
Aviation Maintenance Management

Harry A. Kinnison

Tariq Siddiqui

Second Edition



New York Chicago San Francisco Lisbon London Madrid
Mexico City Milan New Delhi San Juan Seoul
Singapore Sydney Toronto

Contents

List of Figures	xiii
List of Tables	xv
Preface	xvii
Preface to the First Edition	xix
Introduction	xxi

Part I: Fundamentals of Maintenance	1
Chapter 1 Why We Have to Do Maintenance	3
Introduction	3
Thermodynamics Revisited	3
A Saw Blade Has Width	4
The Role of the Engineer	5
The Role of the Mechanic	5
Two Types of Maintenance	6
Reliability	8
Redesign	8
Failure Rate Patterns	10
Other Maintenance Considerations	11
Establishing a Maintenance Program	13
Chapter 2 Development of Maintenance Programs	15
Introduction	15
The Maintenance Steering Group (MSG) Approach	16
Process-Oriented Maintenance	18
Task-Oriented Maintenance	22
The Current MSG Process—MSG-3	25
The Maintenance Program Documents	29
Maintenance Intervals Defined	30
Changing Basic Maintenance Intervals	31
Chapter 3 Definitions, Goals, and Objectives	33
Definitions of Important Terms	33
Maintenance	34

Inherent Reliability	36
Mechanics, Technicians, Maintainers, Engineers	36
Word Pairs Used in Aviation	36
Goals and Objectives of Maintenance	39
Maintenance Program Content	41
Discussion of the Five Objectives	42
Summary	44
 Chapter 4 Aviation Industry Certification Requirements	 45
Introduction	45
Aircraft Certification	45
Delivery Inspection	53
Operator Certification	53
Certification of Personnel	54
Aviation Maintenance Certifications	54
Aviation Industry Interaction	56
 Chapter 5 Documentation for Maintenance	 57
Introduction	57
Manufacturer's Documentation	58
Regulatory Documentation	65
Airline-Generated Documentation	66
ATA Document Standards	69
A Closer Look at the TPPM	74
 Chapter 6 Requirements for a Maintenance Program	 79
Introduction	79
Aviation Maintenance Program Outlined (AC 120-16E)	79
Summary of FAA Requirements	86
Additional Maintenance Program Requirements	87
Summary	89
 Chapter 7 The Maintenance and Engineering Organization	 91
Organization of Maintenance and Engineering	91
Organizational Structure	91
The M&E Organizational Chart	93
General Groupings	93
Manager Level Functions—Technical Services Directorate	94
Manager Level Functions—Aircraft Maintenance Directorate	96
Manager Level Functions—Overhaul Shops Directorate	97
Manager Level Functions—Materiel Directorate	98
Manager Level Functions—Maintenance Program Evaluation Directorate	99
Summary of Management Levels	100
Organizational Structure and the TPPM	100
Variations from the Typical Organization	101

Part II: Technical Services	103
Chapter 8 Engineering	105
Introduction	105
Makeup of Engineering	106
Mechanics and Engineers	107
Engineering Department Functions	109
Engineering Order Preparation	114
Chapter 9 Production Planning and Control	117
Introduction	117
PP&C Organization	117
The Production Planning & Control Department's Function	118
Forecasting	120
Production Planning	121
Production Control	127
Other Scheduled Work	129
Feedback for Planning	130
Chapter 10 Technical Publications	131
Introduction	131
Functions of Technical Publications	131
Airline Libraries	132
Control of Publications	132
Document Distribution	134
Chapter 11 Technical Training	135
Introduction	135
Training Organization	136
Airline Maintenance Training	137
Maintenance Resources Management	139
Airframe Manufacturer's Training Courses	140
Supplemental Training	140
Part III: Aircraft Management, Maintenance, and Materiel Support	143
Chapter 12 Aircraft Maintenance Management	145
Introduction	145
Aircraft Maintenance Management Structure	146
The Role of Management in Aviation	147
Manager of Aircraft Maintenance	147
Front Line Supervisor/Management	148
Management Areas of Concern in an Airline	148
Manager of Overhaul Shops	149

