

# Table of Contents

<b>Acknowledgments .....</b>	<b>ix</b>
<b>Chapter 1: Introduction .....</b>	<b>1</b>
1.1 Background.....	1
1.1.1 Maintenance and NFF–Historical Perspective .....	3
1.1.2 The Growth of NFF within Aerospace .....	4
1.1.3 NFF Related Literature .....	8
1.2 The NFF Phenomena.....	9
1.3 The Cost of NFF .....	13
1.4 Scope of This Book.....	14
1.5 References .....	15
<b>Chapter 2: Basics and Clarification of Terminology.....</b>	<b>17</b>
2.1 Introduction.....	17
2.2 Systems Basics.....	18
2.3 Failure and Types of Failure.....	19
2.4 Fault and Types of Fault.....	20
2.5 Maintenance and Related Terms.....	21
2.6 No Fault Found Terminology.....	23
2.6.1 NFF Classification.....	23
2.6.2 Case Study–The Impact of Inconsistent Terminology.....	30
2.6.3 Other Related Terms.....	31
2.7 Nomenclature.....	33
2.8 Conclusion .....	36
2.9 References .....	36
<b>Chapter 3: The Human Influence.....</b>	<b>39</b>
3.1 Introduction.....	39
3.2 The Human Element .....	40
3.2.1 Organizational Context.....	40
3.2.2 Communication .....	42
3.2.3 Human Factors Impacting NFF.....	44
3.3 The Maintenance Engineer and System Interactions .....	46
3.3.1 Typical Maintenance Processes in Civil Aircraft.....	46
3.3.2 Hardware Interactions .....	47
3.3.3 Software Interactions.....	48
3.3.4 Environment Interactions.....	49
3.4 Human Factors Survey .....	49
3.4.1 Introduction.....	49
3.4.2 Aircraft Testing Resources .....	50
3.4.3 Aircraft Maintenance Manuals.....	52
3.4.4 Organizational Pressures.....	53
3.4.5 Maintenance Engineer: Competence and Training.....	55

3.5	Best Practice Guidelines.....	58
3.6	Conclusion .....	59
3.7	References .....	60
<b>Chapter 4: Availability in Context .....</b>		<b>61</b>
4.1	Introduction.....	61
4.2	Aerospace Maintenance Practice .....	62
4.3	The Quality of Maintenance Systems .....	64
4.4	Design for Maintenance and System Effectiveness .....	66
4.5	Availability.....	67
4.5.1	The Multiple Facets of Availability .....	67
4.5.2	Design Requirements for RAM .....	71
4.6	The Impact of NFF on Availability .....	73
4.7	A Process for Improvement.....	77
4.7.1	Overview.....	77
4.7.2	A Methodology for Monitoring NFF In-Service .....	80
4.7.3	Unit Removal Datasheets .....	80
4.8	Conclusion .....	82
4.9	References .....	82
<b>Chapter 5: Safety Perceptions.....</b>		<b>85</b>
5.1	Introduction.....	85
5.2	Faults and Safety–Some Perceptions.....	86
5.3	A Conceptual Discussion.....	87
5.4	The Regulatory Issues in the Air Environment .....	89
5.5	Faults and the Link with Maintenance Errors .....	91
5.5.1	The Maintenance Contribution.....	91
5.5.2	Operational Pressure.....	92
5.5.3	The Human Factors Contribution .....	93
5.5.4	Diagnostic Maintenance Success.....	96
5.6	NFF and Air Safety–A Case Study .....	97
5.7	Conclusion .....	98
5.8	References .....	99
<b>Chapter 6: Operating Policies for Management Guidance .....</b>		<b>101</b>
6.1	Introduction.....	101
6.2	Through-Life Engineering Services Context.....	102
6.3	Policy Requirements.....	108
6.4	The NFF Control Process .....	111
6.5	Application Example.....	122
6.5.1	Introduction.....	122
6.5.2	Implementation Prerequisites.....	122
6.5.3	Application .....	123
6.6	Conclusion .....	125
6.7	References .....	126

## **Chapter 7: A Benchmark Tool for NFF ..... 127**

7.1	Introduction .....	127
7.2	Benefits of NFF Management.....	127
7.3	Challenges of Investigating NFF .....	130
	7.3.1 Technical Challenges .....	131
	7.3.2 Commercial Challenges.....	131
7.4	A Proposed Tool for Managing NFF .....	132
	7.4.1 The Benchmark Tool.....	132
	7.4.2 A NFF Maturity Model .....	133
7.5	Deployment of the Tool.....	143
	7.5.1 Stage 1.....	143
	7.5.2 Stage 2.....	143
	7.5.3 Stage 3.....	144
	7.5.4 Stage 4.....	144
7.6	Summary of the Tool .....	144
7.7	References .....	144

## **Chapter 8: Improving System and Diagnostic Design ..... 145**

8.1	Introduction .....	145
8.2	Diagnostics Design and NFF.....	146
	8.2.1 In-Service Feedback Activities .....	147
	8.2.2 Diagnostic Design Activities .....	148
8.3	System Design and System Integrity .....	149
8.4	Testability .....	150
	8.4.1 Testability Standards .....	151
8.5	Design for Diagnosis .....	152
8.6	Information Feedback to Diagnostic Design .....	153
8.7	Level of Training .....	154
8.8	User-Interaction and System Design.....	155
8.9	Conclusion .....	155
8.10	References .....	156

<b>Chapter 9: Technologies for Reducing No Fault Found.....</b>	<b>159</b>
9.1 Introduction.....	159
9.2 Advanced Diagnostics .....	160
9.2.1 Health and Usage Monitoring of Electrical Systems.....	160
9.2.2 Built-In Test.....	160
9.2.3 Monitoring and Reasoning of Failure Precursors .....	163
9.2.4 Monitoring Life-Cycle Loads .....	165
9.3 Improvements to Testing Abilities .....	166
9.3.1 Testability as a Design Variable .....	166
9.3.2 Functional and Integrity Testing .....	167
9.3.3 Testing Under Environmental Conditions .....	169
9.3.4 Management of the Test Station .....	170
9.3.5 Tracking Spare Part Units.....	171
9.4 Conclusion .....	172
9.5 References .....	173
<b>Chapter 10: Summary and Ideas for Future Work.....</b>	<b>175</b>
<b>Index .....</b>	<b>181</b>
<b>About the Authors .....</b>	<b>191</b>