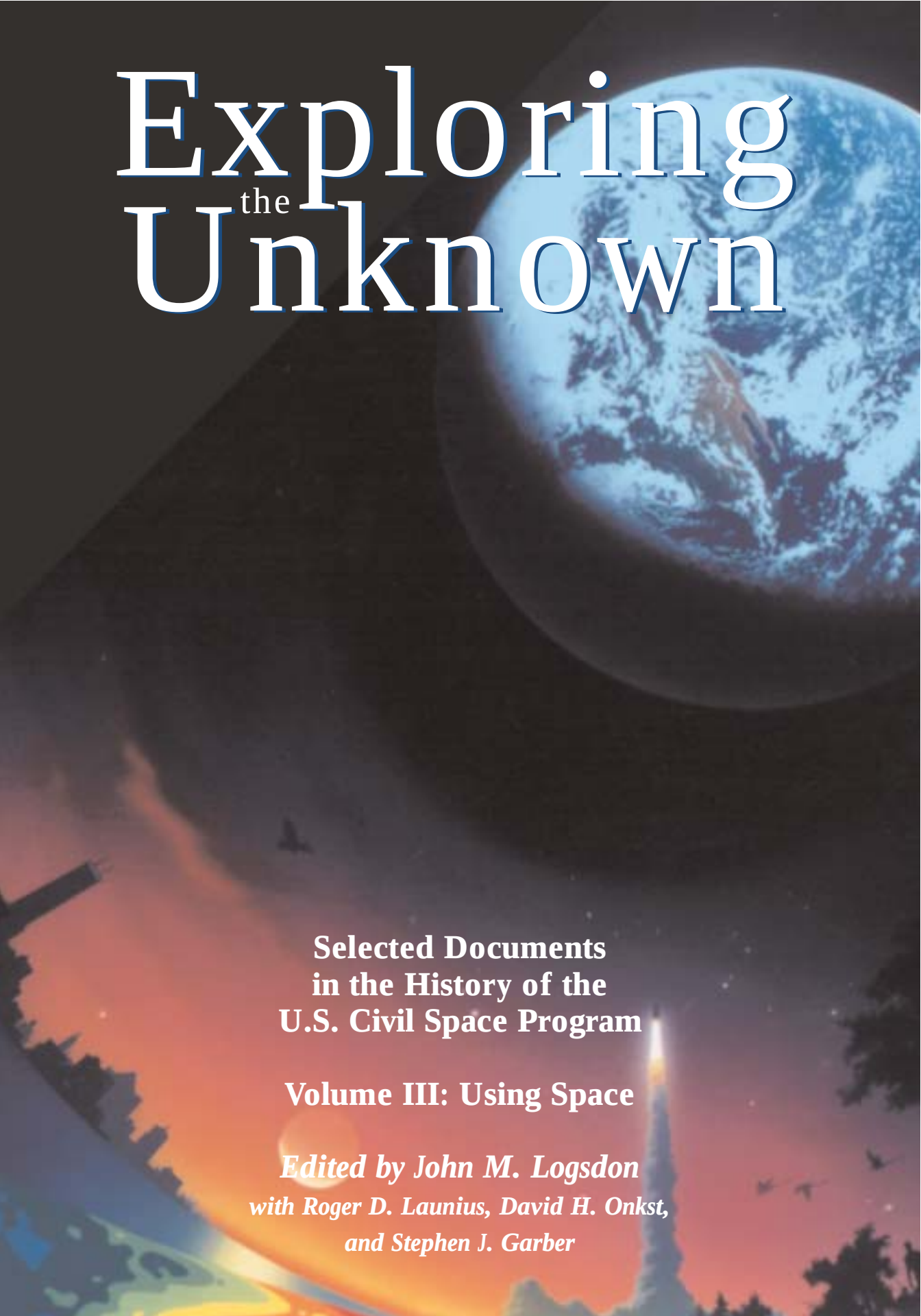
Exploring the Unknown



Selected Documents in the History of the U.S. Civil Space Program

Volume III: Using Space

Edited by John M. Logsdon
with Roger D. Launius, David H. Onkst, and Stephen J. Garber

NSC . . . . . .National Security Council
NSDD . . . . . .National Security Decision Directive
NSF . . . . . .National Science Foundation
NSTC . . . . . .National Science and Technology Council
OCDM . . . . . .Office of Civil and Defense Mobilization
OLS . . . . . .Operational Linescan System
OMB . . . . . .Office of Management and Budget (formerly the Bureau of the Budget)
OMV . . . . . .Orbital Maneuvering Vehicle
OPEC . . . . . .Organization of the Petroleum Exporting Countries
OSSA . . . . . .Office of Space Science and Applications (NASA)
OSTP . . . . . .Office of Science and Technology Policy (White House)
PAM . . . . . .Payload Assist Module
PDD . . . . . .Presidential Decision Directive
POES . . . . . .Polar-orbiting Operational Environmental Satellite
R&D . . . . . .Research and development
RCA . . . . . .Radio Corporation of America
RDSS . . . . . .Radio Determination Satellite Service
RFI . . . . . .Request for information
RFP . . . . . .Request for proposals
ROI . . . . . .Return on Investment
SBIR . . . . . .Small Business Innovation Research (program)
SI . . . . . .Space Industrialization
SIG . . . . . .Senior Interagency Group
SLAR . . . . . .Side Looking Airborne Radar
SOCC . . . . . .Satellite Operations Control Center
SPOT . . . . . .Satellite Pour l'Observation de la Terre
SSI . . . . . .Space Services, Inc.
SSM/I . . . . . .Special Sensor Microwave/Imager
START . . . . . .Strategic Arms Reduction Treaty
STS . . . . . .Space Transportation System
TCC . . . . . .Telecommunication Coordinating Committee
TDRSS . . . . . .Tracking Data and Relay Satellite System
TEA . . . . . .Technical Exchange Agreement
TIROS . . . . . .Television and Infrared Operational Satellite
TM . . . . . .Thematic Mapper
TOS . . . . . .Transfer Orbit Stage *or* TIROS Operational Satellite
TOVS . . . . . .TIROS Operational Vertical Sounder
TSP . . . . . .Technical Support Package
TUO . . . . . .Technology Utilization Office
UHF . . . . . .Ultrahigh frequency
U.N./UN . . . . . .United Nations
UNGA . . . . . .U.N. General Assembly
U.S./US . . . . . .United States
USC/U.S.C. . . . . .United States Code
USDA . . . . . .U.S. Department of Agriculture
USGS . . . . . .U.S. Geological Survey
USG . . . . . .U.S. Government
UV . . . . . .Ultraviolet
VHF . . . . . .Very high frequency

GAO . . . . . .General Accounting Office
GDP . . . . . .Gross Domestic Product
GE . . . . . .General Electric
GHz . . . . . .Gigahertz
GIS . . . . . .Geographic Information System
GNP . . . . . .Gross National Product
GOES . . . . . .Geostationary Operational Environmental Satellite
GPO . . . . . .Government Printing Office
GSP . . . . . .Gross Space Product
GWP . . . . . .Gross Worldwide Product
HF . . . . . .High frequency
HIRS . . . . . .High-Resolution Infrared Sounder
HRMSI . . . . . .High Resolution Multispectral Stereo Imager
ICUS . . . . . .Interim Communication Satellite Committee
IGI . . . . . .Industrial Guest Investigator (agreement)
IPO . . . . . .Integrated Program Office
IPOMS . . . . . .International Polar Orbiting Meteorological Satellite Group
IR . . . . . .Infrared
IRAC . . . . . .Interdepartment Radio Advisory Committee
ITOS . . . . . .Improved TIROS Operational Satellite
ITU . . . . . .International Telecommunications Union
JEA . . . . . .Joint Endeavor Agreement
JSC . . . . . .Johnson Space Center
KC . . . . . .Kilocycle
KW/kW . . . . . .Kilowatt
LACIE . . . . . .Large Area Crop Inventory Experiment
LCG . . . . . .Landsat Coordinating Group
LDC . . . . . .Less Developed Country
LEO . . . . . .Low Earth Orbit
LSI . . . . . .Large Scale Integrated (circuit)
MDAC . . . . . .McDonnell Douglas Astronautics Company
MIT . . . . . .Massachusetts Institute of Technology
MOD . . . . . .Ministry of Defense
MPS . . . . . .Materials Processing in Space
MRI . . . . . .Midwest Research Institute
MSC . . . . . .Manned Space Center (later known as Johnson Space Center)
MSS . . . . . .Multispectral Scanner *or* Mobile Satellite Service
MTCR . . . . . .Missile Technology Control Regime
MTF . . . . . .Man-Tended Facility
MTT . . . . . .Message toll telephone
NACA . . . . . .National Advisory Committee for Aeronautics
NAPA . . . . . .National Academy of Public Administration
NASA . . . . . .National Aeronautics and Space Administration
NESDIS . . . . . .National Environmental Satellite, Data, and Information Service
NIH . . . . . .National Institutes of Health
NMI . . . . . .NASA Management Instruction
NOAA . . . . . .National Oceanic and Atmospheric Administration
NOMSS . . . . . .National Operational Meteorological Satellite System
NPOESS . . . . . .National Polar-Orbiting Environmental Satellite System
NRC . . . . . .National Research Council
NRO . . . . . .National Reconnaissance Office
NSAM . . . . . .National Security Action Memorandum

Glossary

ABMA . . . . . .Army Ballistic Missile Agency
ACDA . . . . . .Arms Control and Disarmament Agency
AFB . . . . . .Air Force Base
AID . . . . . .Agency for International Development (State Department)
ARPA . . . . . .Advanced Research Projects Agency
ASTP . . . . . .Apollo-Soyuz Test Project
ASVT . . . . . .Application System Verification and Test
ATS . . . . . .Applications Technology Satellite
AVHRR . . . . . .Advanced Very High Resolution Radiometer
BSS . . . . . .Broadcast Satellite Service
CBD . . . . . .*Commerce Business Daily*
CFR/C.F.R. . . . . .Code of Federal Regulations
CIA . . . . . .Central Intelligence Agency
COSC . . . . . .Committee on Satellite Communications
COSMIC . . . . . .Computer Software Management Information Center
CSP . . . . . .Center for Space Policy
CSTI . . . . . .Civil Space Technology Initiative
db/dB . . . . . .Decibel
DBS . . . . . .Direct Broadcast Satellite
DCI . . . . . .Director of Central Intelligence
DCS . . . . . .Data collection system
DDR&E . . . . . .Director, Defense Research and Engineering
DDT&E . . . . . .Design, Development, Test and Engineering
DMSP . . . . . .Defense Meteorological Satellite Program
DOC/DoC . . . . . .Department of Commerce
DOD/DoD . . . . . .Department of Defense
DOE/DoE . . . . . .Department of Energy
DOI/DoI . . . . . .Department of the Interior
ELV . . . . . .Expendable Launch Vehicle
EOS . . . . . .Earth Observing System *or* Electrophoresis Operations in Space (program)
EOSAT . . . . . .Earth Observation Satellite Company
EPA . . . . . .Environmental Protection Agency
EROS . . . . . .Earth Resources Observational Satellites (later Systems)
ERS . . . . . .Earth Resources Survey (program)
ERTS . . . . . .Earth Resources Technology Satellite (later known as Landsat)
ESA . . . . . .European Space Agency
ESSA . . . . . .Environmental Science Services Administration
ETM . . . . . .Enhanced Thematic Mapper
EUMETSAT . . . . . .European Organisation for the Exploitation of Meteorological Satellites
EVA . . . . . .Extravehicular activity
FAO . . . . . .Food and Agriculture Organization (U.N.)
FCC . . . . . .Federal Communications Commission
FM . . . . . .Frequency-modulation
FEDD . . . . . .For Early Domestic Distribution
FSS . . . . . .Fixed Satellite Service
FTE . . . . . .Full-Time Equivalent
FY . . . . . .Fiscal year

Joseph N. Pelton is a professor of telecommunications at the University of Colorado at Boulder, having returned from the post of Vice President of Academic Programs and Dean of the International Space University (ISU). Prior to going to ISU, Dr. Pelton held a dual appointment as Director of the Interdisciplinary Telecommunications Program at the University of Colorado, as well as Director of the Center for Advanced Research in Telecommunications and Training. He has worked in a variety of positions at INTELSAT for the past two decades, and he has been involved with satellite applications since 1965, in positions with Rockwell International, NASA, Communications Satellite Corporation (COMSAT), and George Washington University. He also taught at American University in Washington, D.C. After receiving an undergraduate degree in physics, Dr. Pelton went on to receive a master's degree from New York University and a Ph.D. from Georgetown University.

