Contents

Foreword xiii
Acknowledgements xiv
Series Preface xv
Preface xvii
Units and Abbreviations xix

1 Introduction to Unmanned Aircraft Systems (UAS) 1
1.1 Some Applications of UAS 1
1.2 What are UAS? 3
1.3 Why Unmanned Aircraft? 5
1.4 The Systemic Basis of UAS 9
1.5 System Composition 9
References 15

Part 1 THE DESIGN OF UAV SYSTEMS 17

2 Introduction to Design and Selection of the System 19
2.1 Conceptual Phase 19
2.2 Preliminary Design 20
2.3 Detail Design 20
2.4 Selection of the System 20

3 Aerodynamics and Airframe Configurations 25
3.1 Lift-induced Drag 25
3.2 Parasitic Drag 26
3.3 Rotary-wing Aerodynamics 29
3.4 Response to Air Turbulence 32
3.5 Airframe Configurations 34
3.6 Summary 42
References 43

4 Characteristics of Aircraft Types 45
4.1 Long-endurance, Long-range Rôle Aircraft 45
4.2 Medium-range, Tactical Aircraft 55
## Contents

4.3 Close-range/Battlefield Aircraft 59  
4.4 MUAV Types 66  
4.5 MAV and NAV Types 68  
4.6 UCAV 70  
4.7 Novel Hybrid Aircraft Configurations 71  
4.8 Research UAV 74  
References 74  

5  Design Standards and Regulatory Aspects 75  
5.1 Introduction 75  
5.2 United Kingdom 76  
5.3 Europe 88  
5.4 United States of America 88  
5.5 Conclusion 89  
References 89  

6  Aspects of Airframe Design 91  
6.1 Scale Effects 91  
6.2 Packaging Density 93  
6.3 Aerodynamics 94  
6.4 Structures and Mechanisms 95  
6.5 Selection of power-plants 101  
6.6 Modular Construction 106  
6.7 Ancillary Equipment 112  
References 112  

7  Design for Stealth 113  
7.1 Acoustic Signature 114  
7.2 Visual Signature 115  
7.3 Thermal Signature 116  
7.4 Radio/Radar Signature 117  
7.5 Examples in Practice 118  
Reference 126  

8  Payload Types 127  
8.1 Nondispensable Payloads 128  
8.2 Dispensable Payloads 141  
Reference 141  

9  Communications 143  
9.1 Communication Media 143  
9.2 Radio Communication 144  
9.3 Mid-air Collision (MAC) Avoidance 151  
9.4 Communications Data Rate and Bandwidth Usage 151  
9.5 Antenna Types 152  
References 154  

10  Control and Stability 155  
10.1 HTOL Aircraft 155  
10.2 Helicopters 159
Contents

10.3 Convertible Rotor Aircraft 163
10.4 Payload Control 165
10.5 Sensors 165
10.6 Autonomy 167
References 167

11 Navigation 169
11.1 NAVSTAR Global Positioning System (GPS) 169
11.2 TACAN 170
11.3 LORAN C 170
11.4 Inertial Navigation 171
11.5 Radio Tracking 171
11.6 Way-point Navigation 172
References 172

12 Launch and Recovery 173
12.1 Launch 173
12.2 Recovery 177
12.3 Summary 181

13 Control Stations 183
13.1 Control Station Composition 183
13.2 Open System Architecture 185
13.3 Mini-UAV ‘Laptop’ Ground Control Station 185
13.4 Close-range UAV Systems GCS 186
13.5 Medium- and Long-range UAV System GCS 190
13.6 Sea Control Stations (SCS) 195
13.7 Air Control Stations (ACS) 195

14 Support Equipment 197
14.1 Operating and Maintenance Manuals 197
14.2 Consumables 198
14.3 Replaceable Components 198
14.4 Vulnerable and On-condition Components 198
14.5 Tools 198
14.6 Subsidiary Equipment 199

15 Transportation 201
15.1 Micro-UAV 201
15.2 VTOL Close-range Systems 201
15.3 HTOL Close-range Systems 201
15.4 Medium-range Systems 202
15.5 MALE and HALE Systems 203

16 Design for Reliability 205
16.1 Determination of the Required Level of Reliability 206
16.2 Achieving Reliability 208
16.3 Reliability Data Presentation 210
16.4 Multiplexed Systems 212
16.5 Reliability by Design 213
16.6 Design for Ease of Maintenance 216
17 Design for Manufacture and Development

Part 2 THE DEVELOPMENT OF UAV SYSTEMS

18 Introduction to System Development and Certification
18.1 System Development
18.2 Certification
18.3 Establishing Reliability

