The Cambridge Encyclopedia of Space

Missions, Applications and Exploration

Since the launch of Sputnik in 1957, over 8000 satellites and spacecraft have been launched from over 30 countries, costing hundreds of billions of dollars. Over 350 people have made the incredible journey beyond our atmosphere and we all benefit in countless ways from the use of space.

This unique Encyclopedia aims to give a global perspective of our occupation and use of space, whether scientific, industrial, commercial, technical or military. After setting the stage by describing the space environment, orbits and ground tracks, launchers and launch sites, the authors go on to discuss the main space applications (telecommunications, navigation and Earth observation, military), plus science missions, planetary exploration and space stations.

The wealth of full-colour illustrations makes all the information highly accessible, resulting in an invaluable source for everyone interested in our use of space, and the perfect reference book for those working in, or studying, the space arena.

Fernand Verger is Emeritus Professor of Geography at l'École Normale Supérieure, Paris. He was NASA Principal Investigator for the Landsat-1 and -2 programme, and project director of the preliminary programme for assessing the SPOT satellite.

Isabelle Sourbès-Verger is a researcher at the Centre National de la Recherche Scientifique and Fondation pour la Recherche Stratégique, Paris.

Raymond Ghirardi is a cartographic engineer at the Centre National de la Recherche Scientifique and has worked on many geographical and geopolitical projects.

Xavier Pasco is a researcher at the Fondation pour la Recherche Stratégique, and Associate Professor at the Université de Marne la Vallée.

The Cambridge Encyclopedia of Space

Missions, Applications and Exploration

Fernand Verger,
Isabelle Sourbès-Verger,
Raymond Ghirardi

with contributions by

Xavier Pasco

Foreword by **John M. Logsdon**

Translated by **Stephen Lyle** and **Paul Reilly**

CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314-321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India

79 Anson Road, #06-04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9780521773003

Previously published in French as *Atlas de géographie de l'espace*
First published in English 2003

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging in Publication data
Verger, Fernand.
[Atlas de la géographie de l'espace. English]
The Cambridge encyclopedia of space: missions, applications, and exploration/by Fernand Verger, Isabelle Sourbès-Verger, Raymond Ghirardi; with contributions by Xavier Pasco.
p. cm.
Includes bibliographical references and index.
ISBN 0 521 77300 8
1.Astronautics–Encyclopedias. 2. Rocketry–Encyclopedias. 3. Outer space–Exploration–Space Policy–Encyclopedias. I. Sourbès-Verger, Isabelle. II. Ghirardi, Raymond. III.Title.
TL788.V48 2002
629.4'03–dc21 2002067408

ISBN 978-0-521-77300-3 Hardback

Contents

Foreword

This is an exciting volume, hard to put down. Its coverage is literally cosmic in scope. No area of space activity goes unexamined. The book's visualizations of various aspects of space activities and capabilities are unique, provide new perspectives on what actually goes on in the region beyond the atmosphere. Just to pick one example, Figure 4.3 is a remarkable achievement. It summarizes in one chart the whole history of space activity in a clear and immediately understandable fashion. To see the clustering of satellites in various Earth orbits, and then the relatively few space probes that have explored the Solar System away from Earth, charts the path of space development to date in a fashion that dramatically improves upon what can be communicated by words alone. There are many, many similar standout depictions of complex information throughout the volume.

Most of us who have spent long careers working in the space sector are wont to say 'space is just a place,' then ignore the implications of that reality as we discuss what happens in orbit and beyond. Not so Fernand Verger and his colleagues. Professor Verger is one of the most distinguished geographers in France, and his influence on this volume is evident. The *Cambridge Encyclopedia of Space* takes a geographical perspective whenever possible. It first of all describes outer space in physical terms, as an environment with its own natural characteristics that both facilitate and limit what can be done there. This unique perspective sets the stage for the rest of the work.

The first artificial Earth satellite went into orbit less than a half-century ago. This volume sets out in both words and images humanity's achievements, benefits, and aspirations since that historic step towards *homo sapiens* a space-faring species. It provides an understanding of the physical, economic, and political realities that must be taken into account as next steps are planned. It depicts the many uses that have already been made of the capability to put people and machines into space, and suggest next steps in space development.