Ray A. Williamson is a Senior Research Scientist in the Space Policy Institute, focusing on the history, programs, and policy of Earth observations, space transportation, and space commercialization. He joined the Institute in 1995. Previously, he was a Senior Associate and Project Director in the Office of Technology Assessment (OTA) of the U.S. Congress. He joined OTA in 1979. While at OTA, Dr. Williamson was project director for more than a dozen reports on space policy, including: *Russian Cooperation in Space* (1995); *Civilian Satellite Remote Sensing: A Strategic Approach* (1994); *Remotely Sensed Data: Technology, Management, and Markets* (1994); *Global Change Research and NASA's Earth Observing System* (1994); and *The Future of Remote Sensing from Space: Civilian Satellite Systems and Applications* (1993). Dr. Williamson has written extensively about the U.S. space program. He holds a B.A. in physics from Johns Hopkins University and a Ph.D. in astronomy from the University of Maryland. He spent two years on the faculty of the University of Hawaii studying diffuse emission nebulae and ten years on the faculty of St. John's College in Annapolis, Maryland. He is a member of the faculty of the International Space University and is a member of the editorial board for the journal *Space Policy*.

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Roger D. Launius is Chief Historian of the National Aeronautics and Space Administration, Washington, D.C. He has produced several books and articles on aerospace history, including *Frontiers of Space Exploration* (Greenwood Press, 1998); *Organizing for the Use of Space: Historical Perspectives on a Persistent Issue* (Univelt, Inc., AAS History Series, Volume 18, 1995), editor; *NASA: A History of the U.S. Civil Space Program* (Krieger Publishing Co., 1994); *History of Rocketry and Astronautics: Proceedings of the Fifteenth and Sixteenth History Symposia of the International Academy of Astronautics* (Univelt, Inc., AAS History Series, Volume 11, 1994), editor; *Apollo: A Retrospective Analysis* (Monographs in Aerospace History, Volume 3, 1994); and *Apollo 11 at Twenty-Five,* an electronic picture book issued on computer disk (Space Telescope Science Institute, Baltimore, MD, 1994).

John M. Logsdon is Director of the Space Policy Institute of George Washington University's Elliott School of International Affairs, where he is also a professor of political science and international affairs and Director of the Center for International Science and Technology Policy. He holds a B.S. in physics from Xavier University and a Ph.D. in political science from New York University. He has been at George Washington University since 1970, and he previously taught at The Catholic University of America. He is also a faculty member of the International Space University and Director of the District of Columbia Space Grant Consortium. Dr. Logsdon is an elected member of the International Academy of Astronautics and the Board of Trustees of the International Space University and Chair of the Advisory Council of the Planetary Society. He has lectured and spoken to a wide variety of audiences at professional meetings, colleges and universities, international conferences, and other settings, and he has testified before Congress on numerous occasions. He is frequently consulted by the electronic and print media for his views on various space issues. Dr. Logsdon has been a Fellow at the Woodrow Wilson International Center for Scholars and was the first holder of the Chair in Space History of the National Air and Space Museum. He is a Fellow of the American Association for the Advancement of Science and an Associate Fellow of the American Institute of Aeronautics and Astronautics. In addition, he is North American editor for the journal *Space Policy.*

David H. Onkst is a Research Associate at the George Washington University Space Policy Institute and a member of the History Department at American University, both located in Washington, D.C. He has won numerous scholarly awards, including the 1998 Robert H. Goddard Historical Essay Award, a George Meany Memorial Archives Fellowship, and several teaching fellowships at American University. Onkst has written articles on subjects ranging from the possibility of life on Mars and Europa to a history of southern African-American World War II veterans and their use of the G.I. Bill of Rights for such periodicals as *Space Times* and the *Journal of Social History.* He also served as a behind-the-scenes editor for *Eye in the Sky: The Story of the CORONA Spy Satellites* (Smithsonian Institution Press, 1998). Onkst is a specialist in U.S. social and cultural history since 1941.

The editorial method we adopted for publishing these documents seeks to preserve spelling, grammar, paragraphing, and use of language as in the original. We have sometimes changed punctuation where it enhances readability. We have used ellipses (". . .") to note where sections of a document have not been included in this publication, and we have avoided including words and phrases that had been deleted in the original document unless they contribute to an understanding of what was going on in the mind of the writer in making the record. Marginal notations on the original documents are inserted into the text of the documents in brackets, each clearly marked as a marginal comment. When deletions to the original document have been made in the process of declassification, we have noted this with a parenthetical statement in brackets. Except insofar as illustrations and figures are necessary to understanding the text, those items have been omitted from this printed version. Page numbers in the original document are noted in brackets internal to the document text. Copies of all documents in their original form, however, are available for research by anyone interested at the NASA History Office or the Space Policy Institute of George Washington University.

We recognize that there are certain to be quite significant documents left out of this compilation. No two individuals would totally agree on all documents to be included from the more than 2,500 that we collected, and surely we have not been totally successful in locating all relevant records. As a result, this documentary history can raise an immediate question from its users: Why were some documents included while others of seemingly equal importance were omitted? There can never be a fully satisfactory answer to this question. Our own criteria for choosing particular documents and omitting others rested on three interrelated factors:

- Is the document the best available, most expressive, most representative reflection of a particular event or development important to the evolution of the space program?

- Is the document not easily accessible except in one or a few locations, or is it included (for example, in published compilations of presidential statements) in reference sources that are widely available and thus not a candidate for inclusion in this collection?

- Is the document protected by copyright, security classification, or some other form of proprietary right and thus unavailable for publication?

As general editor of this volume, I was ultimately responsible for the decisions about which documents to include and for the accuracy of the headnotes accompanying them. It has been an occasionally frustrating but consistently exciting experience to be involved with this undertaking. My associates and I hope that those who consult it in the future find our efforts worthwhile.

John M. Logsdon
Director
Space Policy Institute
Elliott School of International Affairs
George Washington University

Copies of more than 2,500 documents in their original form collected during this project (not just the documents selected for inclusion), as well as a database that provides a guide to their contents, will be deposited in the NASA Historical Reference Collection. Another complete set of project materials is located at the Space Policy Institute at George Washington University. These materials in their original form are available for use by researchers seeking additional information about the evolution of the U.S. civilian space program or wishing to consult the documents reprinted herein in their original form.

The documents selected for inclusion in this volume are presented in three major chapters, each covering a particular aspect of the utilization of space capabilities and the unique characteristics of the space environment. These chapters address: (1) communicating via satellite; (2) observing the Earth from space for practical purposes (Earth science will be covered in a later volume); and (3) the various ways in which space activities have had economic impacts. Volume I in this series covered the antecedents to the U.S. space program, as well as the origins and evolution of U.S. space policy and of NASA as an organizational institution. Volume II addressed the relationship between the civilian space program of the United States and the space activities of other countries, the relationship between the U.S. civilian and national security space and military efforts, and NASA's relationship with industry and academic institutions. As mentioned above, future volumes will cover space transportation, space science, and human spaceflight.

Each section in this volume is introduced by an overview essay, prepared by individuals particularly well-qualified to write on the topic. In the main, these essays are intended to introduce and complement the documents in the section and to place them in a chronological and/or substantive context. Each essay contains references to the documents in the section it introduces, and many also contain references to documents in other sections of the collection. These introductory essays were the responsibility of their individual authors, and the views and conclusions contained therein do not necessarily represent the opinions of either George Washington University or NASA.

The documents included in each section were chosen by the project team in concert with the essay writer from those assembled by the research staff for the overall project. The contents of this volume emphasize primary documents or long-out-of-print essays or articles and material from the private recollections of important actors in shaping space affairs. Key legislation and policy statements are also included. The contents of this volume thus do not comprise in themselves a comprehensive historical account; they must be supplemented by other sources, those both already available and to become available in the future. Indeed, a few of the documents included in this collection are not complete; some portions of them were still subject to security classification as this volume went to print.

Each document is assigned its own number in terms of the chapter in which it is placed. As a result, the first document in the third section of this volume is designated "Document III-l." Each document is accompanied by a headnote setting out its context and providing a background narrative. These headnotes also provide specific information about people and events discussed. We have avoided the inclusion of explanatory notes in the documents themselves and have confined such material to the headnotes.

Introduction

One of the most important developments of the twentieth century has been the movement of humanity into space with machines and people. The underpinnings of that movement—why it took the shape it did; which individuals and organizations were involved; what factors drove a particular choice of scientific objectives and technologies to be used; and the political, economic, managerial, and international contexts in which the events of the space age unfolded—are all important ingredients of this epoch transition from an Earthbound to a spacefaring people. This desire to understand the development of spaceflight in the United States sparked this documentary history series.

The extension of human activity into outer space has been accompanied by a high degree of self-awareness of its historical significance. Few large-scale activities have been as extensively chronicled so closely to the time they actually occurred. Many of those who were directly involved were quite conscious that they were making history, and they kept full records of their activities. Because most of the activity in outer space was carried out under government sponsorship, it was accompanied by the documentary record required of public institutions, and there has been a spate of official and privately written histories of most major aspects of space achievement to date. When top leaders considered what course of action to pursue in space, their deliberations and decisions often were carefully put on the record. There is, accordingly, no lack of material for those who aspire to understand the origins and evolution of U.S. space policies and programs.

This reality forms the rationale for this series. Precisely because there is so much historical material available on space matters, the National Aeronautics and Space Administration (NASA) decided in 1988 that it would be extremely useful to have a selective collection of many of the seminal documents related to the evolution of the U.S. civilian space program that was easily available to scholars and the interested public. While recognizing that much space activity has taken place under the sponsorship of the Department of Defense and other national security organizations, the U.S. private sector, and other countries around the world, NASA felt that there would be lasting value in a collection of documentary material primarily focused on the evolution of the U.S. government's civilian space program, most of which has been carried out under the agency's auspices since 1958. As a result, the NASA History Office contracted with the Space Policy Institute of George Washington University's Elliott School of International Affairs to prepare such a collection. This is the third volume in the documentary history series; three additional ones detailing programmatic developments with respect to space transportation, space science, and human spaceflight will follow.

The documents collected during this research project were assembled from a diverse number of both public and private sources. A major repository of primary source materials relative to the history of the civil space program is the NASA Historical Reference Collection of the NASA History Office, located at the agency's headquarters in Washington, D.C. Project assistants combed this collection for the "cream" of the wealth of material housed there. Indeed, one purpose of this series from the start was to capture some of the highlights of the holdings at headquarters. Historical materials housed at the other NASA installations, institutions of higher learning, and presidential libraries were other sources of documents considered for inclusion, as were papers in the archives of individuals and firms involved in opening up space for exploration.

There are numerous people at NASA associated with historical study, technical information, and the mechanics of publishing who helped in myriad ways in the preparation of this documentary history. Stephen J. Garber prepared the biographical appendix, helped in the final proofing, and prepared the index of the work and deservedly is listed as a co-editor. Nadine J. Andreassen of the NASA History Office performed editorial and proofreading work on the project; and the staffs of the NASA Headquarters Library, the Scientific and Technical Information Program, and the NASA Document Services Center provided assistance in locating and preparing for publication the documentary materials in this work. The NASA Headquarters Printing and Design Office developed the layout and handled printing. Specifically, we wish to acknowledge the work of Jane E. Penn, Patricia M. Talbert, Jonathan L. Friedman, and Kathleen Gasparin for their design and editorial work. In addition, Michael Crnkovic and Stanley Artis saw the book through the publication process. Thanks are due to all of them.

Roger D. Launius, NASA

Acknowledgments

This volume is the third in a series that had its origins almost a decade ago. The individuals involved in initiating the series and producing the first two volumes have been acknowledged in those volumes [Volume I—*Organizing for Space* (1995); Volume II—*External Relationships* (1996)]; those acknowledgments will not be repeated here. An exception must be made for NASA Chief Historian Roger D. Launius, who has become not only a strong supporter of this series but also an essential collaborator in its implementation.

