

# **Elements of aviation acoustics**



**Elements of  
aviation acoustics**

**G.J.J. Ruijgrok**

VSSD

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# PREFACE

## ABOUT THE CONTENTS

Quieting cabin and flight deck noise, and reducing the impact of noise on communities near airports are matters of great importance to air-manufacturers and airline operators for already more than four decades.

Undoubtedly, knowledge of both aeronautics and acoustics is essential for a clear understanding of any aviation noise problem. Such understanding is a necessary prerequisite to the control of interior and exterior noise.

In view of the importance of education in dealing with noise control, this book is devoted to the branch of aerospace engineering known as aviation acoustics.

The book contains twelve chapters and three appendixes which originate from an annual course on airplane noise given by the author to aerospace engineering students at Delft University of Technology (DUT).

The book is intended to be useful to undergraduate students of aerospace engineering, and also to researchers and practicing engineers who wish to improve their understanding of the topic.

The text assumes little or no previous knowledge of acoustics. For this reason, the first chapter introduces basic facts and concepts about the generation, propagation and specification of sound. The second chapter describes the dynamics of sound waves. Since acoustics can be seen as a fluid mechanics discipline, this chapter starts with deriving the three basic equations of classical aerodynamic theory. These equations are then linearized to obtain their acoustic equivalents and combined into a single wave equation. Also the solutions of plane and spherical wave propagation are presented.

The third chapter develops the free-field radiation properties of the three principal sources of sound, i.e., the acoustic monopole, dipole, and quadrupole. In Chapter the manner four is considered in which the propagation of sound away from the source is influenced by distance, atmospheric absorption losses, and refractive conditions due to vertical wind and temperature gradients. Also a procedure for the determination of atmospheric attenuation rate has been included.

Chapter five outlines, in a concise form, the types of sound field occurring in enclosures and the absorption of sound energy by the walls. Chapter six briefly describes the attenuation of sound in ducts provided by cross-sectional area changes and wall cavities.

In Chapter seven certain practical aspects of frequency analysis are treated, and Chapter eight is concerned with the effects of ground reflection on observed noise levels.

Chapter nine deals with the subjective assessment of airplane noise. The chapter is supplemented by Appendix A, providing data for the calculation of the perceived noisiness of sounds.

A review of the international standards and recommended practices for civil aircraft as published in Annex 16 to the Chicago Convention on International Civil Aviation is given in Chapter ten.

The effects of forward motion on the radiation characteristics of a sound source is the subject of discussion in Chapter eleven. This chapter also includes sections on sonic boom and microphone selection.

The concluding chapter (12) examines the various noise sources found on the different types of airplane.

Experimental results throughout the book are presented in order to illustrate the basic theory enunciated in the text.

References to the literature are indicated in the text and listed at the end of the text. In the book the International System of Units (Système International d'Unités) is used. Besides these metric units, in international civil aviation the use of certain English units is prescribed, such as foot for altitude, and so these are also cited in the text.

In Appendix B information is given about the SI-units. Also a number of factors with which English units can be converted into metric SI-units are tabulated.

In bringing the book to a close, a glossary of terms that appear in the text are collected in Appendix F.

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Delft, The Netherlands  
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This second edition includes three new appendices C, D and E, that describe the assessment of aircraft noise in the vicinity of Dutch airfields, an improved method for the prediction of lateral noise attenuation and existing noise abatement procedures, respectively.

Also the errors found in the first edition have been corrected.

Delft, The Netherlands  
G.J.J. Ruijgrok 1 August 2000