISTRIBUTION
  - A PI <u>RANK ORDER</u> PLOT OF EACH AIRCRAFT MODEL

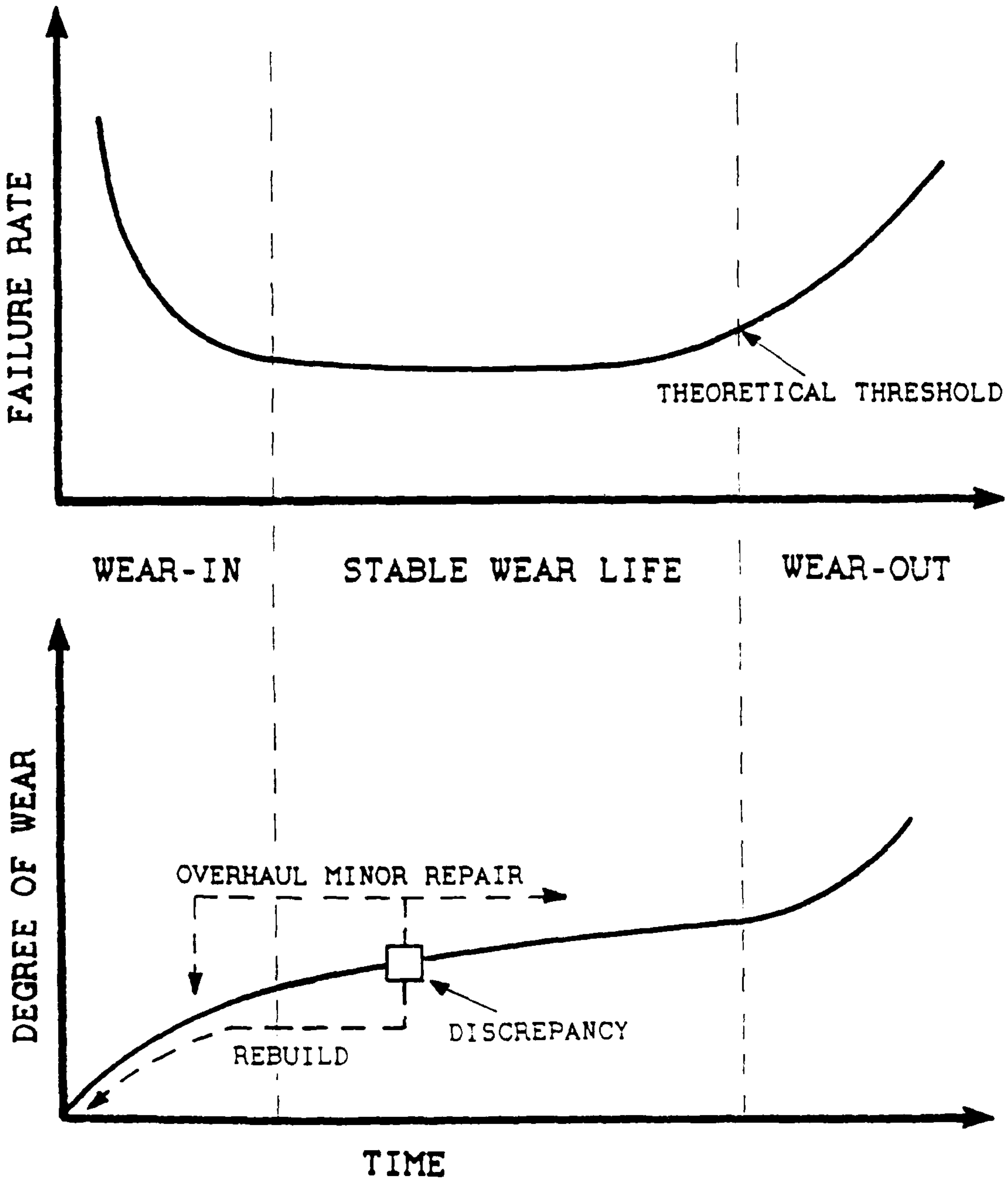
PI DISTRIBUTION (EXAMPLE)



