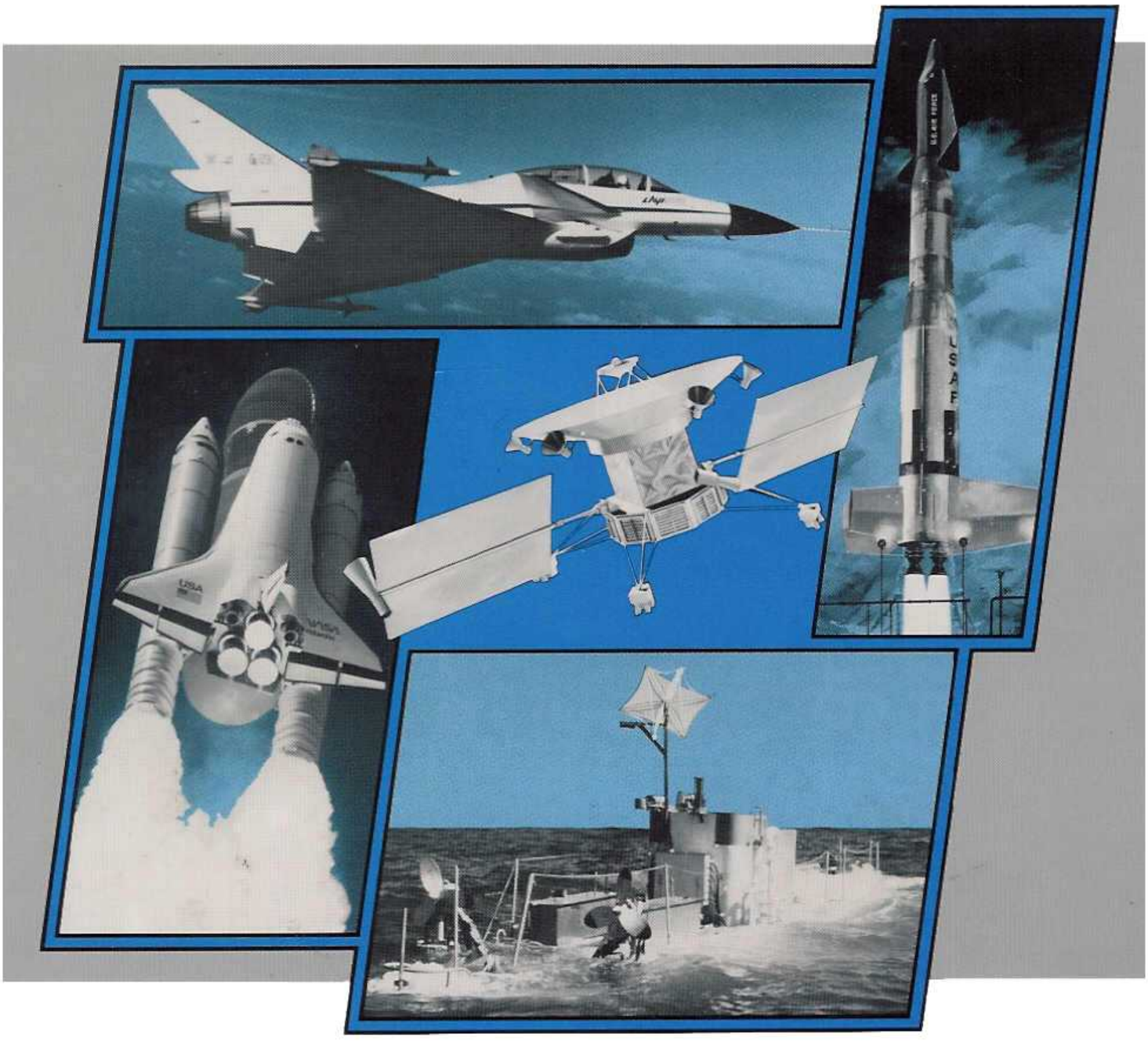
Prentice Hall Series in Advanced Navigation, Guidance, and Control, and Their Applications

MODERN NAVIGATION, GUIDANCE, AND CONTROL PROCESSING

Ching-Fang Lin



Modern Navigation, Guidance, and Control Processing

PRENTICE HALL SERIES IN ADVANCED NAVIGATION, GUIDANCE, AND CONTROL, AND THEIR APPLICATIONS

by Ching-Fang Lin

Modeling, Design, Analysis, Simulation, and Evaluation (MDASE)

Modern Navigation, Guidance, and Control Processing

Advanced Control Systems Design

Integrated, Adaptive, and Intelligent Navigation, Guidance, and Control Systems Design