Chapter 13 Line Maintenance (on-Aircraft)	151
Introduction	151
Functions that Control Maintenance	152
Maintenance Control Center Responsibilities	153
Line Maintenance Operation—General	155
Aircraft Logbook	156
Ramp and Terminal Operations	157
Other Line Maintenance Activities	159
Line Station Activities	160
Maintenance Crew Skill Requirements	161
 Chapter 14 Hangar Maintenance (on-Aircraft)	 163
Introduction	163
Organization of Hangar Maintenance	164
Problem Areas in Hangar Maintenance	165
Hangar Maintenance Activity—A Typical “C” Check	167
Morning Meetings	169
Support and Overhaul Shops Organization	170
Types of Shops	171
Ground Support Equipment Shop (GSE)	174
Ground Support Equipment	174
Outsourcing of Shop Maintenance Work	177
Operation of Overhaul Shops	178
Shop Data Collection	179
 Chapter 15 Materiel Support	 181
Organization and Function of Materiel	181
Materiel Management	182
Support Functions of Materiel	184
Other Materiel Functions	189
 Part IV: Oversight Functions	 195
 Chapter 16 Quality Assurance	 197
Requirement for Quality Assurance (QA)	197
Quality Audits	198
ISO 9000 Quality Standard	202
Technical Records	204
Other Functions of QA	206
 Chapter 17 Quality Control	 207
Introduction	207
Quality Control Organization	207
FAA and JAA Differences	208
QC Inspector Qualifications	209

Basic Inspection Policies	210
Other QC Activities	211
Chapter 18 Reliability	217
Introduction	217
Types of Reliability	218
A Reliability Program	222
Elements of a Reliability Program	222
Other Functions of the Reliability Program	233
Administration and Management of the Reliability Program	233
Chapter 19 Maintenance Safety	237
Industrial Safety	237
Safety Regulations	237
Maintenance Safety Program	239
General Responsibilities for Safety	239
General Safety Rules	241
Accident and Injury Reporting	243
Part V: Appendixes	245
Appendix A. Systems Engineering	247
Introduction	247
Systematic versus Systems Approach	247
Systems Engineering	248
Definitions	249
System Interface Control	251
System Optimization	252
An Example of a System—The “Onion Layered” Structure	252
Summary	254
Appendix B. Human Factors in Maintenance	255
Background	255
Basic Definitions	256
Human Factors and Systems Engineering	256
Goals of the System versus Goals of the User	257
Designing for the Human Interface	258
Human Factors in Maintenance	258
Human Factors Responsibilities	259
Safety	260
Summary	260
Appendix C. The Art and Science of Troubleshooting	261
Introduction	261
Three Levels of Troubleshooting	262

Knowledge of Malfunctions	263
Knowledge Is Power	266
Building Your Own Knowledge Base	268
Understanding the Sequence of Events	269
Eight Basic Concepts of Troubleshooting	270
Summary	273
Appendix D. Investigation of Reliability Alerts	275
Introduction	275
A Review of Reliability	275
Alert Investigation—A Cross-Functional Activity	276
Zeroing in on the Problem	277
About the Alert Analysis Flow Charts	278
Appendix E. Extended Range Operations (ETOPS)	289
Introduction	289
Background	289
Deviation from the 60-Minute Rule	291
ETOPS Maintenance versus Conventional Maintenance	293
ETOPS for Non-ETOPS Airplanes	294
Polar Operations (AC 120-42B)	295
Polar Areas	295
Summary	296
Appendix F. Glossary	297
 Index	 307

List of Figures

Figure 1-1	The difference between theory and practice.	6
Figure 1-2	Restoration of system perfection.	7
Figure 1-3	Effects of redesign on system reliability.	8
Figure 1-4	Perfection vs. cost.	9
Figure 2-1	Simplified MSG-2 flow chart.	18
Figure 2-2	MSG-3—level I analysis—failure categories.	26
Figure 2-3	MSG-3—level II analysis—evident failures.	27
Figure 2-4	MSG-3—level II analysis—hidden failures.	28
Figure 4-1	FAA type certificate (sample).	47
Figure 4-2	FAA supplemental type certificate (sample).	48
Figure 4-3	FAA production certificate (sample).	50
Figure 4-4	FAA production limitation record (sample).	51
Figure 4-5	FAA airworthiness certificate (sample).	52
Figure 5-1	Example of an FIM.	60
Figure 5-2	ATA format for maintenance manuals.	71
Figure 7-1	Typical maintenance and engineering organization.	92
Figure II-1	Organizational chart for technical services.	103
Figure 9-1	The importance of planning.	119
Figure 12-1	Organizational chart for maintenance management and support.	146
Figure 13-1	Functions controlling maintenance.	152
Figure 13-2	Line maintenance operations—turnaround.	156
Figure 14-1	Ground support equipment categories.	175
Figure IV-1	Organizational chart for maintenance program evaluation.	196
Figure 18-1	Comparison of alert level calculation methods.	219
Figure 18-2	Calculation of new alert levels.	225
Figure 18-3	Reading alert status.	226
Figure 18-4	Dispersion of data points.	228
Figure 18-5	Standard bell-shaped curve.	229
Figure A-1	A Rube Goldberg system.	250
Figure D-1	Reliability alerts—a cross-functional process.	283
Figure D-2	Analysis of reliability alerts.	284
Figure D-3	Preliminary investigation of alert conditions.	285
Figure D-4	Detailed investigation of alert conditions.	286
Figure D-5	Determination of corrective action.	287