PI DISTRIBUTION WITH THRESHOLDS (EXAMPLE)



IMPACT OF WEAR



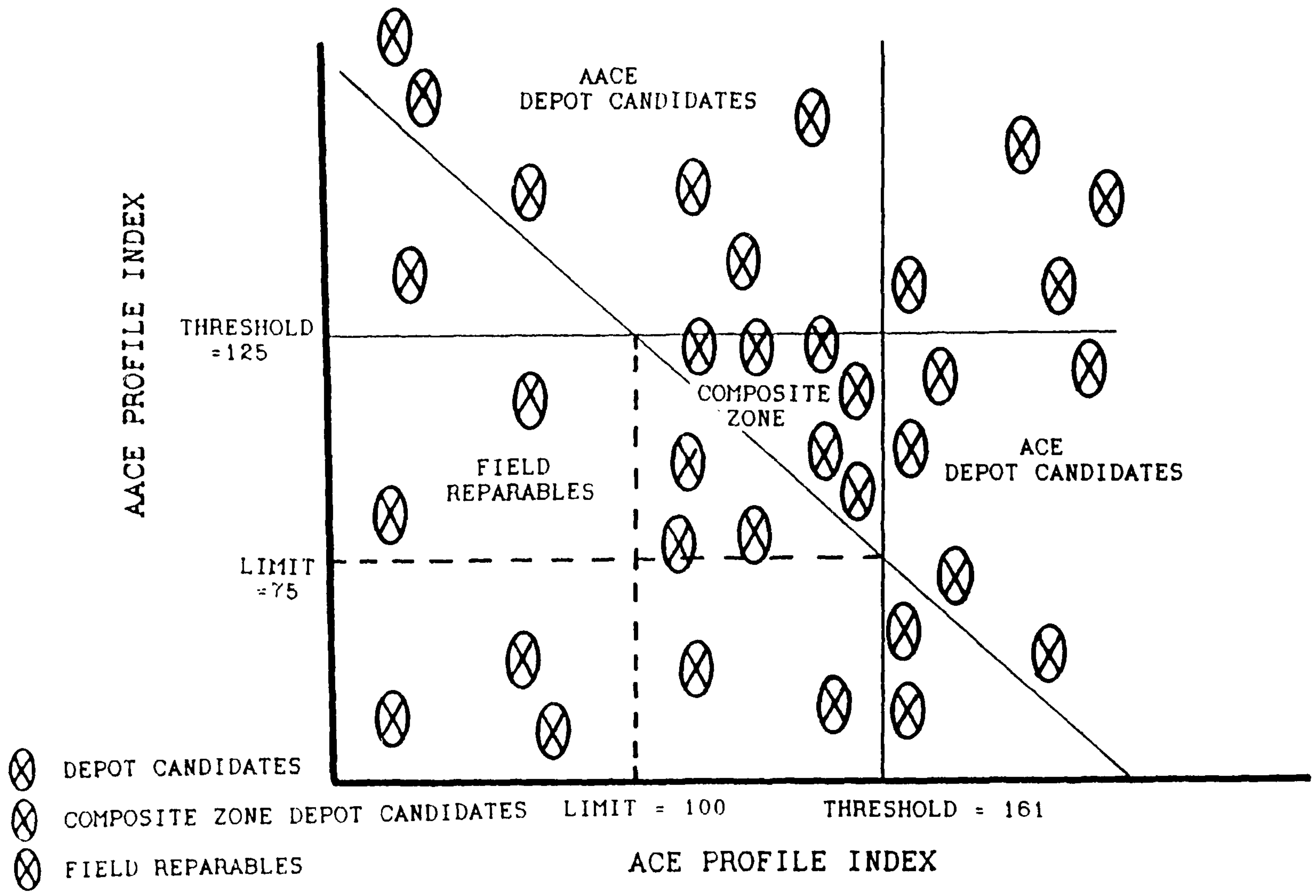
ACE/AACE ACHIEVEMENTS

- COST AVOIDANCE
  - OVER $1.1 BILLION SINCE 1972
- WORLDWIDE FLEET AACE EVALUATION
  - FIRST TIME
- UPDATED AACE
  - IDENTIFIED PROBLEM AREAS
- ACE PROGRAM REFINED
  - HANDBOOKS
  - BOND TESTER
  - TRAINING