Digital Navigation, Guidance, and Control Systems Design

Modern Navigation, Guidance, and Control Processing

Ching-Fang Lin

American GNC Corporation

Prentice Hall, Englewood Cliffs, New Jersey 07632

Library of Congress Cataloging-in-Publication Data

Lin, Ching-Fang.
Modern navigation, guidance, and control processing / by Ching
-Fang Lin.
p. cm. -- (Series in advanced navigation, guidance, and
control, and their applications ; bk. 2)
Includes bibliographical references and index.
ISBN 0-13-596230-7
1. Flight control. 2. Guided missiles--Control systems.
I. Title. II. Series.
TL589.4.L55 1991
629.1--dc20 90-43099
CIP

Editorial/production supervision
and interior design: *Brendan M. Stewart*
Cover design: *Bruce Kenselaar*
Manufacturing buyers: *Kelly Behr* and *Susan Brunke*
Acquisitions editors: *Bernard Goodwin* and *Michael Hays*

A Simon & Schuster Company
Englewood Cliffs, New Jersey 07632

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

ISBN 0-13-596230-7

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
Prentice-Hall Hispanoamericana, S.A., *Mexico*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Simon & Schuster Asia Pte. Ltd., *Singapore*
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

To my family
for their love, understanding,
and support throughout.

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Series Foreword

The role played by modern navigation, guidance, and control (NGC) in the development and advancement of such areas as commercial and military aviation, to name only two, has continually expanded since its earliest inception in the 1950's. As this field began to grow and take on added importance, many books were written dealing mainly with the theoretical aspects of NGC, but most of these were confined to the earlier years of NGC development. Currently, although NGC system applications continue to take on an ever-increasing importance, the availability of reference books, especially textbooks suitable for graduate level and advanced undergraduate students as well as those who practice in the field, has not kept pace. This series emphasizing NGC systems and their applications is long overdue; in fact, it has been 30 years since such a series dealing with NGC systems has been written and available to the academic and professional communities. Moreover, it is the first ever such series to thoroughly discuss the advanced control system design (modern multivariable control analysis; robust control; estimation; adaptive control; nonlinear control; intelligent control; etc.). It comes at a time when concern over issues such as the status of education and the decreasing number of trained, qualified professionals in this country is at an all-time high. It is against such a background that the present series was conceived to assess state-of-the-art systems and control theories, and engineering applications of advanced NGC systems. Another purpose of the series is to develop future research agenda and at the same time encourage

discussions in those areas that do not always find the systems and control community in complete agreement.

The series provides a comprehensive coverage of the latest NGC technology as follows. The first book begins by introducing the various applications of NGC systems, after which it provides a thorough, fundamental treatment of what is considered the five most important stages in NGC system development: modeling, design, analysis, simulation, and evaluation (MDASE). The second book in the series takes up the subject of advanced estimation and guidance systems design, as well as NGC processing. The third book is concerned with the subject of advanced control system design, with particular emphasis placed on the topic of flight control system (FCS) design. The topics that constitute the fourth book include integrated, adaptive, and intelligent NGC systems design, while the fifth book is devoted completely to digital NGC systems design. Although most of the material in these five books is self-contained, there is a natural progression in the series as a whole toward more advanced topics. For example, much of the material in the second book actually serves as a prelude to the third, fourth, and fifth books.

These books are the result of several years of experience gained on the part of the author/editor both as a professor at the university level and as a practitioner in the field. It is believed that this series will provide invaluable insight and instruction to students, mainly at the graduate level but also to advanced undergraduate students, as well as to those engineers who work directly or indirectly in the field of NGC system design and applications. In addition, this series is intended to provide both engineers and managers with the advanced NGC knowledge and concepts necessary to make correct decisions concerning the best NGC system design in a particular situation.

Preface

It is very likely that few people who labor in any scientific discipline are unaware of the contributions of advanced navigation, guidance, and control (NGC) theory to aerospace-related programs. It is, however, equally unlikely that many are aware of the dramatic impact of this field on such diverse areas as medicine, industrial manufacturing, energy management, and chemical engineering. While its broad range of applications would at first appear to indicate that advanced NGC theory is enjoying an immense popularity in scientific and academic settings in general, this unfortunately turns out not to be the case. It is felt by many experts that many of those in the aerospace field in particular either are content to rest on the laurels surrounding the success of NGC theory developed in the 1950's and 1960's or have become so conservative in their design philosophies as to be unduly apprehensive about using advanced NGC theory. The latter appears to be especially true in the area of aviation.