List of Tables

TABLE 1-1	Failure Rate Patterns	10
TABLE 2-1	MSG-2 Process Steps	17
TABLE 5-1	Manufacturer's Documentation	58
TABLE 5-2	Regulatory Documents	65
TABLE 5-3	Airline-Generated Documentation	67
TABLE 5-4	ATA Standard Chapter Numbers	70
TABLE 5-5	Airplane Maintenance Manual Page Block Assignments	72
TABLE 5-6	Technical Policies and Procedures Manual (TPPM)	75
TABLE 9-1	Aircraft Maintenance Check Schedule (Typical A/L Example)	122
TABLE 9-2	Average Check Package Man-hours (Example)	123
TABLE 9-3	Typical Aircraft "A" Check and "C" Check Schedule	124
TABLE 9-4	Summary of Aircraft Check Package Man-hours (Example B1 Check for A330 aircraft)	128
TABLE 10-1	Satellite Libraries	133
TABLE 10-2	Controlled Documents Listing	133
TABLE 13-1	Typical 48-Hour Check (Twin-Engine Jet)	159
TABLE 13-2	Typical Transit Check (Twin-Engine Jet)	160
TABLE 14-1	List of Ground Support Equipment (GSE) Items	176
TABLE 16-1	Quality Audits	199
TABLE 16-2	ISO 9000 Requirements for Quality Organizations	203
TABLE 16-3	Continuous Records	204
TABLE 16-4	Routine Records	205
TABLE 16-5	Repetitive Records	205
TABLE 16-6	Permanent Records	205
TABLE 17-1	NDT/NDI Techniques	212
TABLE 17-2	Mechanical Reliability Reports	214
TABLE 18-1	Pilot Reports per 100 Landings (by ATA Chapter)	230
TABLE 19-1	Occupational Safety and Health Standards	238
TABLE A-1	Systems and Subsystems	253
TABLE B-1	Human Factors Design Guidelines	258
TABLE C-1	Definitions	267
TABLE C-2	Questions to Ask in Troubleshooting	272

Fundamentals of Maintenance

“... maintenance is a science since its execution relies, sooner or later, on most or all of the sciences. It is an art because seemingly identical problems regularly demand and receive varying approaches and actions and because some managers, foremen, and mechanics display greater aptitude for it than others show or even attain. It is above all a philosophy because it is a discipline that can be applied intensively, modestly, or not at all, depending upon a wide range of variables that frequently transcend more immediate and obvious solutions.”

LINDLEY R. HIGGINS
Maintenance Engineering Handbook;
McGraw-Hill, NY, 1990.

These opening chapters contain basic information related to the aviation maintenance field and should be considered background for the maintenance management effort. Chapter 1 begins with a discussion of the fundamental reasons why we have to do maintenance in the first place. After all, our skills and techniques have improved immensely over the 100-year history of flight, but we haven't quite reached total perfection. And, considering the number of components on a modern aircraft, we realize early on that maintenance is a complex, ongoing process. For that reason, we need to approach it systematically.

We need a well-thought-out program to address the diverse activities we will encounter in this endeavor, so in Chap. 2 we will study the industry procedures for developing an initial maintenance program. We will discuss the various maintenance check packages (the 48-hour and transit check, the monthly “A” check, the yearly “C” check, etc.)

used to implement the maintenance tasks. We then address the ongoing process of adjusting that program during the lifetime of the equipment. In Chap. 3, we establish the goals and objectives for an airline maintenance program that will serve the real-life operation.

Chapter 4 discusses the extensive certification requirements levied on the aviation industry from the original design of the vehicle to the establishment of commercial operators and the people who run them. The documentation for the aircraft, its operation, and its maintenance, is discussed in Chap. 5 and includes the documents produced by the equipment manufacturers, by the regulatory authorities, and by the airline itself.