We owe thanks to the individuals and organizations that have searched their files for potentially useful materials, and for the staffs at various archives and collections who have helped us locate documents. Without question, first among them is Lee D. Saegesser of the History Office at NASA Headquarters, who has helped compile the NASA Historical Reference Collection that contains many of the documents selected for inclusion in this work. All those in the future who will write on the history of the U.S. space program will owe a debt of thanks to Lee; those who have already worked in this area realize his tireless contributions.

At the Space Policy Institute, research associate David H. Onkst made so many contributions to the organization of material for this volume that he deservedly has been listed as co-editor. Graduate students Erin Hatch, Becky Dodder, Garth Henning, and David Vaughn also helped in the preparation of the volume, and research Dwayne A. Day has continued his involvement with the series while concentrating on his own research. The overview essays for the satellite communications and remote-sensing sections were written several years ago, before the decision to expand the series beyond the originally planned two volumes. (The total is now up to six.) Ray A. Williamson helped update and expand Pamela E. Mack's discussion of remote sensing, and he has been added as the second author of the essay. I made far fewer modifications to Joseph N. Pelton's original essay on satellite communications. When it became clear that a focus on economic issues would be valuable, Henry Hertzfeld graciously agreed to oversee the collection of documents for that section and to write the overview essay. Trish Mastrobuono and Julie Hudson of the Institute staff have supported the effort throughout and, with graduate student Irena Slage, helped create the document-scanning capability used in the final stages of the project.

My thanks go to all those mentioned above, and again to those who helped get this effort started almost a decade ago.

John M. Logsdon, George Washington University

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Biographical Appendix 579

Index . . . . . ?

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II-50 Robert S. Winokur, Assistant Administrator for Satellite and Information Services, NOAA, to Albert E. Smith, Vice President, Advanced Government and Commercial Systems, Lockheed Missile and Space Company, Inc., April 22, 1994 381

Chapter Three

Essay: "Space as an Investment in Economic Growth," by Henry R. Hertzfeld 385

Documents

III-1 Jack G. Faucett, President, Jack Faucett Associates, Inc., to Willis H. Shapley, Associate Deputy Administrator, NASA, November 22, 1965, with attachment omitted 401

III-2 Roger W. Hough, "Some Major Impacts of the National Space Program," Stanford Research Institute, Contract NASW-1722, June, 1968, pp. 1–2, 19–22, 36 402

III-3 "Economic Impact of Stimulated Technological Activity," Final Report, Midwest Research Institute, Contract NASW-2030, October 15, 1971, pp. 1–11 408

III-4 Michael K. Evans, "The Economic Impact of NASA R&D Spending," Executive Summary, Chase Econometric Associates, Inc., Bala Cynwyd, Pennsylvania, Contract NASW-2741, April 1976, pp. i–iii, 1–18 414

III-5 Robert D. Shriner, Director of Washington Operations, Chase Econometrics, to Henry Hertzfeld, NASA, April 15, 1980 426

II-33	Ed Harper, Office of Management and Budget, Memorandum to Craig Fuller / Martin Anderson, "Resolution of Issues Related to Private Sector Transfer of Civil Land Observing Satellite Activities," July 13, 1981	306
II-34	Government Technical Review Panel, "Report of the Government Technical Review Panel on Industry Responses on Commercialization of the Civil Remote Sensing Systems," November 10, 1982, pp. 1–25	309
II-35	"Transfer of Civil Meteorological Satellites," House Concurrent Resolution 168, November 14, 1983	321
II-36	"Land Remote-Sensing Commercialization Act of 1984," Public Law 98–365, 365, 98 Stat. 451, July 17, 1984	329
II-37	Office of the Press Secretary, The White House, "Statement by the Press Secretary," June 1, 1989	344
II-38	Office of the Press Secretary, The Vice President's Office, "Vice President Announces Landsat Policy," February 13, 1992, with attached: "Landsat Remote Sensing Policy"	345
II-39	Department of Defense and National Aeronautics and Space Administration, "Management Plan for the Landsat Program," March 10, 1992	347
II-40	"Land Remote-Sensing Policy Act of 1992," Public Law 102–555, 106 Stat. 4163, October 28, 1992	352
II-41–II-44	George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, to John H. Gibbons, Assistant to the President, Office of Science and Technology Policy, August 9, 1993; John Deutch, Under Secretary of Defense, to George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, December 9, 1993; John H. Gibbons, Director, Office of Science and Technology Policy, to George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, December 10, 1993; and George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, to John H. Gibbons, Assistant to the President, Office of Science and Technology Policy, December 14, 1993	368
II-45	The White House, Presidential Decision Directive / NSTC-3, "Landsat Remote Sensing Strategy," May 5, 1994	372

II-23 Arnold W. Frutkin, Memorandum to Dr. Fletcher, Administrator, NASA, *et al.*, "Some Recent International Reactions to ERTS-1," December 22, 1972 259

II-24 James V. Zimmerman for Arnold W. Frutkin, Assistant Administrator for International Affairs, to Dr. John V.N. Granger, Acting Director, Bureau of International Scientific and Technological Affairs, Department of State, September 12, 1974, with attached: "Foreign Policy Issues Regarding Earth Resource Surveying by Satellite: A Report of the Secretary's Advisory Committee on Science and Foreign Affairs," July 24, 1974 262

II-25 Clinton P. Anderson, Chairman, Senate Committee on Aeronautical and Space Sciences, U.S. Senate, to Dr. James C. Fletcher, Administrator, NASA, October 14, 1972 269

II-26 Walter C. Shupe, Chief, GAO Liaison Activities, NASA, Memorandum to Distribution, "GAO Report to Congress 'Crop Forecasting by Satellite: Progress and Problems,' B-183184, April 7, 1978," April 21, 1978 272

II-27 Charles J. Robinove, Director, EROS Program Office, Geological Survey, U.S. Department of the Interior, Memorandum to Staff of the EROS Program, "Optimism vs. pessimism *or* where do we go from here? (some personal views)," December 10, 1975 275

II-28 James C. Fletcher, Administrator, NASA, to Mr. John C. Sawhill, Associate Director, Office of Management and Budget, October 19, 1973 277

II-29 Christopher C. Kraft, Jr., Director, Johnson Space Center, to Associate Administrator for Applications, NASA Headquarters, "Private Sector Operation of Landsat Satellites," March 12, 1976 281

II-30 Bruno Augenstein, Willis H. Shapley, and Eugene B. Skolnikoff, "Earth Information From Space by Remote Sensing," report prepared for Dr. Frank Press, Director, Office of Science and Technology Policy, June 2, 1978, pp. ii–iv, 1–14 282

II-31 Zbigniew Brzezinski, The White House, Presidential Directive / NSC-54, "Civil Operational Remote Sensing," November 16, 1979 . . . 294

II-32 David S. Johnson, Chairman, Satellite Task Force, *Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options* (Rockville, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, June 20, 1980), pp. 1–16 296

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II-14	"Prepared by Jaffe and Badgley at Seamans' Request: NASA Natural Resources Program," May 13, 1966	237
II-15	Leonard Jaffe, Director, Space Applications Programs, OSSA, to Deputy Administrator, thru Homer S. Newell, Associate Administrator for Space Science and Applications, "Meeting at the U.S. Geological Survey (USGS), August 25, 1966, regarding Remote Sensing and South America," August 31, 1966, with attached: Robert G. Reeves, For the Record, "Meeting at the U.S. Geological Survey (USGS), 10 a.m., August 25, 1966," August 31, 1966	240
II-16	Office of the Secretary, U.S. Department of the Interior, "Earth's Resources to be Studied from Space," News Release, September 21, 1966	244
II-17	Charles F. Luce, Under Secretary, U.S. Department of the Interior, to Dr. Robert C. Seamans, Jr., Deputy Administrator, NASA, October 21, 1966, with attached: "Operational requirements for global resource surveys by earth-orbital satellites: EROS Program"	246
II-18	Irwin P. Halpern, Director, Policy Staff, NASA, Memorandum for General Smart, "Earth Resources Survey Program," September 5, 1967	248
II-19	Jacob E. Smart, Assistant Administrator for Policy, NASA, Memorandum for Dr. Mueller, *et al.*, "Earth Resources Survey Program," October 3, 1967, with attached: Draft Memorandum for Mr. Webb, Dr. Seamans, Dr. Newell, "Issues Re: The Earth Resources Survey Program"	250
II-20	Edgar M. Cortright for George E. Mueller, Associate Administrator for Manned Space Flight, Memorandum to Assistant Administrator for Policy, "Earth Resources Study Program," November 17, 1967	253
II-21	Interior Department, "Appeal of 1971 Budget Allowance: EROS," November 25, 1969	256
II-22	Robert P. Mayo, Director, Bureau of the Budget, to Honorable Walter J. Hickel, Secretary of the Interior, April 14, 1970, with attached: "Statement for Senator Mundt"	257

II-2	S.M. Greenfield and W.W. Kellog, "Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle," The RAND Corporation, R-365, August 1960, pp. v–vi, 1–23, 31	183
II-3	Hugh L. Dryden, for T. Keith Glennan, NASA, and Roy W. Johnson, Department of Defense, "Agreement Between the Department of Defense and the National Aeronautics and Space Administration Regarding the TIROS Meteorological Satellite Project," April 13, 1959	203
II-4	U.S. Department of Commerce, Weather Bureau, "National Plan for a Common System of Meteorological Satellites," Technical Planning Study No. 3, Preliminary Draft, October 1960, pp. 1–3	204
II-5	Hugh L. Dryden, Deputy Administrator, for James E. Webb, Administrator, NASA, and Luther H. Hodges, Secretary of Commerce, "Basic Agreement Between U.S. Department of Commerce and the National Aeronautics and Space Administration Concerning Operational Meteorological Satellite Systems," January 30, 1964	206
II-6	Robert M. White, Administrator, Environmental Science Services Administration, National Environmental Satellite Center, U.S. Department of Commerce, to Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, August 15, 1966	211
II-7 and II-8	George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, to D. James Baker, Acting Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, February 22, 1993; and Jim Exon, Chairman, Subcommittee on Nuclear Deterrence, Arms Control and Defense Intelligence, U.S. Senate, to Ron Brown, Secretary of Commerce, June 2, 1993	213
II-9	National Performance Review, Department of Commerce, "Establish a Single Civilian Operational Environmental Polar Satellite Program," September 30, 1993	216
II-10	Presidential Decision Directive / NSTC-2, The White House, "Convergence of U.S. Polar-orbiting Operational Environmental Satellite Systems," May 5, 1994	221
II-11 and II-12	D. James Baker, Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, to John Morgan, Director, EUMETSAT, May 6, 1994; and D. James Baker, Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, to Jean-Marie Luton, Director, European Space Agency, May 6, 1994	224

I-23 David Bruce, U.S. Ambassador to the United Kingdom, to the Secretary of State, "Transfer of U.S. Communications Satellite Technology," Telegraphic Message, November 9, 1966 96

I-24 Memorandum from J.D. O'Connell for the President, February 8, 1967, with attached: "A Global System of Satellite Communications: The Hazards Ahead," February 8, 1967 99

I-25 Leonard H. Marks, Ambassador, Chairman, "Report of the United States Delegation to the Plenipotentiary Conference on Definitive Arrangements for the International Telecommunications Satellite Consortium (First Session), Washington, D.C., February 24–March 21, 1969," April 10, 1969. 108

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1-27 George M. Low, Deputy Administrator, NASA, "Personal Notes," December 23, 1972 132

I-28 Committee on Satellite Communications, Space Applications Board, Assembly of Engineering, National Research Council, "Federal Research and Development for Satellite Communications," 1977 135

I-29 John J. Madison, Legislative Affairs Specialist, NASA, Memorandum for the Record, "Advanced Communications Technology Satellite (ACTS) program meeting, October 13, 1983" 145

I-30 William Schneider, Under Secretary of State for Security Assistance, Science, and Technology, and David J. Markey, Assistant Secretary of Commerce for Communications and Information, "A White Paper on New International Satellite Systems," Senior Interagency Group on International Communication and Information Policy, February 1985 147