ACE/AACE FUTURE INITIATIVES

- DATA/TREND ANALYSIS
- IMPROVED FEEDBACK OF DEFICIENCY INFORMATION
- IMPROVED THRESHOLD METHODOLOGY
- IMPROVED AACE INDICATOR CRITERIA
- NEW/REVISED DOCUMENTATION
  - 750-1,2 PAMPHLETS (e.g., AH-64, CH-47D, OH-58D)
  - UPDATED HANDBOOKS
- ACE/AACE DMWR SCRUB
- NEW/UPGRADED DIAGNOSTIC EQUIPMENT
  - UPGRADED BOND INSPECTION EQUIPMENT
  - LASER AIRCRAFT ALIGNMENT EQUIPMENT
  - MOBILE ELECTRONIC AIRCRAFT WIRING ANALYZER
  - FATIQUE MEASUREMENT DEVICE & TECHNIQUE
  - CORROSION MEASUREMENT DEVICE

COMPOSITE ACE/AACE THRESHOLD



EXAMPLES OF INDICATORS AND WHAT THEY INDICATE

AIRCRAFT	INDICATOR	INDICATION
UH-1	AFT FUSELAGE SKIN, EXHIBITING BUCKLING	● MISALIGNMENT OF THE LONGERONS THAT SUPPORT THE TAILBOOM ● HIGH LOCAL STRESSES
OH-58	TRANSMISSION SUPPORT, CRACKING AND LOOSENESS	● EXCESSIVELY HARD LANDING ● EXCESSIVE ROTOR VIBRATION
U-21	NOSE LANDING GEAR ATTACH FITTINGS EXHIBITING LOOSENESS, CRACKING, CORROSION, AND SCRATCHES	● UNEVEN LOADING
OH-6	CABIN DOORS, EXHIBITING CRACKING AND MISALIGNMENT	● HARD LANDING
CH-47	THE NOSE SECTION, EXHIBITING LOOSENESS, CRACKING, IMPROPER HARDWARE, AND BUCKLING	● SEVERE STRUCTURAL VIBRATION