The author is quick to point out, however, that the NGC field itself is somewhat responsible for many of the misperceptions on the part of those who are not convinced of the usefulness of advanced NGC theory. More than a mere shadow of doubt has been cast on the usefulness of this theory as a result of its having taken

a much too mathematically-oriented turn almost immediately after the theory was first applied in the solution of practical problems. It is the author's opinion that, while NGC theory is built around a rather beautiful framework of mathematics, its primary emphasis must nonetheless always be placed on solving engineering problems of great practical importance. NGC technology has always been the focal point of aerospace engineering and automation research and development. A combination of theoretical concepts, the rapid evolution of computer and microelectronics technology, and the continued refinement of sensor and actuator technology has contributed to its advances. This book examines the role of modern NGC processing in the design of advanced NGC systems.

This volume places major emphasis on the practical applications of advanced NGC systems, treating the subject more from an engineering than a mathematical perspective. Nevertheless, theoretical and mathematical concepts are introduced and adequately developed to make the book a self-sufficient source of instruction for readers. The intent of this book is to enable readers to achieve a level of competence that will permit their participation in the practical applications of modeling, design, analysis, simulation, and evaluation (MDASE) to advanced NGC systems. The book presents basic as well as advanced algorithms. A wide range of examples culled from various applications are provided to meet the needs of the different levels and types of readers, extending from issues requiring only a rudimentary knowledge to those involving avant-garde research. Morever, problems in the text span from those that concern only NGC to those that are interdisciplinary, and ultimately to those that encompass the entire systems and control field.

An outline of the topics presented in this book is given in Fig. 1. Following the Introduction (Chap. 1), the text is organized according to five principal topics: MDASE of NGC Processing (Chap. 2), Modern Multivariable Control Analysis (Chap. 3), Design Algorithms for Advanced NGC Systems Design (Chap. 4), Fundamentals of NGC Processing (Chaps. 5 and 6), and Advanced NGC Systems Design (Chaps. 7 and 8). Each of these is in turn divided into a number of subtopics that discuss the relevant theories, algorithms, and computing tools related to their applications in advanced NGC systems. Referring to the outline organizing the five principal topics covered in this book, only those subtopics that are connected by solid lines are treated in this book. Those subtopics that are connected by broken lines are treated specifically in the books referenced under them.

The numerous examples that are included in this book are supplemented by a liberal use of references, thus making it easier for the reader to get access to a tremendous body of literature in this field. As noted by one reviewer, there are no comparable books currently on the market that present in a usable format such a complete collection of practical tools that are applicable to real world problems. Moreover, the organization of the material coupled with comprehensive examples make this book well suited to self-teaching, bridging the gap between the theoretical and the practical.