Chapter Two

Essay: "Observing the Earth From Space," by Pamela E. Mack and Ray A. Williamson. 155

Documents

II-1 Dr. Harry Wexler, "Observing the Weather from a Satellite Vehicle," *Journal of the British Interplanetary Society* 7 (September 1954): 269–276. . 177

I-11	President John F. Kennedy to Honorable Newton Minow, Chairman, Federal Communications Commission, May 15, 1961	60
I-12	Ben F. Waple, Acting Secretary, Federal Communications Commission, "An Inquiry Into the Administrative and Regulatory Problems Relating to the Authorization of Commercially Operable Space Communications Systems: First Report," FCC Report 61-676, 4774, Docket No. 14024, May 24, 1961	61
I-13	National Aeronautics and Space Council, "Communication Satellites," July 14, 1961	65
I-14	Emanuel Celler, Chairman, Committee on the Judiciary, House of Representatives, *et al.*, to the President, August 24, 1961	67
I-15	Frederick G. Dutton, Assistant to the President, Memorandum for the President, November 13, 1961	71
I-16–I-18	Senator Robert S. Kerr, "Amendment to the National Aeronautics and Space Act of 1958, Space Communications," November 28, 1961; E.C. Welsh, Executive Secretary, National Aeronautics and Space Council, Executive Office of the President, Memorandum to the President, April 11, 1962; and "Communications Satellite Act of 1962," Public Law 87-624, 76 Stat. 419, signed by the President on August 31, 1962	72
I-19	Edward A. Bolster, Department of State, to Mr. Johnson, Memorandum, "Space Communication," May 3, 1962; with attached: "Role of the Department of State in Space Communication Development"	85
I-20	Project Telstar, "Preliminary Report, Telstar I, July–September 1962," Bell Telephone Laboratories, Inc., 1962	89
I-21	Memorandum from J.D. O'Connell, Special Assistant to the President for Telecommunications and Director of the Office of Telecommunications Management, to the Secretary of State, Secretary of Defense, Secretary of Commerce, Administrator, National Aeronautics and Space Administration, and Chairman, Federal Communications Commission, "Policy Concerning U.S. Assistance in the Development of Foreign Communications Satellite Capabilities," September 17, 1965, with attached: National Security Action Memorandum 338	91
I-22	National Security Action Memorandum No. 342, "U.S. Assistance in the Early Establishment of Communications Satellite Service for Less-Developed Nations," March 4, 1966	95

Contents

Acknowledgments xix

Introduction xxi

Biographies of Volume III Essay Authors and Editors xxv

Glossary xxvii

Chapter One

Essay: "The History of Satellite Communications," by Joseph N. Pelton 1

Documents

I-1 and I-2 Arthur C. Clarke, "The Space-Station: Its Radio Applications," May 25, 1945; and Arthur C. Clarke, "Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?," *Wireless World,* October 1945, pp. 305–308 11

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I-4 Memorandum from S. G. Lutz to A.V. Haeff, "Commercial Satellite Communication Project; Preliminary Report of Study Task Force," October 22, 1959. 31

I-5 H.A. Rosen and D.D. Williams, *Commercial Communications Satellite,* Report RDL/B-1, Engineering Division, Hughes Aircraft Company, January 1960 35

I-6 "Memorandum for Conference on Communications Satellite Development," December 7, 1960 39

I-7 White House Press Secretary, "Statement by the President," December 30, 1960 41

I-8 Federal Communications Commission, "FCC Relation to Space Communication," Public Notice-G, 1627, March 14, 1961 42

I-9 and I-10 F.R. Kappel, President, American Telephone and Telegraph Company, to the Honorable James E. Webb, Administrator, NASA, April 5, 1961 (with several attachments); and James E. Webb, Administrator, to F.R. Kappel, President, American Telephone and Telegraph Company, April 8, 1961 45

Document I-10

[1]

April 8, 1961

Mr. F. R. Kappel
President
American Telephone and Telegraph Company
195 Broadway
New York 7, New York

Dear Mr. Kappel:

Thank you for your letter of April 5th. I will be happy to see you whenever you plan to be in Washington. I am appearing before the House Committee on Science and Astronautics on Monday morning, April 10th, and am engaged all day on Tuesday, the 11th, with the President's Committee on Equal Employment Opportunity, which is having its first meeting. Otherwise, I will be glad to reschedule my appointments so we can meet at your convenience.

In order that you may understand, perhaps more fully than a report in the *Wall Street Journal*, the questions and answers at my press conference on the budget, I am enclosing the release. You will note, on page 3, my statement is as follows:

> "In order to take full advantage of the potentialities of the communications satellite for both industry and governmental uses, industry financing of research and development costs is postponed and full governmental financing is provided. Ten million dollars is added for this purpose."

[2] On page 8, you will note my statement that:

> "The basic change is simply to postpone, until we know more than we know today, the real decision as to how this new result of space sciences and technology can be most usefully applied."

Again, on page 9, you will note Dr. Dryden's statement that:

> ". . . the program is the same, John (Finney), the program of four flights that you have heard outlined in great detail. This is merely an estimate as to whether the Treasury would recover money. It seems to be such an uncertain thing at this time that we prefer to have the money in hand, to carry it forward to the test program."

Further, in answer to the question as to whether the addition of the ten million dollars to the budget represented any modification of policy, I stated:

> "It represents a policy decision to have a good hard look at this before making commitments."

Since you have referred to the discussion in my office with Dr. Fisk and Mr. Dingman of your company, I suggest you ask them if the above does not represent what I told them was going through my mind as the only sensible way to approach a decision of such magnitude and significance far beyond the communications industry, as well as long-range

Our estimates of costs and traffic volumes lead us to the conclusion that a satellite system such as we propose is economically feasible. We are prepared to move ahead as rapidly as possible and it is important that we be permitted to do so, not only to meet the service requirements for the near future but also to make sure that this country will lead the way in international space communications for peaceful purposes.

Ownership of the facilities involved could be handled in the traditional way. The foreign terminals would be owned by the foreign telecommunication agencies. We have had many years of mutually satisfactory operating experience with these agencies all over the world and are completely confident that we can come to an equitable arrangement with them concerning the ownership and use of the satellites.

Use of the United States portion of the satellite system would be made available, of course, to all international communications carriers serving the United States for any services they now are, or may in the future be, authorized to provide by the FCC under the Communications Act. Here, too, the facilities would be made available on an equitable basis either by ownership participation through pro rata payment of capital investment and operating expenses or by lease arrangements. These arrangements would preserve competition in the international communications field to the extent that it is determined by the FCC to be in the public interest.

We believe the low-orbit system proposed by AT&T is the preferred system at this time. The technology is well advanced for the low-orbit satellite. On the other hand, there are drawbacks [3] to the synchronous high-altitude satellite. To begin with, there is a .6 second round-trip delay which would be a very serious degradation of telephone service. Further, there are the very difficult problems of placing the high-altitude satellite in proper orbit, maintaining it on the station, stabilizing and accurately pointing its directional antenna. The solution to these latter problems is at a minimum several years away and it's imperative to get on with the job now—not years hence.

The producers of electronic gear and other products and services would benefit from the introduction of this new mode of communications which will broaden their markets. A substantial part of the ground station equipment and many of the components of the satellites themselves will be obtained on a competitive basis from industrial suppliers. Rockets and launching facilities will be provided by private suppliers under appropriate arrangements with the Government.

As stated at the outset, we believe that the questions to which the Commission is seeking the answers in this proceeding are essentially technical in character, and they must be answered promptly if the United States is to maintain its leadership in the communications field. The purpose of this letter is to provide information which may be helpful to the FCC as it considers policy decision vital to the vigorous advancement of the nation's space communications program.

Very truly yours,

"J.E. Dingman" [hand-signed]

Att.
Proposal
Exhibit "A"

****

[1]

Attachment No. 5

March 21, 1961

Mr. Ben F. Waple, Acting Secretary
Federal Communications Commission
Washington 25, D.C.

Re: Docket No. 13522

Dear Sir:

The comments filed by A. T. & T. Co. in Docket No. 13522 were directed to the specific questions posed in the Notice of Inquiry and Supplement. It is our understanding that the Commission was seeking technical information concerning frequency requirements for space communications without discussion at this time of legal or economic question. However, in view of the comments of this character in some of the other responses and the publicity they have been given, we believe a brief statement should be made to forestall any misunderstanding of the Bell System position and bring the comments into a better perspective.

Our interest in satellite communications is simply stated. There is a need for point-to-point space communications system—to help meet the growing demand for international communications of all kinds, and to provide alternate routes from a reliability standpoint. Such space communications systems are a natural supplement to and extension of existing common carrier networks.

The traditional communications policy in this country has been to have common carriers serve both domestic and international needs for public communications. This policy was recently restated in FCC Public Notice G1271 dated February 28, 1961 that ". . . overseas public communications are provided by private enterprise, subject to Government regulation. . . ." This notice also included the following:

"(1) The earliest practicable realization of a commercially operable communication satellite system is a national objective.

[2] "(2) The attainment of this urgent national objective in the field of communications may be accomplished through concerted action by existing agencies of Government and private enterprise.

"(3) In accordance with the traditional policy of conducting international communications service through private enterprise subject to Government regulation, private enterprise should be encouraged to undertake development and utilization of satellite systems for public communication services."

We do not seek a monopoly in satellite communications. We do not wish to exclude other international carriers either from establishing such systems or from sharing the use of the system we propose. We seek only the opportunity to employ private initiative, management and capital in the public interest and under public regulation in a manner wholly consistent with traditional public policy with respect to international communications.

Bell Telephone Laboratories has been actively pursuing a program of research and development in satellite communications. This work has been undertaken because of the Bell System's position as a major U.S. international communications carrier and the obligation this imposes upon it to develop and provide any new means of communications that hold promise of improving its services to the general public and the government. The Bell System's program, for developing a satellite communications system and for placing such a system in commercial service in collaboration with the telecommunications agencies of other countries, is expected to parallel in many respects the System's achievements in the development and establishment of transoceanic submarine telephone cable systems. As was done with the cables, the Bell System will under- [2] take to work out mutually satisfactory arrangements with the other United States international carriers whereby they can obtain facilities for the services furnished by them.

We believe that NASA and the Bell System have a common interest in pointing experimental work in the field of satellite communications toward the realization of a commercial system as quickly as possible with a minimum of cost and without duplication of effort. For this reason, we strongly favor Proposal 2 or Proposal 3, since the 6 kmc and 4 kmc frequencies are already being used in common carrier communications systems in both the United States and Europe. The Bell Telephone Laboratories' program, which is based on the use of these frequencies, is well under way and maximum progress toward our mutual goal will, we believe, be achieved with the experimental satellite contemplated under Proposal 2 or 3. Not only will this permit the testing, in the experimental satellite, of components of the kind that will be used in later prototypes of commercial satellites, but valuable information will he obtained on the problems of sharing the proposed frequencies by terrestrial and satellite common carrier systems.

In response to a specific NASA request, an offer to undertake this program on a cost-plus-fixed-fee basis is associated with each of the proposals. In view of the Bell System interest expressed above, however, each proposal also contains an offer to undertake the program on a cost-sharing basis. These offers involve billing NASA an amount equal to about one-fourth of the expense associated with Proposal 1 or a considerably smaller part of the expense associated with Proposals 2 or 3, since the work to be undertaken under these latter proposals will make a larger contribution to our own research and development program than the work under Proposal 1. All of these cost-sharing offers are on a cost reimbursement basis. Each offer, however, includes a maximum dollar limit of cost to be billed to NASA.

The A. T. & T. Company has offered to provide ground station equipment and operation in the United States and to undertake to arrange for related ground station equipment and operation overseas. NASA has been assured that the United States ground station will be operational in time to meet the planned launching schedule and that these facilities will be made available to NASA for this experiment.

[3] Every attempt has been made to include in the three parts of our response, General Evaluation Information, Scientific and Technical Proposal, and Cost Proposal, all of the information requested in connection with this procurement. The representation relating to small business is attached as a separate item.

This quotation, in response to NASA Request for Proposal GS-1861, is firm for a period of ninety days from the date of this letter. Questions in connection with this quotation should be directed to Mr. R. P. Wilson of this office on Extension 5735.