Chapter 6 will identify those activities required by the FAA to accomplish maintenance as well as those additional requirements deemed necessary by operators to coordinate and implement an effective maintenance and engineering program. Chapter 7 defines a maintenance and engineering (M&E) organization for a typical midsized airline. Variations for larger and smaller airlines will also be discussed. Part I, then, can serve as background to the remainder of the book and can, if desired, be used as the basis for a first or introductory course on the subject of aviation maintenance management.

Why We Have to Do Maintenance

Introduction

Why do we have to do maintenance? It is simple: “The maintenance of an aircraft provides assurance of flight safety, reliability, and airworthiness.” The aircraft maintenance department is responsible for accomplishing all maintenance tasks as per the aircraft manufacturer and the company’s requirements. The goal is a safe, reliable, and airworthy aircraft.

The aircraft maintenance department provides maintenance and preventive maintenance to ensure reliability, which translates into aircraft availability. These functions do not preclude a random failure or degradation of any part or system, but routine maintenance and checks will keep these from happening and keep the aircraft in good flying condition.

Thermodynamics Revisited

Nearly all engineering students have to take a course in thermodynamics in their undergraduate years. To some students, aerodynamicists and power plant engineers for example, thermodynamics is a major requirement for graduation. Others, such as electrical engineers for instance, take the course as a necessary requirement for graduation. Of course, thermodynamics and numerous other courses are “required” for all engineers because these courses apply to the various theories of science and engineering that must be understood to effectively apply the “college learning” to the real world. After all, that is what engineering is all about—bridging the gap between theory and reality.

There is one concept in thermodynamics that often puzzles students. That concept is labeled *entropy*. The academic experts in the thermodynamics field got together one day (as one thermo professor explained) to create a classical thermodynamic equation describing all the energy of a system—any system. When they finished, they had an equation of more than several terms; and all

but one of these terms were easily explainable. They identified the terms for heat energy, potential energy, kinetic energy, etc., but one term remained. They were puzzled about the meaning of this term. They knew they had done the work correctly; the term had to represent energy. So, after considerable pondering by these experts, the mysterious term was dubbed “unavailable energy”—energy that is unavailable for use. This explanation satisfied the basic law of thermodynamics that energy can neither be created nor destroyed; it can only be transformed. And it helped to validate their equation.

Let us shed a little more light on this. Energy is applied to create a system by manipulating, processing, and organizing various elements of the universe. More energy is applied to make the system do its prescribed job. And whenever the system is operated, the sum total of its output energy is less than the total energy input. While some of this can be attributed to heat loss through friction and other similar, traceable actions, there is still an imbalance of energy. Defining entropy as the “unavailable energy” of a system rectifies that imbalance.

The late Dr. Isaac Asimov, biophysicist and prolific writer of science fact and science fiction,¹ had the unique ability to explain the most difficult science to the layperson in simple, understandable terms. Dr. Asimov says that if you want to understand the concept of entropy in practical terms, think of it as the difference between the theoretically perfect system you have on the drawing board and the actual, physical system you have in hand. In other words, we can design perfect systems on paper, but we cannot build perfect systems in the real world. The difference between that which we design and that which we can build constitutes the natural entropy of the system.

A Saw Blade Has Width

This concept of entropy, or unavailable energy, can be illustrated by a simple example. Mathematically, it is possible to take a half of a number repeatedly forever. That is, half of one is $1/2$; half of that is $1/4$, half of that is $1/8$, and so on to infinity. Although the resulting number is smaller and smaller each time you divide, you can continue the process as long as you can stand to do so, and you will never reach the end.

Now, take a piece of wood about 2 feet long (a 2×4 will do) and a crosscut saw. Cut the board in half (on the short dimension). Then take one of the pieces and cut that in half. You can continue this until you reach a point where you can no longer hold the board to saw it. But, even if you could find some way to hold it while you sawed, you would soon reach a point where the piece you have left to cut is thinner than the saw blade itself. When (if) you saw it one more time, there will be nothing left at all—nothing but the pile of sawdust on the floor. The number of cuts made will be far less than the infinite number of times that you divided the number by two in theory.

¹Dr. Asimov wrote over 400 books during his lifetime.

The fact that the saw blade has width and that the act of sawing creates a kerf in the wood wider than the saw blade itself, constitutes the entropy of this system. And no matter how thin you make the saw blade, the fact that it has width will limit the number of cuts that can be made. Even a laser beam has width. This is a rather simple example, but you can see that the real world is not the same as the theoretical one that scientists and some engineers live in. Nothing is perfect.

