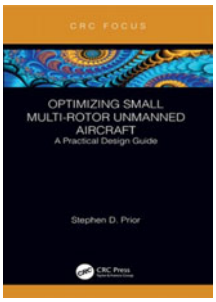


# Optimising Small Multi-Rotor Unmanned Aircraft: A Practical Design Guide

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*CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA. 2018. Distributed by Taylor & Francis Group, 2 Park Square, Milton Park, Abingdon OX14 4RN, UK. xviii; 119 pp. Illustrated. £51.99. (20% discount available to RAeS members via www.crcpress.com using AKQ07 promotion code). ISBN 978-1-138-36988-7.*

*Optimising Small Multi-Rotor Unmanned Aircraft* is a handy monograph for students or professionals wishing to design their own multi-rotor flying platform instead of buying and assembling a kit. It is also beneficial for those who have purchased a kit and wish to modify it to enhance specific flight parameters. At this juncture, I would strongly agree with the author that, until recently, there was very little consolidated information in literature that could help the would-be technical multi-rotor designer to quickly get accustomed to the required technology and then select key components to start a build. This book is a good entry-level monograph from a practical point of view.

The book can be roughly divided into four logical sections that are interconnected. The first section consists of six small components which act as a mini-road map. It may not be required in a first reading unless the reader is intent on reading it cover to cover. However, it is useful when the book is used as a reference resource, or when the reader, on subsequent readings, recalls a piece of information and wishes to locate it quickly within the book.

The preface begins by providing a background to the development of the material presented in it. The author provides the courses and projects taught by him previously in international institutions. He also introduces the student competitions of IMechE from 2015 to 2018, which forms the basis of the development work of multi-rotor unmanned aerial platforms and sets the tone for the rest of the book.

The main section comprises seven main chapters and six appendices. Along the way, the author makes many useful references to the requirements of the IMechE design competition as well as other competitions. The reason for this is that the rules and regulations of these competitions are closely correlated to CAA regulations on commercial drone operations.

Chapters 1 to 5 rapidly bring the reader up to speed with the basic components which make up the airframe and propulsion system of a multi-rotor and their operations. Chapter 1 is a short, three-page introduction and covers initial design and configurations. Ironically, this section does not cover the reasons for selection and pros/cons

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of different airframe configurations such as quad crucifix, quad diagonal, trirotor, hexacopter hub and spoke, hexacopter Y, octo and so on. It simply mentions in passing that these configurations exist. However, it heavily emphasises the iterative nature of the design and design optimisation process and provides the component steps that should be taken to arrive at a design.

Chapter 2 covers batteries. The emphasis is on the various parameters such as discharge rate, capacity, weight and so on. The author has also linked the material with battery data which can be used for design selection in appendix A. In addition, he has also touched upon connectors; very often, these small details are overlooked in other, more theoretical literature.

Chapter 3 covers electronic speed controllers. The author has elaborated on the practical aspects, selection, programming and limitations of Electronic Speed Controllers (ESCs), which are a requirement if the type of motors in the subsequent chapter is used. The author has also included comments on ESC programming.

Chapter 4 covers Brushless Direct Current (BLDC) outrunner motors. Their conceptual design and principle of operation is covered, followed by the operating principles. This is then logically followed by useful formulas which allow analytical and empirical predictions of motor performance, namely power and torque outputs and associated current draw based on input voltage.

Chapter 5 covers propellers. The author has gone to great pains to cover propeller selection from both analytical and experimental perspectives. The advantage of this section is the highlighting of the experimental setup to obtain both static and dynamic thrusts such as the motor test rig in a wind tunnel. The author has correctly pointed out that these propellers must be tested on a rig and preferably mounted in a wind tunnel to correctly determine actual efficiency and thrusts. He has also correlated the techniques with the right amount of analytical and numerical content, from the calculation of local Reynolds numbers and the use of aerofoil tools to the estimation of thrust using momentum disc theory. Finally, it covers wash effects and thrust reduction of coaxial contra-rotating propellers as well.

The novice multi-rotor builder and the technical hobbyist should begin with a thorough reading of these first five chapters. Chapter 6 is where all the material in the previous four chapters comes together and is applied to the design of multi-rotor aircraft. The unique aspect of this chapter is the introduction of an Excel spreadsheet which allows the designer to carry out ‘what–if’ analysis to ‘fine-tune’ or optimise the design. It is, however, not very convenient that the Excel sheet is displayed in a very tiny font n the appendix. What is useful though is the introduction of the following concepts; firstly, the dihedral and cant of motor mounts for stability, and secondly, the discussion of effective frontal propeller area as related to the pitch of the multirotor and vectored thrusting propulsion.

Chapter 7 is the concluding chapter and talks about future trends in multirotor platform design. This chapter is useful in providing a forward-looking scope to the book. It contributes to the book’s relevance in a sector which has well become one of the fastest growing in the field of aerospace.

Plenty of other useful information is included in the book, such as safety aspects

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of operation, safe battery charging, communication frequencies and the wiring layout of a widely used drone autopilot – the PIXHAWK.

Reflectively, from an active user's standpoint, the book could have been a little bit better had there been greater use of the wonderful case studies of the platform included with associated calculations in appendix E of the book. This appendix showcases the parameters and specifications of platforms which won the IMechE competitions. There has not been an explicit correlation of these calculations with the component selection spreadsheet in Appendix D.

A book which is targeted at practitioners should have the right balance of technical complexity, where the number of formulas should be sufficient to calculate key design parameters. In addition, the book should not, and in this case does not, tire the reader with endless derivations from first principles. The language used allows for easy understanding of the material.

Academics and theorists might argue that most of the material in the book does conform to the academic definition of optimisation where multi-objectives are defined in terms of mathematical equations and algorithms are run to satisfy constraints for a specific design point. This reviewer would argue that this optimisation has been done with a different context in mind: the iterative design procedure utilised and appropriate for this scale of aircraft in this specific design environment. Hence, both the title and content are totally compatible with the subject area and target audience.

In conclusion, this book is well suited to the target readership of the advanced hobbyist or the undergraduate student doing a final-year project or competition project involving advanced design of multi-rotor unmanned vehicles.

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