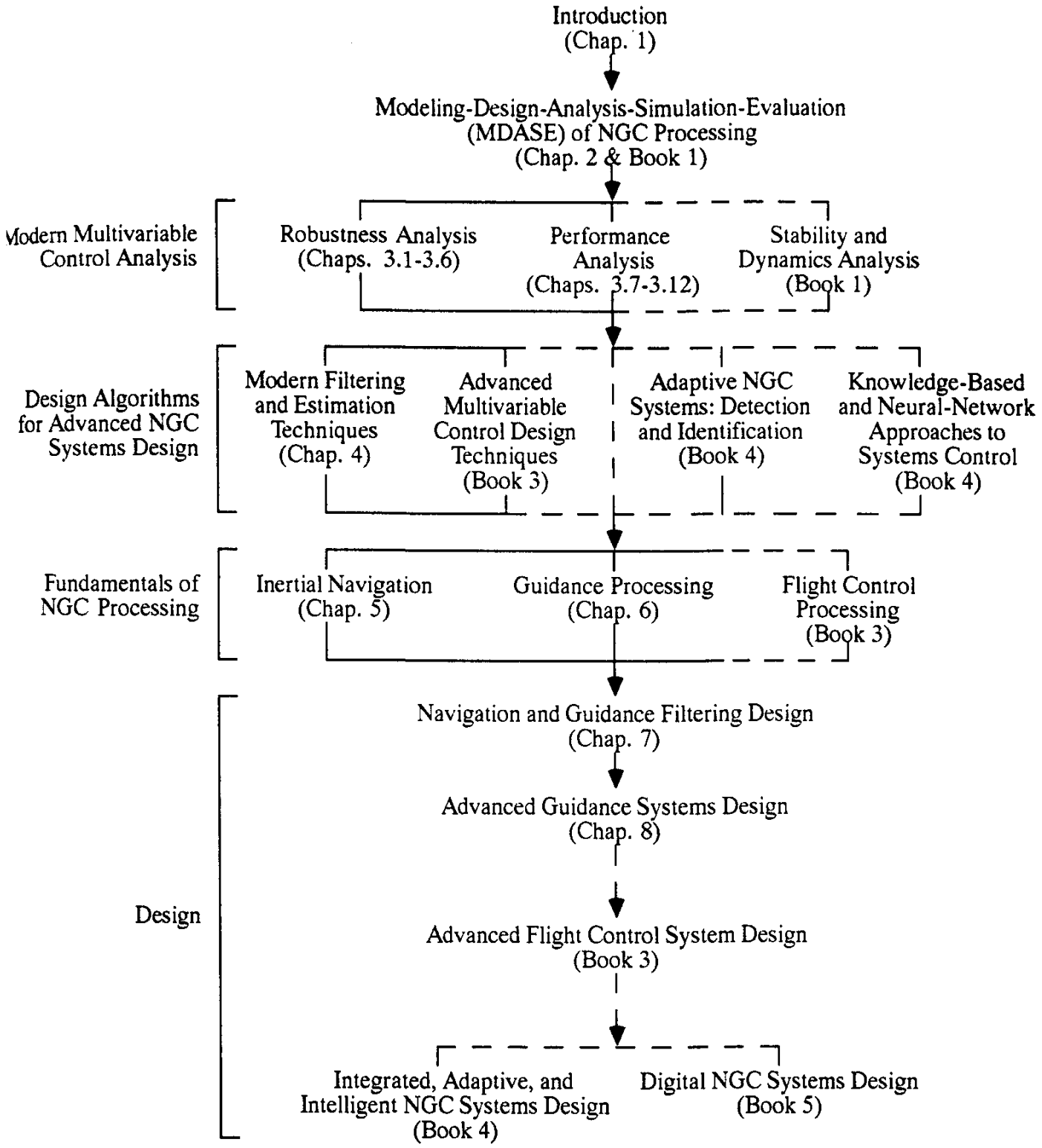

Figure 1. Modern Navigation, Guidance, and Control (NGC) Processing

Acknowledgments

The number of people who have lent assistance in one way or another to this book is too great to allow me to thank each one individually. I am indebted to each person who has contributed to making this project a success, but I feel that I must acknowledge a few individuals by name for their support and effort during the countless hours spent on this project. My first acknowledgement goes out to my staff at American GNC Corporation (AGNC) who have assisted me as follows: Chun Yang and Jerry Juang have provided important technical input, while Jim Wright has spent many hours editing the manuscript. Special thanks are due to Kylie Hsu and Janet Young for their involvement in designing, planning, coordinating, and preparing the entire manuscript, including word processing and numerous original pieces of computer and manual artwork. I am also grateful to William R. Yueh for his technical advice.

Several of my colleagues and friends have provided invaluable technical assistance. I specifically want to acknowledge William H. Gilbert of Martin Marietta Electronic Systems who, through his ardent support and encouragement of this project, made this impossible task appear less so at times. I am deeply touched by his unselfish giving of his time in the overall guidance and input to this project. I am

am also indebted to J. Stanley Ausman of Litton Guidance and Control Systems Division who has greatly improved the quality of Chapter 5. Dr. Ausman is an authority on the subject of this chapter and has co-authored a book on *Inertial Guidance* (Wiley, 1962). I would also like to thank him for granting me permission to adopt his lecture notes in Tactical Aircraft Weapon Delivery Systems.

I also want to express my gratitude to Gary Hewer of Naval Weapons Center, Hsi-Han Yeh of Wright-Patterson Flight Dynamics Lab., and Keqin Gu of Southern Illinois University for their painstaking effort in reviewing Chapter 3. T. Sen Lee of MIT Lincoln Lab., is also appreciated for his effort in reviewing Chapters 4 and 5.

A very special note of thanks goes out to Bernard Goodwin, Vice-President, Professional and Technical Reference Publishing of Prentice Hall, who has taken on the task of publishing this book and has continued to support enthusiastically throughout this project. I would also like to extend my appreciation to Michael Hays, Executive Editor and Assistant Vice-President, Professional and Technical Reference Publishing of Prentice Hall, for his constructive advice and his special interest in this project. Also deserving special mention is Brendan Stewart, Production Editor of Prentice Hall, for his excellent job throughout the production process. I am equally obliged to other Prentice Hall personnel who have participated behind the scenes in the different stages of this book project.

Finally, I would like to acknowledge those individuals and organizations that have permitted me to reprint/adapt portions of their outstanding work in order to make this book a well-rounded source of information. They include (in alphabetical order): AACC, AGARD, AIAA, Arthur Gelb of TASC, Frederick W. Hardy of Hughes Missile Systems Group, Robert J. Heaston of GACIAC, Kaz Hiroshige formerly of General Dynamics Convair Division, IEEE, Johns Hopkins APL Technical Digest, Robert J. Kelly of Allied-Signal Aerospace Co., Litton, James A. McLean of the U.S. Army Missile Command, Pergamon Press, Rockwell International Collins Avionics Division, and SCS International.

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