The Role of the Engineer

The design of systems or components is not only limited by the imperfections of the physical world (i.e., the “natural entropy” of the system), it is also limited by a number of other constraints which we could refer to as “man-made entropy.” A design engineer may be limited from making the perfect design by the technology or the state of the art within any facet of the design effort. He or she may be limited by ability or technique; or, more often than not, the designer may be limited by economics; i.e., there just is not enough money to build that nearly perfect system that is on the drawing board or in the designer’s mind. Although the designer is limited by many factors, in the tradition of good engineering practice, the designer is obliged to build the best system possible within the constraints given.

Another common situation in design occurs when the designer has produced what he or she believes is the optimum system when the boss, who is responsible for budget asks, “How much will it cost to build this?” The designer has meticulously calculated that these widgets can be mass produced for \$1200 each. “Great,” says the boss. “Now redesign it so we can build it for under a thousand dollars.” That means redesign, usually with reduced tolerances, cheaper materials, and, unfortunately, more entropy. More entropy sometimes translates into more maintenance required. The design engineer’s primary concern, then, is to minimize (not eliminate) the entropy of the system he or she is designing while staying within the required constraints.

The Role of the Mechanic

The mechanic [aircraft maintenance technician (AMT), repairer, or maintainer], on the other hand, has a different problem. Let us, once again, refer to the field of thermodynamics. One important point to understand is that entropy not only exists in every system, but that the entropy of a system is always increasing. That means that the designed-in level of perfection (imperfection?) will not be permanent. Some components or systems will deteriorate from use, and some will deteriorate from lack of use (time or environment related). Misuse by an operator or user may also cause some premature deterioration or degradation of the system or even outright damage. This deterioration or degradation of the system represents an increase in the total entropy of the system. Therefore, while the engineer’s job is to minimize the

entropy of a system during design, the mechanic's job is to combat the natural, continual increase in the entropy of the system during its operational lifetime.

To summarize, it is the engineer's responsibility to design the system with as high degree of perfection (low entropy) as possible within reasonable limits. The mechanic's responsibility is to remove and replace parts, troubleshoot systems, isolate faults in systems by following the fault isolation manual (FIM, discussed in Chap. 5), and restore systems for their intended use.

Two Types of Maintenance

Figure 1-1 is a graph showing the level of perfection of a typical system. One hundred percent perfection is at the very top of the y-axis. The x-axis depicts time. There are no numbers on the scales on either axis since actual values have no meaning in this theoretical discussion. The left end of the curve shows the level of perfection attained by the designers of our real world system. Note that the curve begins to turn downward with time. This is a representation of the natural increase in entropy of the system—the natural

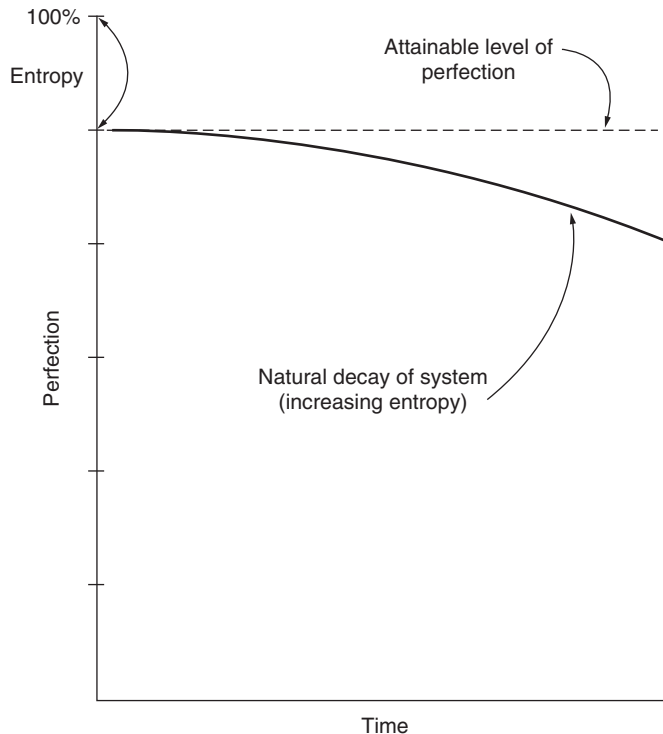


Figure 1-1 The difference between theory and practice.