19 System Ground Testing
19.1 UAV Component Testing
19.2 UAV Sub-assembly and Sub-system Testing
19.3 Testing Complete UAV
19.4 Control Station Testing
19.5 Catapult Launch System Tests
19.6 Documentation

20 System In-flight Testing
20.1 Test Sites
20.2 Preparation for In-flight Testing
20.3 In-flight Testing
20.4 System Certification

Part 3 THE DEPLOYMENT OF UAV SYSTEMS

21 Operational Trials and Full Certification
21.1 Company Trials
21.2 Customer Trials and Sales Demonstrations

22 UAV System Deployment
22.1 Introduction
22.2 Network-centric Operations (NCO)
22.3 Teaming with Manned and Other Unmanned Systems

23 Naval Rôles
23.1 Fleet Detection and Shadowing
23.2 Radar Confusion
23.3 Missile Decoy
23.4 Anti-submarine Warfare
23.5 Radio Relay
23.6 Port Protection
23.7 Over-beach Reconnaissance
23.8 Fisheries Protection
23.9 Detection of Illegal Imports
23.10 Electronic Intelligence
23.11 Maritime Surveillance
23.12 Summary
Contents

24 Army Rôles 259
24.1 Covert Reconnaissance and Surveillance 259
24.2 Fall-of-shot Plotting 261
24.3 Target Designation by Laser 261
24.4 NBC Contamination Monitoring 263
24.5 IED and Landmine Detection and Destruction 266
24.6 Electronic Intelligence 266
24.7 Teaming of Manned and Unmanned Systems 266
24.8 System Mobility 266
24.9 Persistent Urban Surveillance 267

25 Air Force Rôles 269
25.1 Long-range Reconnaissance and Strike 269
25.2 Airborne Early Warning 269
25.3 Electronic Intelligence 269
25.4 Pre-strike Radar and Anti-aircraft Systems Counter 270
25.5 Interception 270
25.6 Airfield Security 270

26 Civilian, Paramilitary and Commercial Rôles 273
26.1 Aerial Photography* 273
26.2 Agriculture 273
26.3 Coastguard and Lifeboat Institutions 274
26.4 Customs and Excise 275
26.5 Conservation 275
26.6 Electricity Companies 275
26.7 Fire Services 276
26.8 Fisheries 276
26.9 Gas and Oil Supply Companies 277
26.10 Information Services 277
26.11 Local Civic Authorities 277
26.12 Meteorological Services* 277
26.13 Traffic Agencies 277
26.14 Ordnance Survey 278
26.15 Police Authorities* 278
26.16 Rivers Authorities and Water Boards 278
26.17 Survey Organisations 278
26.18 Communications Relay 278
26.19 Landmine Detection and Destruction 279
26.20 Other Applications 279

References 279

Part 4 UAS FUTURE 281

27 Future Prospects and Challenges 283
27.1 Introduction 283
27.2 Operation in Civilian Airspace 284
27.3 Power-plant Development 288
27.4 Developments in Airframe Configurations 292
<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.5 Autonomy and Artificial Intelligence</td>
</tr>
<tr>
<td>27.6 Improvement in Communication Systems</td>
</tr>
<tr>
<td>References</td>
</tr>
<tr>
<td>28 UAV Systems Continuing Evolution</td>
</tr>
<tr>
<td>28.1 Introduction</td>
</tr>
<tr>
<td>28.2 Cruise Missiles</td>
</tr>
<tr>
<td>28.3 World War II Systems</td>
</tr>
<tr>
<td>28.4 The 1950s</td>
</tr>
<tr>
<td>28.5 The 1960s</td>
</tr>
<tr>
<td>28.6 The 1970s</td>
</tr>
<tr>
<td>28.7 The 1980s</td>
</tr>
<tr>
<td>28.8 The 1990s</td>
</tr>
<tr>
<td>28.9 The 2000s</td>
</tr>
<tr>
<td>28.10 The 2010s</td>
</tr>
<tr>
<td>28.11 Into the Future</td>
</tr>
<tr>
<td>Appendix A: UAS Organisations</td>
</tr>
<tr>
<td>A.1 Conferences</td>
</tr>
<tr>
<td>A.2 Industry Associations</td>
</tr>
<tr>
<td>A.3 Press Organisations</td>
</tr>
<tr>
<td>A.4 Useful Websites</td>
</tr>
<tr>
<td>A.5 Test Site Facilities</td>
</tr>
<tr>
<td>A.6 Regulators</td>
</tr>
<tr>
<td>Index</td>
</tr>
</tbody>
</table>