



SERIES EDITOR: **JOE WATSON**

**SENSORS TECHNOLOGY SERIES**

# **AEROSPACE SENSORS**



EDITED BY

**ALEXANDER NEBYLOV**



**MOMENTUM PRESS**

# **AEROSPACE SENSORS**



# **AEROSPACE SENSORS**

**ALEXANDER V. NEBYLOV**



**MOMENTUM PRESS, LLC, NEW YORK**

*Aerospace Sensors*

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# SERIES PREFACE

The present series is concerned with sensors *per se*, and because the subject matter is so wide-ranging in both scope and maturity, this must be reflected within the individual volumes. So, whereas care has been taken to include a considerable amount of practical material, the proportion of such leavening is inevitably variable. The present volume will be found to include material on the basic processes that are addressed by the sensors used in most aspects of aerospace technology, plus considerable detail on the relevant sensors themselves and their applications. In the context of aerospace engineering, however, there are many items of complex equipment—mostly radio and navigationally oriented—that can be considered as sensors in their own right. This situation has been addressed in a companion volume that is in production at the time of writing, and will act as an adjunct to the present work.

Sensors cannot, of course, be divorced from their associated instrumentation, and problems that arise in atmospheric flight (aircraft) are to some considerable extent different from those relevant to space flight (spacecraft). Nevertheless, many aeronautically-oriented sensors do qualify for use in spacecraft, especially those like NASA's now-retired shuttle, that need terrestrial and landing instrumentation. Hence, there is still common ground between the two, and this has been addressed by the inclusion of some basic material on both atmospheric and space flight.

Much of aerospace engineering is currently—and happily—an international endeavor, and the present volume clearly recognizes this by the inclusion of material from both Eastern and Western countries. In particular, it has benefited greatly from the expertise of the Volume Editor and contributor, Alexander V. Nebylov, one of Russia's most eminent authorities in the field.

J. Watson,  
Series Editor  
Swansea, UK, 2012



# PREFACE

This book is devoted to modern sensors and their applications in control systems relevant to aerospace vehicles.

Two centuries ago, a person who wished to move faster than walking or running would mount a good horse and enjoy riding using all his or her sensory perceptions. Since that time, many kinds of vehicles have been created for satisfying the desire for fast and elaborate transportation. In the air, and more recently in space, considerable increases in the speed-ranges of various forms of transport have taken place, but have demanded the creation of a huge variety of sensing elements for detecting the state and behavior of the relevant vehicles.

A horse-rider does not need to supervise the function of a horse's legs, and to turn, it is enough to give a clear command via the harness. However, all aerospace vehicles demand the monitoring of many parameters and it is only recently that control systems have become sufficiently "intelligent" to relieve the pilot of constantly monitoring the behavior of those parameters and interpreting their aggregate meaning. Thus, a modern aerospace vehicle may be compared to a good horse, which itself knows how to operate each leg so as to orient its body in the direction desired by its rider.

Another example is afforded by birds, which may be considered excellent examples of "intelligent" flight control. They too can be compared with modern aircraft, which some believe are actually winning the competition with nature, and which demand near-perfect sensors and control algorithms for the realization of such phenomenal performance.

The automatic control of aerospace systems with huge numbers of operating parameters is one of the highest technological achievements of modern civilization, and does indeed compete functionally with those inherent in natural life-forms, including human beings. However, the operating principles of the various necessary sensors and automatic systems are often essentially different from those utilized in nature and form the knowledge base of leading designers and firms in the field of aerospace instrumentation. It should also be noted that the majority of aerospace sensors differ considerably from those designed for applications in automobile, ship, railway, and other forms of transportation, or those used in industrial, chemical, medicinal, and other areas. The topic of aerospace sensors therefore merits special treatment, and it is hoped that this book will to some extent fulfill this requirement.

The intent of the volume is to present the fundamentals of design, construction and application of numerous aerospace sensors, a concept born in the International Federation of Automatic Control (IFAC), especially in its Aerospace Technical Committee. An international team of twelve authors represents four countries from Eastern and Western Europe and North America, and all of whom have considerable experience in aerospace sensor and systems design.