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SATELLITE COMMUNICATIONS: ADVANCED TECHNOLOGIES

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PREFACE

The theme of these companion volumes is Satellite Communications Systems for the 1980's, the third decade, and the advances in technology needed to make these new systems possible. In this preface, a perspective view is offered of the relationship between demand and improved cost effectiveness, and approaches are suggested in which new systems and technologies can be brought to bear to accommodate the required dramatic increases in capacity while at the same time conserving our natural resources of frequency spectrum and orbital space.

At the time of this writing, we are just coming to the end of the second decade of the use of communications satellites. Today, we take the availability of high quality and reliable communications "via satellite" for granted. In addition to the Intelsat Global Network, we now have several operational national domestic systems, and regional systems are being planned. The total communications capacity of today's space segment exceeds that of the 1965 Intelsat 1 by a factor exceeding 500! Intelsat continues to grow in capacity at 15-18% per year, and this growth is expected to continue into the 1980's; a number of domestic carriers project growth rates of 12-15%. Some predict that this growth rate will flatten out, citing such examples as "What happens when each individual in the world has a telephone?" My own subjective answer to this question is that it will not be the ability of any individual in the world to talk to any other individual at any time that will limit growth, but rather his ability to pay for it. This telephony example was used here since it is used by all of us and since it is the largest user today of communication satellite systems capacity. Similar growth arguments can be made for newer services such as: high-rate data transmission, specialized television services, and eventually videotelephony. It also is important to remember that the communication needs of the underdeveloped nations are just beginning to be met. It is very probable that dramatic improvements in cost effectiveness of communication satellite systems will exert an equally dramatic effect on growth and demand for these services.

It is important to consider, in this connection, the availability of frequency bands and the availability of geosynchronous orbit positions to meet this growing demand. It is well known that the number of frequency bands available for satellite telecommunications is limited. In addition to defense systems bands, three commercial bands have been allocated by international agreements in the region between 4 and 31 GHz. These are the 4/6-GHz, 12/14-GHz, and 20/30-GHz bands. Next, it is clear that satellites operating within the same frequency band must be separated adequately in orbit to assure an acceptably low level of radio interference between them. It is also necessary that satellite earth stations be located so that they do not interfere with terrestrial microwave radio relay stations operating in the same frequency bands. These factors, together with a limited spectrum, limit the number of orbit positions available for satellite telecommunication. For example, the region of orbital space most useful to North America is limited to about 60°. The number of orbital positions available in the 4/6-GHz bands is about 15, and of these only six permit full United States coverage – i.e., all 50 states and Puerto Rico. Twelve of the fifteen slots already are occupied or soon will be by the United States or Canada. These positions do not include any allocations of orbital space to Central or South American needs. In the 12/14-GHz bands, which are planned for high power television broadcast or telecommunications to relatively small earth terminals, there are perhaps 10 to 15 positions available (depending on the mix between them), of which 10 already are committed to North American use. We see, therefore, that before the needs of most of the developing world (in this case, Central America and the Western States of South America) are met, we already will have nearly consumed the available spectral and orbital space in the 4/6-GHz and 12/14-GHz frequency bands. This same trend will soon follow around the world.

It seems inevitable that the 4/6-GHz and 12/14-GHz bands cannot satisfy all potential users and that it will be necessary to move to higher frequency bands to satisfy our demands for communication. Not only do the higher frequency bands, 20/30-GHz, provide greater bandwidth, but they permit closer spacing of satellites operating in these bands as well. These advantages come at the price of overcoming the increased attentuation in rain. New concepts and technologies can be used here with great effect. In addition to the concepts of power control (both in the uplinks and downlinks) and of earth station space diversity, new technologies appropriate for the 1980's will lead to significantly new trends in system design.

We should take full advantage of the new technologies and the increased orbital weight the shuttle will afford in the 1980's to place larger payloads into the limited number of geosynchronous orbital positions. New technologies, such as high-speed satellite switched time division multiple access (SSTDMA), higher frequency components, and better spacecraft pointing accuracy associated with narrower antenna beams, can further increase the telecommunication capacity of future geosynchronous satellites. It will be possible to build large communication satellites operating at digital rates of 1 to 2 Gbits/sec in the 20/30-GHz frequency band. The full frequency band can be fully reused in each of many spot beams. These satellites will handle tens of thousands of voice circuits, television, and high-speed computer data, all simultaneously. The number of equivalent voice circuits of high-speed digital satellites operating in 20/30-GHz bands will be five to ten times greater than at the 4/6-GHz bands predominantly used today, and these new satellites can be spaced more closely in orbit by a factor of four, since the satellites can be spaced less than 1° apart instead of the 4° spacing required at 4/6 GHz. This capacity can be employed by using the available spectral and orbital space more efficiently and by dedicating satellites to single high-capacity users, or by simultaneously serving several users in one satellite, using an on-orbit sharing approach. All this is not to say that the 4/6-GHz and the 12/14-GHz frequency bands will not have their place in the 1980's – quite the contrary – but their use should be properly balanced with those services planned for the higher frequency bands. A single large shuttle-launched spacecraft can accommodate communications capability in all three frequency bands simultaneously at a single orbital location although, of course, not every 1° of arc can be so equipped.

To summarize, this writer's view is that the next decade will present a dramatic increase in demands for telecommunications on a worldwide basis. These demands can be accommodated by new technologies, at the same time conserving our precious natural resources of radio-frequency spectrum and geosynchronous orbital space.

Volumes 54 and 55 of *Progress in Astronautics and Aeronautics* are organized to follow a twin-thread theme. Volume 54 describes satellite communication systems for the 1980's. The first four chapters cover specific classes of satellite systems: North American Domestic, Intelsat, National and Regional, and Defense Systems. Chapter 5 provides a significant and coherent overview of launch options for the satellite systems engineer. Chapter 6 presents several outstanding advanced systems concepts.

Companion Volume 55 describes the new technologies which will make the systems in Volume 54 possible. A key principle used in the preparation and organization of Volume 55 has been to present more papers in the "other than communications" disciplines. Although we recently have gone through a period when the major emphasis in communications satellites was in communications technologies, significant and major advances have been made in other technologies equally important to the future of these satellites.

The papers presented in these volumes were selected (with one exception) from the 1976 AIAA Communication Satellite Systems Conference co-sponsored by the Canadian Aeronautics and Space Institute, for which I was privileged to serve as Conference General Chairman. The selected papers were then revised and edited for these AIAA archive volumes. Acknowledgments are due the many contributors to that Conference, the Conference Committee, and the Editorial Committee. I owe special thanks to Mr. Richard S. Davies, who aided immensely as a key member of both Committees. Acknowledgment is also due Dr. Martin Summerfield, Series Editor-in-Chief; Miss Ruth F. Bryans, Director of Scientific Publications at AIAA Headquarters; her secretary, Mrs. Jeanne Godette; and my secretary, Mrs. Helen Miller, who provided most of the coordination and all of the secretarial assistance.

David Jarett
April 1977

Table of Contents

Chapter I – Advanced Spacecraft Engineering Mechanics