The geostationary applications satellite

CAMBRIDGE AEROSPACE SERIES

The geostationary applications satellite

PETER BERLIN

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CAMBRIDGE UNIVERSITY PRESS

Cambridge

New York   New Rochelle

Melbourne   Sidney

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK
40 West 20th Street, New York NY 10011–4211, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain
Dock House, The Waterfront, Cape Town 8001, South Africa

http://www.cambridge.org

First published 1988
First paperback edition 2004

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

Library of Congress cataloguing in publication data

Berlin, Peter.
The geostationary applications satellite/by Peter Berlin.
p. cm. - (Cambridge aerospace series)
Includes index.
1. Geostationary satellites. I. Title. II. Series.
TL796.6.E2B47 1988
629.43′4 - dc19 88-9560
CIP

ISBN 0 521 33525 6 hardback
ISBN 0 521 61603 4 paperback

Contents

In memory of
Monteraldo Schiavon
and
Don Baird

Preface

Twenty-two thousand miles above the equator, a very special family of man-made satelllites circles the earth. Basking in the sunshine, their wings dark blue and their bodies golden, they look like parrots perched side by side on an endless telephone wire. Most strain their ears to pick up messages from one part of the world and relay them to another. Some spend all their time observing the evolution of weather patterns in the atmosphere below. A few size up the earth to the nearest inch, while others perform scientific experiments. All of the satellites are hypochondriacal chatterboxes who mix tales about what they have just seen, heard or felt with frequent reports about their precarious health.

This is the family of *geostationary* satellites, so named because to an observer on the earth they appear to be fixed at one point in the sky. In fact they are not fixed at all but travel around the earth at the same rate as the earth turns about its axis. Unlike spacecraft in any other orbit, a geostationary satellite remains constantly within view of almost half the earth at all times, which is why it is so eminently suited for telecommunications and earth observation.

The spacecraft literature abounds with titles on *payloads*, such as telecommunication transponders, radiometers and scientific instruments. The rest of the spacecraft, called the *platform*, is usually only presented in outline, and the presentation of launch vehicles, orbits and programmatic issues is often schematic. The role of a payload is perhaps more glamorous than that of a platform, but from an engineering viewpoint the payload is merely the *primus inter pares*.

The purpose of the present book is to describe geostationary applications spacecraft technology from A to Z, taking an even-handed approach to launch vehicles, orbits, platforms, payloads and programmatic issues. Although the book concentrates on geostationary satellites, much of the text is also relevant to low-orbiting unmanned spacecraft. This is a vast range of subjects to cover in 214 pages, and inevitably the narrative has had to be condensed. Important topics such as military and scientific missions, ground stations, data links, control centres, data processing and operational management could therefore not be accommodated.

I have opted to show a cross-section of geostationary spacecraft technology as seen through the eyes of a project management team. Such a team has to acquire a broad perspective of technical progress in the context of performance, quality, schedule and cost. This perspective is lacking in the existing space engineering literature which largely consists of books on specialized subjects, compiled essays by several authors, and papers submitted to symposia; hence the present book which attempts to tell a coherent story about geostationary satellites.

In order to allow the reader to explore analytical issues in greater depth on his own, the text has been supplemented with basic mathematical equations which may be readily programmed on a personal computer.

The book is intended for undergraduate university students and for engineers and technicians associated with the space business. Lecturers and journalists, as well as management staff in industry and in space organizations, may also find it helpful.

My special thanks to go David Birdsall, Roger Moses and David Leverington for their critique of the substance and form of the typescript. I wish to express my gratitude to former colleagues of the European Space Agency for their valuable advice on specialized topics, and for their assistance in my search for literature references and illustrations. I am indebted to INMARSAT for granting me permission to write the book, and to members of the INMARSAT-2 satellite project team who patiently answered my barrage of questions on their subjects of expertise. Last but not least, I owe thanks to my wife Shirley for her steadfast encouragement, and for ironing out logical and editorial wrinkles in my writing.

Peter Berlin
May 1988

Cambridge University Press
0521616034 - The Geostationary Applications Satellite
Peter Berlin
Frontmatter
More information

List of acronyms

Some of the most common acronyms in the spacecraft trade are listed below. Whenever a particular acronym has been used in this book, reference is given to the page where the arconym first appears.