Sincerely

"C. R. Smith" [hand-signed]

As is common practice, we would expect that much of the work on the communications system would be contracted to other private companies as was done in the Echo experiment, for example, on the transmitting antenna. NASA may also wish to contract with others for many of the other items involved, such as mechanisms for multiple launching, satellite orientation arrangements, etc.

If, as we are confident, this experiment is successful, it is our plan to move as promptly as possible toward the establishment of a commercial satellite communications system which will be integrated with existing common carrier communications facilities, both here and abroad. When this system is operational circuits will be made available to other communications common carriers for use in their business, just as circuits are now available in overseas telephone cables. The proposals that we are making should [5] be of substantial value to the military and other government departments as well as to the other users of our services and those of other communications carriers.

I hope that this outline will offer a useful basis for approaching the problems which we discussed last week.

Sincerely,

F. R. KAPPEL

****

[1] Attachment No. 4

Western Electric Company
INCORPORATED
Defense Activities Division
120 Broadway, New York 5, N.Y.
Area Code 212 571-5761

C. R. SMITH
VICE PRESIDENT

March 20, 1961

The National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Procurement and Supply Division
JDC:241:mj

Gentlemen:

The attached proposal is submitted in response to your Request for Proposal No. GS-1861, Low Altitude Active Communications Satellite, dated January 4, 1961 and the Telegraphic Amendment thereto dated February 24, 1961.

This response contains three separate and complete proposals. Proposal 1 is based on the use of frequencies in the 400-500 and 2,200-2,300 mc bands. Proposals 2 and 3 are based on the use of frequencies in the 5,925-6,425 and 3,800-4,200 mc bands, as requested in the Telegraphic Amendment of February 24, 1961. Proposal 3 differs from Proposal 2 in that it includes a contractor-furnished radiation experiment package.

diodes, solar cells, and reliable traveling wave tubes. Out of the work which the Bell Laboratories has done in the Echo experiment, and from its long and extensive participation in radar have come a series of developments directly applicable to satellite communications, such as high-quality antennas of the horn and Casegranian types, microwave masers as low noise receivers, FM circuits with feedback, also for low noise, and various techniques for precision tracking.

[3] The achievement of a communications satellite system will depend not only on effective satellite relays and expert communications systems engineering. These must be joined in a unique fashion with space technology where NASA's primary responsibility lies. Moreover, space relaying of signals, like other isolated communications techniques, can provide useful communications service only when combined with existing land facilities. It is this joining of the communications and space arts and facilities which indicates the desirability for the joint efforts of our organizations.

It is our thought that such joint efforts would have as their objectives both demonstrating transatlantic TV (which we understand to be one of NASA's primary objectives) and other experiments which will represent the first step in an orderly developmental program for an operating communications system.* Concurrently we would have extensive effort on ground stations for transmitting and receiving, as well as tracking facilities for controlling the antennas. The problems of the entire communication system, including economic problems as well as such important matters as optimum bandwidth, operating margins, systems balance and reliability of components would receive prime attention.

This experiment in its public communications aspects would, we believe, provide information and an opportunity for experimentation not only to us but also to other interested common carrier communication companies. This can be accomplished by inviting other international common carriers to use the satellite circuits experimentally for their own forms of communication.

With this as background, we would like to offer the following specific proposals:

a. That NASA and we join in the setting of performance specifications for the first experimental active satellite.

b. That we develop and build the first satellite taking advantage of research already done and developments well under way. We are prepared to pay for this work in its entirety, or for such part of the expense as would reflect our respective interests in the project.

[4] c. That NASA launch the first satellite and provide tracking data from its Minitrack stations. In this connection, we are willing to bear the whole cost of launching and tracking or to share these costs with NASA in any way you feel will properly reflect our respective interests in the project.

d. That the existing ground station at Holmdel be made available and modified at our expense for the purpose of making the necessary communications tests. (This station is, of course, compatible with the communications network of this Company.)

e. That, taking advantage of our long established working relations with overseas communications operating agencies, arrangements be made with at least one of them for one or more overseas ground stations.

f. That other common carriers be invited to use the satellite circuits experimentally when such circuits are operational.

g. That full information on satellite performance be made available to NASA.

---

* A program for the Development of an Active Satellite Communication System has been prepared by Bell Telephone Laboratories and is available for detailed discussion.

[1]

Attachment No. 3

December 14, 1960

DR. T. KEITH GLENNAN, Administrator
National Aeronautics and Space Administration
1520 H Street, N.W.
Washington 25, D.C.

Dear Dr. Glennan:

Our discussion of December 7 regarding satellites for communication purposes raised a number of questions relative to the respective efforts of NASA and A.T.&T. Co. in this area of scientific exploration. I believe there was no disagreement on the need for advancing scientific knowledge as fast as possible to the point where commercial communications by satellites can be undertaken by the common carrier communications companies and their international counterparts, each in their respective areas of service.

In our conversation, we indicated we are proceeding at our own expense with the development and construction of experimental active satellites which will be ready for launching within a year, this to be an initial step toward the establishment in a few years of a commercial satellite system. You in turn advised that NASA is also planning experimentation in the field of active communications satellites, with the view to developing further scientific information in this area.

It was agreed that our objectives, stemming as they do from our respective areas of responsibility and competence, have much in common. Moreover, I believe we were in accord that the national interest could be best served if our efforts were combined in this field so as to avoid wasteful duplication and delay in the development of a final system.
[2] It is recognized that NASA has broad responsibilities to advance "the role of the United States as a leader in aeronautical and space technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere." This charges your organization with a broad obligation to assure that the activities necessary to achieve this result are being carried out. It does not, however, seem to require that NASA itself duplicate work now being done or planned by private industry but only that it encourage industry in its efforts and be prepared to move in should industry be unable or unwilling to take full advantage of its opportunities.

The common carriers of the United States have the responsibility to the American public to furnish the best possible communications service not only within this country but also internationally. In the course of discharging A.T.&T.'s responsibilities, we have developed overseas radiotelephone service and overseas telephone cables and have established telephone communications with nearly every country in the world. The technical problems which were solved in bringing these facilities into service are comparable to those which are faced in satellite communication systems.

We are also constantly seeking to improve the communications art and find better and more economical means of doing the job to which we are dedicated. In so doing we maintain the most extensive communications research and development laboratories in the world, Bell Telephone Laboratories, whose responsibility is to explore every possible way of improving communication. The exploration of the use of satellites as a means of radio communication is a natural part of the Bell Laboratories overall program and it has been devoting substantial effort to activities in this area for a number of years. In this connection, our Bell System technology has already been the source of the essential components which enable a satellite to act as a communications relay. These include transistors,

Ground Transmitting Station at Holmdel: Existing 60' dish, used in Echo I, modified for 6875 mc operation, or a new similar dish. Improved antenna control system. 1 kw transmitter, using either a commercially available klystron or a traveling wave tube under development by Bell Laboratories, choice to be determined by engineering considerations.

Ground Station or Stations in Europe: Same as at Holmdel, possibly with variations in detail required to satisfy foreign partners.

Antenna Pointing: Use Minitrack data. Have Goddard Space Flight Center compute orbit parameters to be transmitted to BTL. Track computation and antenna control orders by Bell Laboratories.

Estimated Performance: With satellite 7.5° above horizon, and assuming total noise temperature of 34° K, 2 db [decibels] satellite antenna gain and achievable accuracy in antenna pointing, system would provide peak-to-peak signal-to-rms noise ratio of 47 db. Such performance will provide a path for about 450 one-way, high-grade telephone channels, or in the order of 100 two-way channels. Alternatively, the experimental system will provide one-way-at-a-time transmission of a black-and-white television picture of a quality only slightly inferior to American commercial standards, and not noticeable on the average home receiver.

Schedule: The system is expected to be operational in 12 months, assuming no undue delays are encountered in: (1) assignment of the necessary experimental radio frequencies, (2) availability of a suitable satellite launching vehicle, and (3) agreements with the foreign partner(s) and execution of their agreed-upon technical tasks.

October 20, 1960

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[no pagination]

28 September 1960

Mr. G. L. Best, Vice President
American Telephone and Telegraph Company
195 Broadway
New York 7, New York

Dear Mr. Best:

Thank you for your letter dated September 15, 1960, which you handed me on that date. It was a pleasure to see you and Dr. Baker again.

The proposal of the Bell System to integrate satellite systems into its commercial operations is of considerable interest to NASA.

From a broad point of view, as you no doubt appreciate, your request that NASA launch trial satellites for the Bell System raises issues of national policy which we are currently studying. Accordingly, there is no simple or ready-made response that I can give you at this time.

It is helpful to me to know the position of your company and its particular plans for the future. If you are able to be more specific about any facet of your program at any time in the future, please be assured that I would appreciate being informed.

Sincerely yours,

T. Keith Glennan
Administrator

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Since Dr. Fisk is out of town, I am enclosing the statement, which has his agreement.

Sincerely yours,

E. I. GREEN
Executive Vice President

Enc.

***

[1]

PROPOSED BELL SYSTEM EXPERIMENT ON
ACTIVE SATELLITE COMMUNICATION

OBJECTIVE

To carry out an experiment in transoceanic communications with a satellite carrying an active repeater suitable for multichannel telephony and for television. The experiment is an important part of a continuing Bell System development program directed toward large scale application of radio satellites for broad-band communications. The program includes extensive laboratory research and development work leading to long life and reliable operation of such a system.

SYSTEM CHARACTERISTICS

Proposed Operating Frequencies:	6775-6875 mc [megacycle] ground to satellite. 6425-6525 mc satellite to ground.
Baseband Width:	2 mc.
Modulation:	FM with ± 10 mc swing.
Transmission Path:	Europe to U.S.A. and reverse.

Satellite: Microwave receiver; 2-watt microwave transmitter; circularly polarized reception and radiation; solar cells for primary power; nickel-cadmium storage battery. Separate beacon transmitter, 150 milliwatts at about 136 mc for tracking. Satellite essentially spherical, about 4' diameter, weight 175 lbs. or less. The initial satellite will not be engineered primarily for the long life needed for commercial operation. Orbit of satellite should be as nearly polar as possible, at an altitude of 2,000 to 5,000 miles. (Note: This experiment is directed particularly toward normal telephone communication in which one way transmission delay of 1/4 second, such as would be encountered with a 24-hour satellite, would be intolerable.)

Ground Receiving Station at Holmdel: Existing 20' x 20' horn reflector antenna, used in Echo I. Improved antenna control system. (Construction of a larger 60' x 60' horn reflector antenna is to be started immediately, [2] but this may not be in operation until a few months after the first active satellite experiment.) Maser for operation at 6475 mc. Wideband FM feedback receiver.

facilities in intercontinental communications as soon as possible. The telephone administrations of England, France, and Germany have all indicated a desire to participate in such a project. We hope to be ready for a transatlantic trial in eighteen to twenty months, or less. The experimental satellite, or satellites, would be placed at an orbital altitude of perhaps 2,200 miles and would carry a repeater designed to make initial use of a 5-megacycle radio-frequency bandwidth. We are willing to assume the cost involved in this experiment, except that we would expect the participating foreign administrations to pay at least the cost of their own ground stations.

Our present thinking is that we would design and construct the trial satellites for our own use, making sure that the mechanical design would be compatible with the design and capability of whatever launching vehicle was used. While it is probably too early to know just what facilities for launching could be made available, we would hope that the National Aeronautics and Space Administration would be willing to launch these trial satellites for us, at our expense, if this proved to be the most practicable arrangement.

Although our primary interest is in proceeding with a trial of active satellites, we shall be glad to cooperate with your organization in any further tests of passive satellites that you may wish to conduct, using not only the ground equipment now available but also the equipment that would be developed for active satellite trials.

I am sure you understand that these thoughts may be subject to some modification as the program develops, but I believe they will hold basically. We would, of course, seek the advice of your organization in all phases of the work and keep you informed of our progress.

We would welcome any comments you may care to make about any part of this proposed program.