CONDITION CODE EXAMPLE

OH-6 INDICATION - PAINT CONDITION

CONDITION CODES

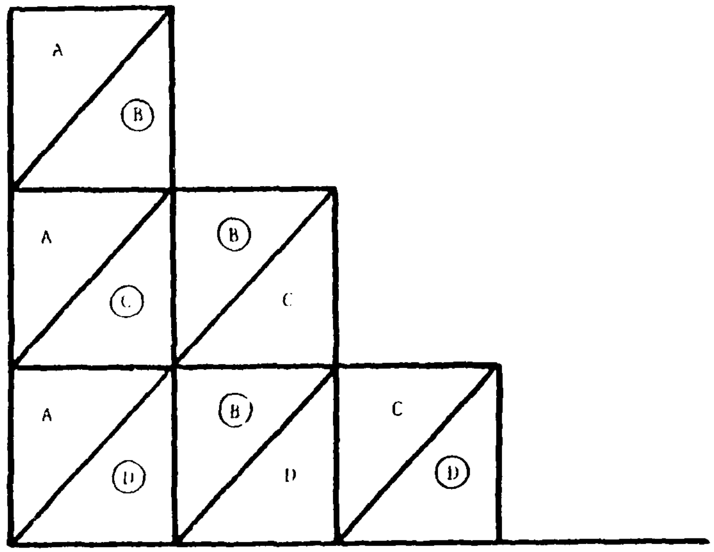
C - DETERIORATED

K - POOR

L - FAIR

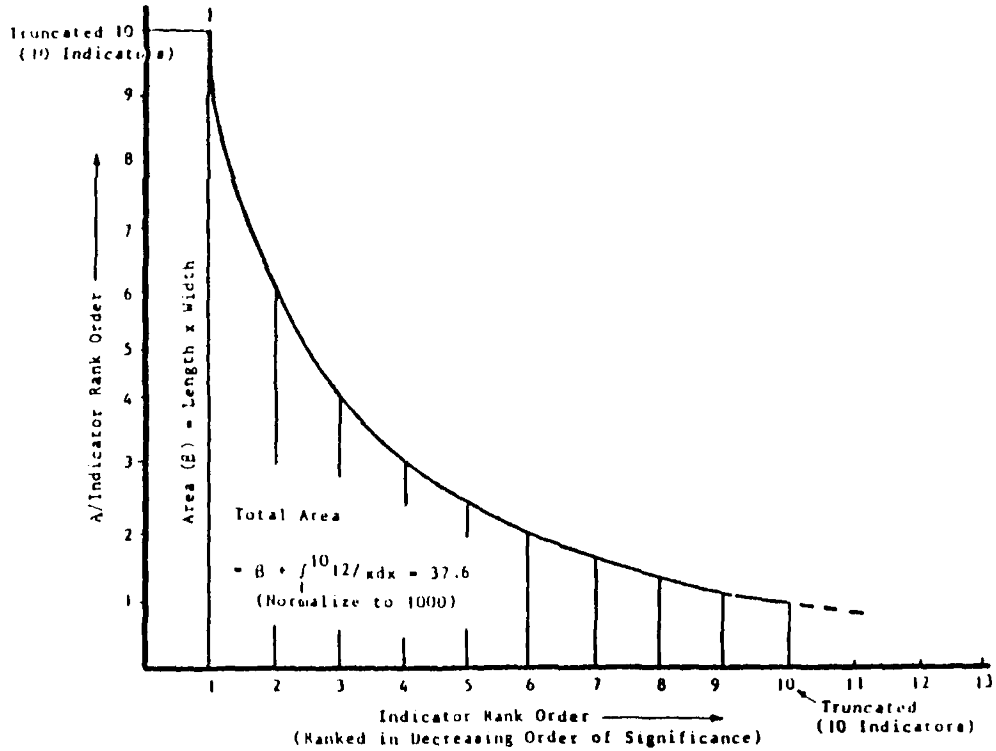
M - GOOD

EMPHASIS CHART



INDICATORS	RANKING
A. CORROSION PROTECTION	1. MAIN LIFT BEAM (CIRCLED 3 TIMES)
B. MAIN LIFT BEAM	2. UPPER AFT BULKHEAD (CIRCLED 2 TIMES)
C. NOSE FUSE, SKIN	3. NOSE FUSE, SKIN (CIRCLED 1 TIME)
D. UPPER AFT BULKHEAD	4. CORROSION PROTECTION (NOT CIRCLED)

PARETO DISTRIBUTION CURVE
(EXAMPLE)



	INDICATOR INTERNAL AREA	INDICATOR WEIGHT *
AREA (β) OF INDICATOR WITH RANK ORDER 1	AREA 1 = 10 x 1 = 10	266
AREA UNDER CURVE OF INDICATOR WITH RANK ORDER 2	AREA 2 = $\int_1^2 12/x\,dx$ = 8.317	221
AREA UNDER CURVE OF INDICATOR WITH RANK ORDER 3	AREA 3 = $\int_2^3 12/x\,dx$ = 4.866	129

* SUM OF INDICATOR WEIGHTS = 1000

CONDITION CODE WEIGHT DISTRIBUTION

No. of Faulty Codes	% of Total Indicator Weight for Codes (listed worst to best)					
	First Code	Second Code	Third Code	Fourth Code	Fifth Code	Sixth Code
6	100	50	20	15	10	5
5	100	50	25	15	10	0
4	100	50	30	20	0	0
3	100	60	40	0	0	0
2	100	60	0	0	0	0
1	100	0	0	0	0	0

