# Table of Contents

## Chapter 1

**Introduction**
- Historical Perspective 2
- Current Practice 4
- CBM and SHM 6
- Systems Engineering Aspects of CBM 8
- Conclusions 10
- Abbreviations 10
- References 11

## Chapter 2

**“On Condition” Maintenance** 13

## Chapter 3

**Can a Fleet Be Over Maintained?** 29
- Introduction 29
- History of Preventive Maintenance 30
- Better Inspections Needed 30
- A Typical Preventive Maintenance Program 31
- Dependability and Cost Factors 31
- The Inspectors 32

## Chapter 4

**Economic Considerations in Maintenance Program Development** 33
- Why Have a Maintenance Program? 34
- Maintenance and Reliability 36
- Program Evolution 36
- Economic Impact 37
- Conclusions 41
- References 41
CHAPTER 5

Airline Maintenance Operations and Programs 43

Introduction 43
Airline Maintenance 44
Fleet Size 44
Number of Aircraft Types 44
Route Network 45
Number of Stations 45
Skill Levels 45
Aircraft Complexity 46
Maintenance Delays 46
Background 46
Delay Costs 47
Maintenance Costs 47
Labor Costs 47
Maintenance Programs 48
Engines 49
Shop Maintenance 49
ETOPS 49
Safety 50
Conclusions 50
About the Author 51

CHAPTER 6

A Framework for Developing an EPS Health Management System 53

Introduction 53
System Health Management Principles 54
An EPS Health Management System Development Framework 55
Developing System Requirements 57
Application to 737/P-8A Aircraft EPS Components 58
Integration into the Vehicle and Support System 59
Conclusion 61
Acknowledgments 61
References 61
CH A P T E R  7

Design and Implementation of Aircraft System Health Management (ASHM) Utilizing Existing Data Feeds

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>63</td>
</tr>
<tr>
<td>Aircraft Data Sources</td>
<td>64</td>
</tr>
<tr>
<td>Summary of Software Architecture</td>
<td>65</td>
</tr>
<tr>
<td>Custom Analytic Development Process</td>
<td>67</td>
</tr>
<tr>
<td>Generation of Actionable Information</td>
<td>71</td>
</tr>
<tr>
<td>Case Study: Coolant Leakage</td>
<td>72</td>
</tr>
<tr>
<td>Summary/Conclusions</td>
<td>74</td>
</tr>
<tr>
<td>References</td>
<td>75</td>
</tr>
<tr>
<td>Definitions/Abbreviations</td>
<td>75</td>
</tr>
</tbody>
</table>

CH A P T E R  8

New Guidelines for Implementation of Structural Health Monitoring in Aerospace Applications

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>78</td>
</tr>
<tr>
<td>The Scope and Major Components of SHM Guidelines ARP 6461</td>
<td>79</td>
</tr>
<tr>
<td>Scope</td>
<td>80</td>
</tr>
<tr>
<td>Essential Aspects of SHM</td>
<td>81</td>
</tr>
<tr>
<td>Automated SHM</td>
<td>82</td>
</tr>
<tr>
<td>SHM Requirements</td>
<td>83</td>
</tr>
<tr>
<td>Detection Requirements</td>
<td>85</td>
</tr>
<tr>
<td>Technology Assessment</td>
<td>86</td>
</tr>
<tr>
<td>Validation and Verification of SHM</td>
<td>88</td>
</tr>
<tr>
<td>Methods for Verification and Validation</td>
<td>88</td>
</tr>
<tr>
<td>Certification of SHM</td>
<td>89</td>
</tr>
<tr>
<td>Implementation of SHM in Military Aircraft</td>
<td>89</td>
</tr>
<tr>
<td>Conclusions and Summary</td>
<td>90</td>
</tr>
<tr>
<td>References</td>
<td>91</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>91</td>
</tr>
</tbody>
</table>
CHAPTER 9

Challenges for Costs and Benefits Evaluation of IVHM Systems

Introduction 93

IVHM Systems 94
  Systems Health Management
  Structural Health Management

Challenges for IVHM Cost-Benefit Analysis 97
  Structural Health Management
    Knowledge of MSG-3 Methodology and Continuous Airworthiness Requirements 98
    Starting with S-SHM Applications 98
    Simplify the S-SHM Ground Support Equipment 99
    Develop S-SHM Systems as "Bridges" for Initial A-SHM Applications 100
  Systems Health Management
  Other Challenges 102

Summary/Conclusions 103

References 103

Definitions/Abbreviations 104

CHAPTER 10

Developing IVHM Requirements for Aerospace Systems

Introduction 108

General Considerations 109

The Process of Developing Requirements 110
  Exploratory and Concept Stage 112
  Development and Production Stage 112
    High Level Requirements 112
    Detailed Design 112
    System Implementation and Testing 113

Guidelines and an Example 113
  Exploratory and Concept 113
  High Level Requirements 114
  Allocation of Requirements to the Platform 115
  Flow Down Process and Low Level Requirements 116
    Requirements for LGS Performance Indication 117
    Requirements for Proximity Sensor Degradation 117
    System Verification and Validation 117
CHAPTER 11

Creating a System Architecture for a Vehicle
Condition-Based Maintenance System

Introduction 122

The Architecture Development Process 123

Develop CBM System Architecture: A Case Study 125

The Case Description 125

Requirements Definition 126

The Scope of the CBM System 126

The CBM System Design Constraints 127

The CBM System Operational Scenarios 127

The CBM System Functional Analysis and Functional Requirements 129

The CBM System Quality Requirements 129

CBM Architecture Development 130

Conclusions 131

References 131

Contact Information 132

Definitions/Abbreviations 132

About the Author 133