Sincerely yours,

G. L. BEST
Vice President

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[no pagination]

Attachment No. 2

October 20, 1960

DR. T. KEITH GLENNAN, Administrator
National Aeronautics and Space Administration
1520 H Street, N.W.
Washington, DC

Dear Dr. Glennan:

Dr. Fisk agreed to provide you with a brief statement of the objectives and principal features of the experiment the Bell System proposes to conduct on long distance communication via an active satellite.

As indicated in the statement, the experiment is an important part of a continuing Bell System development program directed toward large scale application of radio satellites for broad-band communications.

there can be no important differences between us as to ultimate objectives, and perhaps we can by discussion at this time advance the attainment of those objectives. Will you please call me at your convenience.

Sincerely yours,
[hand-signed: "F.R. Kappel"]
President

Attachments

****

[1]

Attachment No. 1

September 15, 1960

Dr. T. Keith Glennan, Administrator
National Aeronautics and Space Administration
1520 H Street, N.W.
Washington 25, D.C.

Dear Dr. Glennan:

During the discussion which Messrs. Botkin, Pierce and I had with you and your people several weeks ago, we expressed the view that the commercial satellite communication systems of the future should be owned and operated in this country by communications carriers. In other words, we believe that existing national policy and practice in the communications field should be extended to embrace the new medium.

By so doing, it will be possible to achieve efficient integration of the planning, construction, and operation of overseas cable systems, satellite systems, and other radio facilities, and also assure the integration of domestic and overseas operations that is so necessary to the orderly planning and development of telephone service in particular. Communication with other countries by any medium, of course, requires the cooperation of the organizations or administrations responsible for furnishing external communication services in those countries.

It is assumed that there will be some form of Government supervision of the launching and orbiting of satellites, as well as, of course, regulation of the communication services rendered and the radio frequencies used. It also seems to us that any international action which our Government may feel desirable in order to adequately coordinate with other governments the use of satellites may be taken without Governmental ownership or management of the facilities required to furnish commercial communications.

During our conversation there was also considerable discussion as to what part of the work of developing a practical satellite communication system might be undertaken by commercial communications carriers, and what part of the expense of such work should be borne by them. At the close of this discussion you asked that we set down our thoughts on [2] these matters, or, more specifically, state what the Bell System companies' plans are for the future and what part they were looking to the National Aeronautics and Space Administration to do. Our present views on this subject are outlined below.

The Bell System now has under way the development of an active satellite and associated ground radio facilities and would like to proceed with an experimental trial of these

During discussions which preceded our bid, we pointed out that whether such a project would take the place of one step in the Bell System's proposed program would depend on the type of satellite which was placed in orbit. At that time we expressed the hope that if our requirements were not met by NASA's project, NASA would launch a Bell System satellite later at our expense.

In our studies of satellite communications, while paying primary attention to the needs of international common carriers, we have also considered certain specific Defense Department needs—for example, mobility and the provision by the Defense Department of a few reliable voice channels to remote locations. The early experiments and tests of satellite relays can be made to serve both civilian and defense objectives and we have discussed such matters of common interest with agencies of the Department of Defense. I believe Dr. Fisk and Mr. Dingman of this Company discussed this briefly with you and Dr. Dryden a few weeks ago.

Summing up these events, I think it is clear that we have made every effort to find a way of getting this very vital experimental work done promptly and that, contrary to our not having made any specific proposals, we have actually made three specific proposals to NASA. Mr. Best has gone over this matter by telephone with Dr. Dryden but I thought that you might like to have this statement of the situation from me.

[3] We are extremely anxious to avoid any further delay in getting trials under way for a number of reasons, the most important of which can be summarized as follows:

1. There is a need for point-to-point space communications systems—to help meet the growing demand for overseas communications.
2. Such systems would be a natural means of augmenting existing connecting links between the common carrier networks of this country and those of foreign countries and would also provide alternate routes for reliability.
3. Our estimates of costs and traffic volumes lead us to the conclusion that a satellite system such as we propose is economically feasible.
4. Trials of active communications satellites are needed to determine the basic facts upon which a commercial communications satellite system may be designed.
5. We are prepared to move ahead rapidly if permitted to do so.
6. If this country does not maintain the leading position in space communications for peaceful purposes, which is now within its grasp, others will take the lead.
7. The severity and frequency with which sunspot disturbances are occurring threaten to disrupt existing forms of overseas radio communication seriously during the next several years. This is of great importance to military as well as to civilian communications.

There need be no fear that this Company is seeking a monopoly in international communications through the use of satellites. Our only interest in satellites is their use as another means of connecting the Bell System's communications network in this country with similar networks in foreign countries.

We have stated both to the Government and publicly that any satellite system which we sponsor will be available to all United States international communications common [4] carriers—either through lease or ownership arrangements—for any services authorized by the Federal Communications Commission. We have also stated that rockets and launching facilities will be provided by private suppliers under appropriate arrangements with the Government. (See Mr. Dingman's letter of March 21, 1961 to the Federal Communications Commission—Attachment No. 5.) Furthermore, the creation of the satellite system we propose, to do our public service job, will not preclude in any way the development of other space communications systems for other purposes.

In view of the urgency of this whole matter, I <u>should like very much to drop in and</u> [handwritten underlining] discuss some of its aspects with you in more detail. I am sure

The new Democratic administration of President John F. Kennedy was less sympathetic than its Republican predecessor to AT&T's plans to establish the leading position in the development of communications satellites. This exchange of letters reflects the position taken by new NASA Administrator James E. Webb—that it was desirable to re-examine the government role in communications satellite development before deciding that the government should take a secondary position in that development to AT&T and possibly other U.S. communications carriers. The position of AT&T President Fred R. Kappel to that stance, as reflected in his letter to Webb, is supported by a series of attachments indicating AT&T's plans as they had developed in the preceding months.

Document I-9

[1]

April 5, 1961

THE HONORABLE JAMES E. WEBB, Administrator
National Aeronautics and Space Administration
1520 H Street Northwest
Washington 25, D.C.

Dear Mr. Webb:

It has come to my attention that the *Wall Street Journal* on March 29, 1961 carried an article stating that invitations were issued last year to companies such as American Telephone and Telegraph Company to come forward with partnership proposals with the Government (on communications satellites), but that NASA has yet to receive a firm proposal from any company.

In view of events which have taken place during the past few months, this statement, which we understand grew out of a press conference which you held with respect to NASA's budget, is of deep concern to me. The specific events to which I refer are as follows.

On September 15, 1960, Mr. G. L. Best of this Company, wrote to Dr. Glennan (Attachment No. 1) saying that we had under way the development of an active communications satellite and associated ground radio facilities and would hope that NASA would be willing to launch trial satellites for us at our expense if this proved to be the most practicable arrangement.

This letter was followed by several informal discussions after which Dr. E. I. Green of the Bell Telephone Laboratories wrote Dr. Glennan on October 20, 1960 (Attachment No. 2) and enclosed a statement of the objectives and principal features of the experiment which the Bell System proposed to make.

[2] Subsequently, there were several discussions during which Dr. Glennan and his people outlined some of the problems which NASA felt were involved in accepting our original proposal. During these conversations, various possibilities of a joint NASA-Bell System project were discussed, and on December 14, 1960 I wrote to Dr. Glennan outlining in some detail several specific proposals as to how a joint undertaking might be accomplished (Attachment No. 3).

Shortly after, NASA decided to ask for bids covering the construction of an active satellite of its own design and to seek the cooperation of private industry here and of the telephone administrations of Great Britain and France in trials using such a satellite. We were offered an opportunity to bid on such a project and did so, making substantial allowance in our bids for the value which we thought the telephone industry might get from such an experiment. A copy of the transmittal letter which accompanied these bids is also enclosed (Attachment No. 4).

EXPERIMENTATION

The Commission is encouraging experimentation in this new field in the hope that private industry can develop considerable additional technical information which will serve to further the country's over-all space program.

In this regard, an experimental authorization was granted in January of this year to the ITT Laboratories, Nutley, N.J., to bounce signals off the moon and passive (non-radio-equipped) earth satellites for basic research and study.

Also in January of this year, an experimental authorization was granted to the American Telephone and Telegraph Co. to permit it to go forward with plans to develop an experimental program wherein earth terminal facilities at Holmdel, N.J., would transmit to and receive from active (radio-equipped) earth satellites which also are undergoing development by AT&T.

MONITORING

Another FCC activity is the continued monitoring of channels being used for space communication. This started with its long range direction finding work in tracing Sputnik I, before the Government established special installations to track space objects. Commission monitoring is to prevent unauthorized use by other stations of channels employed for space communication, and to identify and locate sources of interference on those channels. At a number of FCC monitoring stations, special equipment includes sensitive receivers, high gain directional antennas and automatic frequency scanning devices.

[4] RADIO ASTRONOMY

Related to space communication is the use of radio in astronomy. The Geneva 1959 conference, for the first time in history, provided for protecting specific frequencies utilized in radio astronomy. The FCC has completed the groundwork for putting these provisions into effect domestically when the Geneva agreement is ratified by the United States.

Meanwhile, the Commission has adopted rules to minimize interference to frequencies used for radio astronomy observations in this country, particularly at the National Radio Astronomy Observatory at Green Bank and the Naval Radio Research Observatory at Sugar Grove, both in West Virginia.

Document I-9

Document title: F.R. Kappel, President, American Telephone and Telegraph Company, to the Honorable James E. Webb, Administrator, NASA, April 5, 1961 (with several attachments).

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

Document I-10

Document title: James E. Webb, Administrator, to F.R. Kappel, President, American Telephone and Telegraph Company, April 8, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

The U.S. Committee for Study Groups IV and VIII of the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU), with which the FCC participates through subgroups;

The Space Science Board (SSB), of which the FCC's Chief Engineer is a member of the International Relations Committee concerned with international basic space research activities, working internationally through the Committee on Space Research (COSPAR);

The International Radio Scientific Union (URSI), which has FCC participation and, in turn, is a member of the International Council of Scientific Unions (ICSU); and

The National Bureau of Standards Central Radio Propagation Laboratory, with which the FCC maintains liaison through membership on the Interdepartment Council on Radio Propagation and Standards.

INTERNATIONAL CONSIDERATIONS

The International Administrative Radio Conference, held at Geneva in 1959 under the auspices of the ITU, adopted an international table of frequency allocations which, for the first time, provided bands of frequencies for space and earth-space services. These bands, however, are for research purposes only and are useful principally for tracking, control and telemetry functions. Although no bands were allocated internationally for space satellite relay communication, a special ITU Administrative Radio Conference was scheduled tentatively for late 1963 to deal specifically with space problems on the basis of developments as of that time. At the request of the Department of State, preparatory work toward formulating the United States position at that conference has been initiated jointly by the FCC and the IRAC.

[3] Domestically, steps have been taken by the FCC to implement the 1959 Geneva Radio Regulations nationally pending ratification of that treaty by the President upon the advice and consent of the Senate.

FCC PROCEEDINGS

As a result of developments in space communication during 1960, the Commission reopened its proceeding in the general inquiry relative to the allocation of frequencies above 890 Megacycles (Docket 11866) to determine, in the light of evidence then available, whether the frequency requirements for communication via space satellites would require modification of the Commission's decision to permit some additional classes of users to establish communications systems on frequencies between 1,000 and 10,000 Mc. After a careful analysis of all the evidence then on hand, the Commission concluded that its earlier decision need not be modified at that time.

However, in view of rapid developments in space communication, the Commission instituted an inquiry (Docket 13522) as to space frequency needs on a longer-range basis. This information will assist the Commission in its preparatory work leading to a United States position for [a] future international conference on space needs and usage. The inquiry was augmented to consider conditions for sharing space bands with other radio services and whether protected areas might be established and held in reserve for future earth terminals for civil communication systems using space relays.

[1]
PUBLIC-G, 1627 March 14, 1961

FCC Relation to Space Communication

GENERAL

The Federal Communications Commission activities in connection with space communication have increased greatly because of the many new and unique problems posed by rapid technological and scientific developments in this field.

Although the Commission is not responsible for any over-all space program or any particular space vehicle launching project, the mounting activity in space communication has an impact on its regulation of non-Government radio users. This stems from its obligations under the Communications Act which, among other things, requires the FCC to "study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest" as well as to "make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service."

