Preface

The material presented in this book provides a general overview of the major issues related to the development of automatic rendezvous and docking systems, without restricting the discussion to any particular project. It is intended to explain the general principles, and examples of actual developments are included only to demonstrate these general principles. Because of the large number of aspects to be discussed, the depth of discussion of each single issue will necessarily be limited and cannot go further than an introduction.

The information presented is based on the experience of the author, gained during his work with the European Space Agency (ESA), where, between 1981 and 1998, he was responsible for the development of rendezvous and docking technology. ESA has conducted a comprehensive development programme, within which it has awarded to European industry a large number of study and development activities to prepare the rendezvous and docking techniques and technology, first for the *Hermes–Columbus Free-Flyer* scenario, which was abandoned in 1992, and thereafter for the *ATV–ISS* scenario. The Automated Transfer Vehicle (ATV) is one of Europe's contributions to the International Space Station (ISS) Programme. In this context, the two largest technology development activities, among many others, were:

- the Rendezvous and Docking Pre-Development Programme for Hermes–Columbus (1989–1993),
- the ATV Rendezvous Pre-Development (1994–1998).

The design and development of the automatic rendezvous control system of the ATV, for which these two activities formed the basis, are driven to a large extent by the interfaces and requirements given by the ISS. This required extended and detailed discussions with the international partners involved. The information on techniques and technology for automated rendezvous and docking, presented in this book, relies mainly on (a) the results of the above-mentioned research and development activities prepared by European industry under ESA guidance and (b) information obtained in the course of ESA's cooperation with its international partners (NASA, RSC-Energia, NASDA) under the aegis of the International Space Station Programme.

Concerning the ESA RVD development programme, the great effort made by all the individuals at ESA and in industry, without which this book could not have been written,

is gratefully acknowledged. The industrial team involved in the European rendezvous technology development included the following companies:

- MATRA Marconi Space (Toulouse) and DASA (Bremen, Ottobrunn), now merged in the Astrium company,
- Aerospatiale, now part of EADS (Les Mureaux),
- Alenia (Turin),
- GMV (Madrid),
- Sener (Bilbao),

and many others.

A large amount of information concerning the development of automated rendezvous and docking systems by Russia, the USA and Japan was available thanks to cooperation within the International Space Station Programme. In this international cooperative effort, rendezvous and docking/berthing became one of the major operational and physical interfaces between vehicles of different space powers, requiring an openness of information transfer between the international partners which was previously unheard of.

No project such as this book can successfully be concluded without help. The author also wishes to express his gratitude to all colleagues who supported him. In particular, the author wants to thank two colleages, who contributed major inputs to the written text:

> F. Ankersen, ESA-ESTEC, contributed Appendix A on 'Motion dynamics' and supplied information for chapter 6 'The onboard rendezvous control system'. He is ESA's leading person in the control system development of all ESA rendezvous development activities.
>
> J. Sommer, Astrium Bremen, also contributed inputs to chapter 6. He was one of the key development engineers in industry for both of the above mentioned technology projects.

The author owes both these contributors a great debt of gratitude for their contributions not only to the book but also to the rendezvous development work in general.

In addition, the following colleagues and friends of the international rendezvous and docking community helped to review some of chapters and provided valuable comments and suggestions, for which the author expresses his gratitude: E. Belikov, Sener, Bilbao; Ch. Beskow, ESA-ESTEC, Noordwijk; J.-L. Gonnaud, Astrium, Toulouse; S. Mancuso, ESA-ESTEC, Noordwijk; G. Ortega, ESA-ESTEC, Noordwijk; I. Rasmussen, ESA-ESTEC, Noordwijk; V. Semyachkin, RSC Energia, Moscow; D. Wilde, Astrium, Bremen; K. Yamanaka, NASDA, Tokyo.

The European Space Agency has made this project possible by giving permission for the publication of development results. The author is grateful in particular to ESA's *Control and Data Systems Division* for providing accommodation, computer infrastructure, software and administrative support.

The manuscript was written in LaTeX and most of the figures have been prepared with the Xfig drawing program. For trajectory plots the 'Fast Interactive Rendezvous Simulation Tool' (FIRST), developed by ESA, was used; this is a trajectory analysis software, based on the commercial computer aided dynamic analysis package MATRIX$_X$ from Integrated Systems Inc.