As the volume discusses the building blocks of space activity – spaceports, launch vehicles, and various space missions themselves, its words are complemented throughout by innovative visual and graphical presentations and by well-chosen photographs. The text is of course an essential element of any encyclopedia, and the text here both provides comprehensive and reliable information and offers penetrating insights regarding the factors that shape activity in space. That said, it is its visual material that sets this volume apart from any previous attempts to capture in one place the complexity of space activity. Professor Verger and his associates have spent many years perfecting their depictions of space activity, and they have made a real contribution to our appreciation of how far we have come in opening up the space frontier, and to the increasingly global character of space exploration and exploitation. The *Cambridge Encyclopedia of Space* will be an essential reference work for every space professional and a boon for those just learning about this new arena for human activity.

John M. Logsdon
Director, Space Policy Institute
The George Washington University
Washington, DC, USA

Preface

Over the last forty years, circumterrestrial space has been gradually occupied as unmanned satellites have been put into orbit to carry out a range of different functions, and in a more limited way, as human beings have also increased their presence, annexing the closer regions of the cosmos to the inhabited world. It has hence become possible to build up a geography of space, and it is this idea that lies at the heart of the present work.

Designed along the lines of an explanatory atlas, this encyclopedia allows the reader to understand the extent to which space has been occupied and to follow the main motivations underlying its development. To begin with, it provides a cartographical view of this occupation, briefly specifying the conditions that prevail in the medium and the physical laws that hold sway over the use of circumterrestrial space. Many constraints must be faced in space development. These constraints explain the unequal distribution of satellites and probes gravitating in a number of different orbits, nearby or distant, circular or eccentric, equatorial, polar or other, depending on their mission, whether it be for exploration of our cosmic neighbourhood or further afield, civilian Earth observation, telecommunications, military surveillance, or human occupation.

However, space-based activities can also be considered in terms of their relationship to Earth. The successive passages of satellites criss-cross the whole surface of our planet, their tracks winding around it like the thread around a ball of wool. Satellites supply a new image of the globe and encourage links between different peoples. At the same time, the complexity of space technology creates a genuine hierarchy amongst the countries of the world, reasserting the traditional balance of power on Earth, yet introducing new features. The main steps in space conquest have led to the steady constitution of what appears today to be an exclusive club of space powers. However, the different activities have been mastered to quite varying degrees. Almost all countries around the planet now use space systems. Many are those who operate the satellites that only a much more restricted group of countries are able to put together. On the other hand, very few nations can provide their own launch capacity, and even fewer can claim to master the whole range of manned and unmanned, civilian and military space resources.

The present book aims to describe and account for space endeavour around the world and to provide a careful analysis of the policies that guide the great space powers. Apart from the chapter specifically devoted to space policy, the means of access and main areas of application are presented to show how the various programmes express different national preferences and their consequences for world affairs. The geopolitical aspect of the space phenomenon is indeed a key feature, since satellites procure for us a new vision of our planet and a clearer picture of its resources. Hence, remote sensing which is so important for cartographic applications raises the problem of how data should be made available, for it is as relevant to national independence and international security as it is to territorial development. In the same way, the flow of information, by telephone or television, for positioning or other purposes, provides the subject for a cartographic representation which illustrates the main areas of exchange, the weakened and transformed notion of border, and the appearance of ever sharper international features heavily dominated by the United States. Finally, the navigation programmes are closely linked to questions of strategic independence in a field where applications are still emergent.

Space activities thus have many repercussions and, on a global level, increase the weight of the dominant powers, whether they be military or civilian. These manifest themselves on an economic level through the development of new systems made possible by state-of-the-art technology and answer to a growing need to dominate the markets. Space bestows an undeniable advantage upon those that lay claim to it, not only by the information it offers, but also by the possibilities for direct intervention which it opens up. Finally, the occupation of space by human beings and projects to set up long-term space outposts lead to new prospects, although sensitive to the vacillation of political commitment.

Going beyond a simple description of the way current projects attempt to occupy space, this work aims to provide a conceptual basis for a genuine geography of space, without which it would be difficult to comprehend its development or the growing number of related issues in today's world.

Acknowledgements

Images have been supplied by CNES, SpotImage, DLR, ESA, GRGS, ImageSat, ISAS, ISRO, NASA, NASDA, NRSA, Radarsat, Space Imaging.