This involves the allocation and assignment of frequencies for space communication and the authorization of privately conducted research and experimentation looking toward the use of natural or man-made satellites to provide civil communication services on a regular basis. Radio signals "bounced" or relayed from such satellites would permit the transmission of large amounts of telephone, telegraph and other traffic, including television, over great distances. Such developments present a new and complex array of technical problems. Not the least of these is finding suitable and sufficient frequencies and insuring compatibility between space communication systems and surface systems so that the public interest will best be served. Many regulatory problems will flow from adding space communication to radio's already manifold uses.

COORDINATION AND COOPERATION

The achievement of these purposes involves both national and international considerations. Consequently, the Commission is working closely with the interests involved.

This coordination and cooperation requires particularly close relationship by the FCC with the National Aeronautics and Space Administration (NASA), which directs the Nation's non-military space effort. On February 28, 1961, the FCC and NASA announced a joint "memorandum of understanding" for delineating and coordinating their respective responsibilities in civil communication space activities.

[2] Other interagency activities include FCC participation in the following:

The Telecommunication Coordinating Committee (TCC) [all underlining is handwritten] of the Department of State, which has an ad hoc working group under the chairmanship of FCC Commissioner T.A.M. Craven to draft foreign policy recommendations on space communication systems;

The Telecommunication Planning Committee (TPC) which advises the Office of Civil and Defense Mobilization (OCDM), with FCC representation on space study panels;

The FCC and the OCDM have joint responsibility for national frequency allocations, with staff work through joint meetings of FCC representatives with the Interdepartment Radio Advisory Committee (IRAC) and its Subcommittee on Frequency Allocations (SFA);

Statement by the President

The commercial application of communication satellites, hopefully within the next several years, will bring all the nations of the world closer together in peaceful relationships as a product of this nation's program of space exploration.

The world's requirements for communication facilities will increase several fold during the next decade and communication satellites promise the most economical and effective means of satisfying these requirements.

Increased facilities for overseas telephone, international telegraph, and other forms of long-distance person-to-person communications, as well as new facilities for transoceanic television broadcasts, through the use of man-made satellites, will constitute a very real benefit to all the peoples of the world.

This nation has traditionally followed a policy of conducting international telephone, telegraph and other communications services through private enterprise subject to Governmental licensing and regulation. We have achieved communications facilities second to none among the nations of the world. Accordingly, the government should aggressively encourage private enterprise in the establishment and operation of satellite relays for revenue-producing purposes.

To achieve the early establishment of a communication satellite system which can be used on a commercial basis is a national objective which will require the concerted capabilities and funds of both Government and private enterprise and the cooperative participation of communications organizations in foreign countries.

Various agencies of Government, including the Department of State, the Department of Defense and the Office of Civil and Defense Mobilization, have important interests and responsibilities in the field of communications.

With regard to communication satellites, I have directed the National Aeronautics and Space Administration to take the lead within the Executive Branch both to advance the needed research and development and to encourage private industry to apply its resources toward the earliest practicable utilization of space technology for commercial civil communications requirements. In carrying out this task NASA will cooperate closely with the Federal Communications Commission to make certain that the high standards of this nation for communications services will be maintained in the utilization of communication satellites.

[handwritten note—"Drafted Dec 23, 1960"]
[handwritten note—"Released Dec 30, 1960"]

Document I-8

Document title: Federal Communications Commission, "FCC Relation to Space Communication," Public Notice-G, 1627, March 14, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

The question of authority over determining space communications policy was unclear at first. NASA and the Department of Defense had both been assigned responsibility for technology development, but the Federal Communications Commission (FCC) had a say in the allocation of frequencies for satellite communications. In addition, several other committees and organizations, both international and within the U.S. government, were responsible for different aspects of the subject.

d. NASA's approach includes competitive hardware acquisition for at least two Thor-based flights at Government expense and competitive launchings (including satellite, vehicle and launch costs) at [4] private or Government expense using at least two Atlas-based vehicles.
   1. The key to this approach is "competition" because it is the only way in which NASA can assure the Congress that its approach is not preferential.
   2. Competition may also result in a better system.

5. Special Problems
   a. Reimbursement depends upon a ruling by the Comptroller General. If favorable, then NASA can develop a relationship with industry which is not dependent upon the budget-authorization-appropriation cycle. If not favorable, then NASA would have to seek legislation to authorize it to credit such reimbursements to its own appropriations.
   b. Patents depend upon the application of the present law, unless NASA is successful in getting its statute amended. This means that AT&T's case for waiver under the present law is one way the ownership of inventions might be determined and the application of the law to a "cooperative agreement" is a less preferred way of determining ownership. NASA intends to seek a legislative amendment of its statute in the same terms as were proposed to the last Congress.
   c. Follow-on R&D and prototype launchings must be planned since it is hardly likely that a four-shot program will be adequate to develop an operational prototype satellite and an operational system. Back-up vehicles should be available for repetitive shots within three months of any failure.
   d. Participation by AT&T in all satellite communications experiments under NASA programs in a manner similar to that employed in the Echo program seems desirable from the standpoint of all concerned.

[5] e. Publicity by AT&T should avoid "predictions" involving launchings and avoid the impression that AT&T can "go it alone" in the R&D phase. There should be closer cooperation between [public information] offices in AT&T and NASA so that AT&T releases are available to NASA in a timely manner.

Document I-7

Document title: White House Press Secretary, "Statement by the President," December 30, 1960.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Shortly before he left office, President Dwight D. Eisenhower issued a number of policy statements in an attempt to set the future agenda on various issues, including communications satellite policy. In a statement released to the press on December 30, 1960, Eisenhower reiterated his position that private industry should establish and operate communications satellite systems.

b. Both AT&T and NASA should avoid duplication and waste, from the total national point of view, including manpower, time, and money.
c. Both AT&T and NASA favor private ownership and operation of communication satellites.
d. Both AT&T and NASA must consider the national interest, which includes all of the various competitive interests, in communication satellite system operation.
[2] e. Neither AT&T nor NASA can afford to let the development of the utilization of the commercial satellite systems become a "political" issue.
f. It follows that a common objective and a disciplined common approach to it must be mutually understood.

3. AT&T's Position As Presently Understood
a. AT&T's approach may give others the impression that AT&T is seeking to preempt responsibility for the nation's non-military, satellite-based, communications program.
b. This can not be allowed to occur either in reality or in appearance for the following reasons:
1. It would seem to constitute an abandonment by NASA of its responsibility under the law.
2. It would seem to constitute a "give away" by NASA, impliedly [sic] sanctioning AT&T as the chosen owner and operator, which is beyond NASA's legal authority.
3. It would contribute fuel to the fire of the arguments by those who favor Government ownership and operation of all satellites.
4. It would stimulate debate instead of action and thereby engender delay and diversion from the main technological task ahead of us.
5. The nation can be assured of continued development only by Government activity and control of R&D [research and development] programs, since AT&T does not and probably can not provide assurance of continuity of effort should unforeseen obstacles arise.

[3] 4. NASA's Approach
a. AT&T must fit its activities, even when using its own funds, into the communications program of NASA as a part of it. Present here is the implication that the interests and technical approaches of AT&T and NASA will be substantially the same.
b. This does not involve NASA's pre-empting AT&T because NASA is in the forefront of the proponents of private ownership and operation.
c. This is otherwise essential for the following reasons:
1. It assures the avoidance of wasteful duplication.
2. It supports NASA in its affirmation of private ownership and its belief in the feasibility of an industry-Government "partnership" for developmental purposes.
3. It assures the Congress of the Government control of R&D and therefore improves the possibility of getting on with the job with the minimum of legislative delay which might be caused if the Congress gets the impression that the Executive Branch is not giving adequate direction to the total national effort.
4. It takes account of the fact that vehicles and launch facilities are scarce national assets and must be utilized under Governmental control.
5. The only way the Government can enter into a "partnership" is to reserve unto itself the authority to identify and the authority to protect valid public interests.

[28] 7. CONCLUSIONS AND RECOMMENDATIONS

It is concluded that it is technically feasible, within the present state of the art of rocket and electronic technology, to establish a commercial 24-hour communication satellite using the Scout rocket vehicle. It is recommended that NASA encourage such a program and recognize it as an important new application of the Scout. This program can be accomplished by the Hughes Aircraft Company within a year at a cost of 5 million dollars.

Document I-6

Document title: "Memorandum for Conference on Communications Satellite Development," December 7, 1960.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

In the closing months of the Eisenhower administration, NASA Administrator T. Keith Glennan and his associates paid much attention to the appropriate relationship between government and the private sector in the development of communications satellites. AT&T's active interest in trying to establish a leading position in this new technology stimulated Glennan and his colleagues to focus on this issue. This memorandum, with no credited author, but almost certainly prepared by Robert Nunn, Glennan's special assistant for communications satellites, summarizes the situation as of December 1960.

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[1]

Memorandum for Conference on Communications Satellite Development

December 7, 1960

1. Basic Mutual Recognition
   a. AT&T uniquely has the greatest and most obvious private business interest in satellites because of its overseas telephone business.
   b. Other companies have expressed varying degrees of interest in and shown varying degrees of initiative with respect to participation in the development of elements of a communication satellite system, although none has given evidence of desiring to spend company funds in substantial amounts as has AT&T.
   c. NASA alone has the statutory responsibility to the nation for developing space technology and facilitating its civil application to communications.
   d. It follows that all these respective interests must be harmonized on a common ground.

[handwritten notes in margin: "1) May - June 1961 - firm up our coop. utilization of A's," "2) Obtain assurance of A-participation in comm.," and "3) NASA must preserve bid n (and) competition."]

2. Common Ground
   a. Neither AT&T nor NASA should pre-empt the other's central area of responsibility and competence.

Terminal			
Antenna Design	0.05 M		
Transmitter Modifications	0.05 M		
Low Noise Receiver Design	0.10 M		
Total	0.20 M		
Guidance - Perigee			
Transmitter Design	0.05 M		
Receiver Design	0.09 M		
Antennas	0.02 M		
Computer	0.04 M		
Total	0.20 M		
Guidance - Apogee			
Auxiliary Antennas	0.05 M		
Computer	0.05 M		
Total	0.10 M		
Total Development Cost			$1.20 M

Table 6-1
Development Cost

[27]
Development Cost

Terminal Cost			
Antenna	$0.30 M		
Transmitter	0.12 M		
Receiver	0.03 M		
Building and Land	0.10 M		
	$0.55 M	x 2	$1.10 M (2)
Jarvis Island Installation			
Construction of Buildings	$0.25 M		
Construction of Airstrips	0.25 M		
Launcher	0.25 M		
Ground Support Equipment	0.70 M		
Transportation	0.25 M		
	$1.70 M	x 2	$3.40 M (2)
Launchings			
Scout with Attitude Guidance	$0.361 M		
Payload	0.072 M		
	$0.433 M	x 3	$1.30 M (3)
Miscellaneous			
Salaries of Field Personnel	$0.200 M		
Reserve	0.200 M		
	$0.400 M		$0.40 M
Total Program Cost			$5.00 M

Table 6-2
Program Cost

[3] 2. SUMMARY OF TECHNICAL FEATURES

The proposed communication system consists of a satellite repeater in a synchronous, equatorial orbit operating in conjunction with two or more ground terminals, each of which is linked by land lines or microwave relays to the appropriate domestic communication systems.

The repeater consists of a transistorized UHF receiver and an L-band (2 KMC) transmitter having a power output of 2.5 watts. Since the electrical power is supplied by solar cells, the useful life of the repeater is expected to be limited only by the life of the transmitting tube to about one year. Besides serving as the communication repeater, the receiver-transmitter is also used as a guidance signal repeater, and the receiver additionally acts as a command receiver.

The payload also contains a compressed nitrogen attitude and vernier velocity control system, which provides for proper illumination of the solar cells, correct aiming of the directional antenna, and precise adjustments of the orbit.

The ground terminals consist of a large aperture antenna shared by the 25-KW [kilowatt] UHF transmitter and the low noise L-band receiver. The antenna reflector will be fixed, and the small departures of the payload from an exactly stationary orbit will be followed by moving the antenna feed.

