Preface

Electric propulsion was first envisioned 100 years ago, and throughout most of the 20th century was considered the technology of the future for spacecraft propulsion. With literally hundreds of electric thrusters now operating in orbit on communications satellites, and ion and Hall thrusters both having been successfully used for primary propulsion in deep-space scientific missions, the future for electric propulsion has arrived.

The literature contains several books from the 1960s and numerous journal articles and conference papers published over the years discussing electric thruster concepts, benefits, physics, and technological developments. Much of this work has been based on empirical investigations and laboratory-based development programs of different thruster types. As such, the fundamental understanding of how these thrusters work has generally lagged behind the technological achievements and applications of electric thrusters in space.

The quest over the past 10 years to improve often technically mature thruster performance and significantly extend thruster life for applications in deep-space propulsion and satellite station-keeping requires a much deeper understanding of the physics of electric thrusters. The purpose of this book is to discuss and explain how modern ion and Hall thrusters work by describing the fundamental physics of these devices. This is a challenging task requiring a basic knowledge of plasma physics, ion accelerators, cathodes, electrical discharges, high voltage, gas dynamics, and many other technologies. As such, we rely heavily on physics-based models that are often greatly simplified compared to the complex two-dimensional and three-dimensional codes required to accurately predict the plasma dynamics that drive thruster performance, and ultimately determine their life. Work in this field is still progressing, and we hope this book will lead to further research and advances in our understanding of these surprisingly complex devices.

While this effort encompasses a large body of literature in the area of ion and Hall thrusters, it is based largely on the research and development performed at the Jet Propulsion Laboratory (JPL). Therefore, this book should not be considered an all-inclusive treatise on the subject of electric thrusters or a review of their development history, but rather one that delves into the basics of two of the more modern electric engines that are finding increasingly more applications, specifically ion and Hall thrusters, in an attempt to provide a better understanding of their principles.

Dan M. Goebel and Ira Katz
March 2008