		Page
ABM	Apogee Boost Motor	
AC	Alternating Current	100
AEF	Apogee Engine Fire	
AIT	Assembly, Integration and Test	201
AKM	Apogee Kick Motor	2
AM	Amplitude Modulation	163
AOCS	Attitude and Orbit Control Subsystem	199
ASE	Airborne Support Equipment (Shuttle)	16
ASW	Address & Synchronization Word	151
BAPTA	Bearing and Power Transmission Assembly	79
BER	Bit Error Rate	161
CFRP	Carbon Fibre Reinforced Plastic	75
CDR	Critical Design Review	
C/N	Carrier-to-Noise Ratio	161
DC	Direct Current	100
DOD	Depth of Discharge	98
DPA	Destructive Physical Analysis	190
EGSE	Electrical Ground Support Equipment	205

EIRP	Equivalent Isotropically Radiated Power	174
ELDO	European Launcher Development Organisation	24
EMC	Electromagnetic Compatibility	
EMI	Electromagnetic Interference	72
EOL	End of Life	
EPC	Electronic Power Conditioner	169
ESA	European Space Agency	151
ESD	Electrostatic Discharge	71
ET	External Tank (Shuttle)	
FDM	Frequency Division Multiplex	
FDMA	Frequency Division Multiple Access	166
FDR	Final Design Review	
FET	Field Effect Transistor	168
FIT	Failure in Ten-to-the-nine hours	192
FM	Frequency Modulation	163
FOV	Field of View	
FSK	Frequency Shift Keying	
GEO	Geostationary Orbit	2
GFRP	Glass Fibre Reinforced Plastic	
GMT	Greenwich Mean Time	50
GSO	Geostationary Orbit	
G/T	Gain-to-Noise Ratio	176
GTO	Geosynchronous Transfer Orbit	2
HPA	High-Power Amplifier	168
ICBM	Intercontinental Ballistic Missile	20
IF	Intermediate Frequency	167
I/F	Interface	
IR	Infrared	84
I_{sp}	Specific Impulse	5
ITO	Indium-Tin Oxide	85
IUS	Inertial Upper Stage	18
LEO	Low Earth Orbit	
LH	Liquid Hydrogen	
LNA	Low Noise Amplifier	168
LOX	Liquid Oxygen	
L/V	Launch Vehicle	

MGSE	Mechanical Ground Support Equipment	205
MLI	Multi-Layer Insulation	
MMH	Monomethylhydrazine	5
MRB	Material Review Board	196
NASA	National Aeronautics & Space Administration	78
NTO	Nitrogen Tetroxide	
OBDH	Onboard Data Handling	
OCOE	Overall Checkout Equipment	
OMS	Orbital Manoeuvring System (Shuttle)	13
OSR	Optical Solar Reflector	87
PA	Product Assurance	
PAM-D	Payload Assist Module – Delta	18
PCM	Pulse Code Modulation	154
PDR	Preliminary Design Review	
PFD	Power Flux Density	173
Pixel	Picture Element	183
PKM	Perigee Kick Motor	2
P/L	Payload	
PM	Phase Modulation	
PPL	Preferred Parts List	190
PSK	Phase Shift Keying	
PSS	Power Supply Subsystem	
PWM	Pulse Width Modulation	100
QA	Quality Assurance	195
RCS	Reaction Control Subsystem	
RCT	Reaction Control Thruster	
RF	Radio Frequency	159
RG	Rate Gyro	142
RIG	Rate Integrating Gyro	143
RX	Receiver	
S/C	Spacecraft	
SCOE	Special Checkout Equipment	
SCPC	Single Channel per Carrier	
SHF	Super High Frequency	
SIW	Spacecraft Identification Word	155

S/N	Signal-to-Noise Ratio	161
SPELDA	Structure Porteuse Externe de Lancement Double Ariane	10
SPF	Single Point Failure	
SRM	Solid Rocket Motor	13
S/S	Subsystem	
SSM	Second Surface Mirror	87
SSME	Space Shuttle Main Engines	13
STS	Space Transportation System (Space Shuttle)	13
SYLDA	Système de Lancement Double Ariane	10
TC	Telecommand	
TCS	Thermal Control Subsystem	
TDM	Time Division Multiplex	
TDMA	Time Division Multiple Access	166
TM	Telemetry	
TPA	Transistorized Power Amplifier	168
TT&C	Telemetry, Tracking and Command	149
TTC&M	Telemetry, Tracking, Command and Monitoring	
TWT	Travelling Wave Tube	169
TWTA	Travelling Wave Tube Amplifier	168
TX	Transmitter	
UDMH	Unsymmetrical Dimethylhydrazine	5
UHF	Ultra High Frequency	
VHF	Very High Frequency	
VIS	Visible	181