EXAMPLE: OH-6 Indication - Paint Condition Has Weight of 79

Condition Code	Numerical Value Used in Formulating PI
C - Deteriorated	79 (100% of 79)
K - Poor	47 (60% of 79)
L - Fair	32 (40% of 79)
M - Good	0 (0% of 79)

ACE WORKSHEET
(EXAMPLE, PAGE 1 OF 2)

AIRFRAME CONDITION EVALUATION (ACE) UH-1B/C/M TUW AVSCOM PAM 750-1 (4)	MASTER	EAM	UNIT	AREA	LOCATION

Card Col	PROFILE	INDICATOR NOMENCLATURE	ITEM	
01	T U W	TYPE/MODEL/SERIES	1	A/C SER #
02-08		SERIAL NUMBER	2	
09		SPECIAL MISSION	3	
10		MAJOR COMMAND	4	
11-12		GEOGRAPHICAL LOCATION	5	
13-16		JULIAN DATE OF ACE	6	
17	N O	A/C NEW OR OVERHAULED	7	
18	C N P S K	O/H BY	8	
19-22		A/C HRS AT TIME OF OVERHAUL	9	
23-26		JULIAN DATE OF OVERHAUL	10	
27-30		TOTAL HRS ON A/C	11	
31	C K L M	OVERALL CONDITION	12	
32	C K L M	PAINT CONDITION	13	
33	E G F Y R	CARGO DOOR POST UPPER & LOWER L/H	14	
34	E G B Y R	CARGO DOOR UPPER FRAME L/H	15	
35	S C Y J D U R	UPPER AFT CABIN BULKHEAD PANEL L/H	16	
36	S C Y J D U R	FUEL CELL FORWARD BULKHEAD PANEL L/H	16	
37	S C Y J D U R	UPPER AFT CABIN BULKHEAD CENTER PANEL	16	
38	S C Y J D U R	UPPER AFT CABIN BULKHEAD PANEL R/H	16	
39	S C Y J D U R	FUEL CELL FORWARD BULKHEAD PANEL R/H	16	
40	S C Y J D U R	FUEL CELL UPPER OUTBOARD PANEL L/H	16	
41	S C Y J D U R	FUEL CELL CENTER OUTBOARD PANEL L/H	16	
42	S C Y J D U R	FUEL CELL LOWER OUTBOARD PANEL L/H	16	ACE FY
43	S C Y J D U R	FUEL CELL UPPER AFT BULKHEAD L/H	16	
44	S C Y J D U R	FUEL CELL LOWER AFT BULKHEAD L/H	16	
45	E A Y R	UPPER AFT DOOR TRACK L/H & R/H	17	
46	E A Y R	LOWER AFT DOOR TRACK L/H & R/H	17	
47	S C Y J D U R	WORK DECK PANEL L/H	16	
48	C E Y R	WIRE BUNDLES, AVIONICS COMPARTMENT	25	
49	E G B Y R	AFT FUSELAGE VERTICAL WEB	18	
50	E G B Y R	TAILBOOM VERTICAL SKIN	19	
51	E G Z R	TAILBOOM ATTACH FITTING UPPER & LOWER L/H	20	
52	E G Z R	TAILBOOM ATTACH FITTING UPPER & LOWER R/H	20	
53	S C Y J D U R	FUELL CELL AFT BULKHEAD PANEL R/H	16	
54	S C Y J D U R	FUEL CELL UPPER OUTBOARD PANEL R/H	16	
55	S C Y J D U R	FUEL CELL LOWER OUTBOARD PANEL R/H	16	
56	S C Y J D U R	WORK DECK PANEL R/H	16	
57	S C Y J D U R	CENTER SERVICE (ENGINE) DECK	16	
58	E G B Y R	PYLON ASSEMBLY HORIZONTAL WEBS, L/H & R/H	21	
59	E G Y R	FIFTH MOUNT ATTACH AREA	22	
60	E G Y T Z R	LIFT BEAM, WEBS AND LOOSE HI-SHEARS	23	
61	S C Y J D U R	ROOF DECK PANEL	16	
62	E G B Y A R	CARGO DOOR UPPER FRAME R/H	15	

NAME PROFILER	RECORDS