The satellite is launched using the NASA Scout, and two additional solid-propellant rockets are used to establish the desired orbit. The launching site will be Jarvis Island, an equatorial island approximately 1300 nautical miles south of Hawaii. The use of this suitably located equatorial site results in a large decrease in required propulsion system performance and guidance complexity.

Further technical detail is furnished by the following sections of this proposal. . . .

[25] 6. PROGRAM COST

An estimate of the development cost of the communication system is given in Table 6-1, and an estimate of the cost of the entire program is given in Table 6-2.

The amount of confidence which can be placed in these figures is worth some discussion. The costs of the Scout rocket, attitude guidance, launcher, and ground support equipment were obtained from the Vought Astronautics brochure, “Space Research Vehicle Systems Developed from NASA Scout,” published in August, 1959. The UHF TV transmitter is a production item and its cost is firm. The cost of the ground antenna was estimated by an experienced supplier of such devices. Island construction costs were estimated by an overseas construction company which has had considerable experience with [Atomic Energy Commission] projects in the Marshall Islands.

The development cost estimates were obtained from the individuals who would be responsible for the various items. Although some variation in cost of particular items is to be expected, the chances that the total will remain under the 1.2 million dollar figure seems quite good, because of the strong appeal of the project to creative engineers and the subsequent high degree of enthusiasm with which the job will be performed.

[26]

Payload	
TWT	$0.15 M
Electronics	0.15 M
Structure	0.05 M
5th and 6th Stages	0.25 M
Environmental Testing	0.10 M
Total	$0.70 M

[i]

Commercial Communications Satellite

[1] 1. INTRODUCTION - PROGRAM OBJECTIVES

This document describes an inexpensive communication satellite system for intercontinental transmission of television, telephonic, and teletype messages on a commercial basis.

The system proposed uses an active repeater in a satellite having a circular orbit in the plane of the earth's equator with a period of 24 hours. Such a satellite is generally recognized as the ultimate communication satellite because it remains stationary to the earth.

The NASA has a program which is expected to lead eventually to such a satellite. The schedule for the program is not firm, but NASA testimony to Congress* indicates that the goal is four to five years away. This conclusion is reached from the technical specifications that NASA has until now believed are necessary, involving heavy (800 to 3000 pounds), complex payloads with two to three years' life as an objective. As a more immediate program, NASA will put a number of 100-foot diameter passive balloon reflectors into orbit during this year. These balloons will be tracked by several organizations, and will provide valuable scientific information. However, such reflectors are not of any real commercial value because [of] large amounts of power per unit bandwidth and immense tracking antennas required to give even the intermittent coverage afforded by low-altitude orbits.

There are several military communication satellite programs now under way. None of these conflict with the commercial program proposed here; the military programs use high power active repeaters in low-altitude orbits in order to avoid any requirements for large antennas at the terminals.

The presently proposed commercial system can be put into operation within one year. This radical improvement in schedule is achieved primarily through the design of a very light (25 pound) satellite repeater, a design based on realistic objectives for satisfactory commercial [2] application. The light payload required with the present concept permits use of an inexpensive solid-propellant booster, the Scout. This results in a program cost of 5 million dollars.

The advantages of such a program would be severalfold. Financially, it is believed that the initial development, terminal installations, and launching costs could be recovered in a fraction of the first year's operation. It is expected that the useful life of a repeater will be about one year, and that the cost of replacing the repeater in orbit will be about 0.5 million dollars.

The suggested communication system is capable of large growth. The first repeater will cover most of the continental United States, all of Europe, all of South America, and much of Africa. An additional repeater would cover Hawaii, Australia, Japan, and other parts of the Orient. In addition to extension of geographic coverage, the existence of the communication link will result in an increase in foreign business which in turn will result in greater use of the facility. Extrapolation of recent trends in overseas messages shows that the present cable capacity between the U.S. and Europe will be exceeded within the next two years. Since the proposed facility is much less expensive than a cable, it is logical to expect this overflow to be handled by the proposed facility.

In addition to its commercial value, the proposed communication satellite should contribute greatly to national prestige and friendly foreign relations.

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* "Hearings before the NASA Authorization Subcommittee of the Committee on Aeronautical and Space Sciences, United States Senate," U.S. Government Printing Office, 1959.

RECOMMENDATIONS

I. If another company gets into orbit first, much of the publicity and prestige value will be lost and we would have to compete for traffic. Furthermore, this must be a low-cost program and delays increase costs. Consequently, the program should be planned to start development now. The expensive commitments (for rockets, ground installations, etc.) can be deferred for a few months without delaying the launching date.

[5] II. Fund the traveling-wave-tube development separately as a commercial product. A one-pound tube of this capability should find application in Signal Corps portable microwave relay repeaters, possibly in field television transmitters, as well as in other programs. A quarter-million for its development seems a normally good product development risk. This tube is the heart of the proposed satellite electronic system and will be its longest lead-time component.

III. Fund the remainder of the payload development and earth-terminal (antenna and low-noise receiver), in an amount of about $850,000.00. Also, take an option three Scout boosters, plus necessary real-estate, etc. If this is too large a commitment in advance of completion of the comprehensive market survey and negotiations with potential customers, fund a sufficient fraction to carry the development program this long. Delaying the start of development would delay completion of the program correspondingly.

IV. Explore with General Telephone Company, at top management level, their interest in a non-Bell long-distance and overseas capability and their willingness to cooperate as the common carrier in the proposed program. Avoid disclosing details which might permit General's electronic subsidiary, Sylvania, to attempt to replace us. Reach a working agreement which will permit prompt working-level discussions of General's cooperation in the program. If negotiations with General fail, try the next best company.

V. A task force, or project team, consisting of key personnel loaned as required from several organizations—Communications Division, Research Laboratories, Systems Development Laboratories—should be set up to carry out the program.

Document I-5

Document title: H.A. Rosen and D.D. Williams, *Commercial Communications Satellite,* Report RDL/B-1, Engineering Division, Hughes Aircraft Company, January 1960.

Source: Hughes Space and Communications Company, Los Angeles, California (used with permission).

By the end of 1959, Harold A. Rosen and his team had reworked their initial mid-1959 design for a geosynchronous communications satellite into a form that was very close to what was actually first launched as Syncom 1 in 1963. This report describes that design; only relevant excerpts appear here. The report anticipated a NASA program for communications satellite research and development that might provide a source of funding to Hughes for developing the satellite; however, NASA first chose to support a lower orbit satellite proposed by RCA called Relay. During discussions with NASA in 1960, the space agency suggested to Hughes the use of a larger Thor Delta booster rather than the Scout booster specified in this report. This would allow the satellite to be launched from Cape Canaveral in Florida rather than the Jarvis Island launch site discussed in the report.

bility of bandwidth reapportionment between earth-terminals in accordance with shifting relative traffic loads. In short, this approach overcomes the "two at a time" limitation of most prior proposals and thus approached more closely the eventual many-user "exchange in orbit" concept. Furthermore, it accomplishes this without sacrificing television capability, requiring only that other traffic be limited during a television program and be kept out of the television band.

[4] 10. Determination and resolution of possible legal and political problems and governmental restrictions obviously is beyond the scope of this Task Force. A few of the possible problems will be mentioned. The usual difficulties with the Federal Communications Commission can be expected in obtaining a license for a new type radio service for frequencies have not yet been allocated. Similar, or worse, difficulties can be expected with the corresponding regulatory bodies of other nations where earth-terminals are located. Characteristically, the FCC makes no precedent-setting decisions without holding industry-wide hearings and these could be competitively detrimental. Furthermore, the State Department might become involved because of the international nature of this venture. Next, some governmental agency probably has control of Jarvis Island and would insist on approving its use. Finally, NASA probably would have to sanction the commercial sale and use of Scout boosters and could impose other controls on the program, such as requiring provision for removing dead repeaters from orbit, or provision for disabling their electronics in event that the project is abandoned with repeaters still in orbit. As a ray of sunshine, NASA's mission is non-military space technology. They have expressed encouragement toward commercial projects which would not require NASA funds. If NASA becomes "sold" on the proposed project, they might provide inestimable assistance in surmounting the other governmental obstacles. One recognizes that exploration by a Hughes representative of the above governmental restrictions could readily "leak" to competitors, or even to the press, and be highly detrimental. This danger can be avoided, it is believed, by retaining a consultant to make this preliminary investigation without disclosing his client or the details of the project.

11. The impact of the proposed program on the military services could be both good and bad. It would be conclusive proof of Hughes' competence to execute a major space program and in Hughes' confidence and initiative in undertaking it without governmental funds. Thus, it should put us in better competitive position for managing future governmental space projects. It could have a bad impact, however, in "showing up" the inefficiency of military satellite programs.

12. It is known that Bell, RCA and probably other large companies recognize the potential attractions of satellite communication and probably have program plans. It is reasonable to assume that Bell would plan to invest several times the cost of the trans-Atlantic cable in a big stationary orbit project, timed to the availability of big boosters, five or ten years hence. Pressure for additional international circuits may lead them to re-examine the feasibility of moving faster by using a smaller booster and lighter payload, much as we propose. Certainly they could be expected to do this if they learned that their chief competitor, General Telephone, planned such a program in cooperation with Hughes. Most of the prestige value and a portion of the economic value would be sacrificed if our communication satellite were not the first. This indicates the need for a quick decision and a fast program under tight security.

* * * * * *

6. How can Hughes expect to do so much better than others? The answer does not lie in any startling but questionable innovations, inventions or break-throughs. Rather, the answer lies chiefly in application of the Hughes brand of System Engineering, plus exploiting Hughes competence in low-noise reception and traveling-wave-tube development. The starting point was to assume a quasi-stationary orbit (satellites held within about 5° angular limits of desired point on the stationary orbit), to be put there by a Scout booster. The limited payload weight to 30 lbs on the basis of Chance-Vought performance predictions, or to 25 lbs on derating the predicted velocity by 800 fps. This obviously limits the satellite transmitting power, energized from solar cells, to a watt or so. [3] Transmission at or near 2 kmc (the accepted optimum frequency for space communication) favors high antenna gain and use of traveling-wave-tubes. The nearest to a breakthrough was the assurance by Dr. J. T. Mandel of the feasibility of developing a 2.5 watt periodic PM focused 2 kmc high efficiency traveling-wave-tube of one pound, including its INDOX VI focusing magnets. The low satellite power is handled at the earth terminals by low noise (cooled maser or parametric) reception and very high antenn [sic] gain (58 db). In achieving the latter at reasonable costs, the quasi-stationary position of the satellite avoids the need for full azimuth and elevation control which has been made even 80 ft steerable parabolas so expensive. At similar cost, the beam from a 150 ft truncated parabola can be steered through a $\pm 5^\circ$ range. Thus, the burden is put on the earth-terminals, where it belongs. The satellite antenna design is a compromise between using an omni-directional antenna for maximum simplicity and using a 17° beam for maximum gain. While either of these extremes could be fatal, the compromise of a spin-stabilized doughnut pattern provides 6 to 9 db gain, with simplicity. Finally, with adequate design for a 14 db S/N ratio, the addition of frequency modulation raises the S/N ration to a commercial 32 db.

7. Because of the importance of assessing feasibility of staying within the weight capability of the Scout booster, Ed Felkel was named to the Task Force to analyze the weight of the payload package. His report (attached in Appendix B) shows confidence of keeping it safely within weight.

8. Putting the satellite in orbit and keeping it in position entails a sequence of individually-practicable operations within today's state of the art. Cumulatively, however, the multiplicity of stages plus operations of velocity adjustment, de-spinning, re-spinning and incremental orbit adjustment present a currently-indeterminable hazard to the success of any one firing. It is believed that a combination of (a) careful and conservative engineering with step-by-step pre-testing, (b) adequate training on analog simulators, (c) study of any troubles in earlier NASA Scout firings, and (d) adequate determination of the cause of any initial Hughes failure, will result in adequate probability of success within the programmed three tries. Admittedly, there can never be certainty of success in only three attempts. However, a fourth or subsequent firings should not increase the program cost proportionately.

9. As might be expected, the Task Force study has resulted in significant system improvements, by Dr. Rosen as well as by Task Force members and others. For example, the payload configuration has been broadened to improve spin-stability and has been stiffened by a central column. More important, perhaps, has been the swing away from design primarily for television relaying, with additional narrower i-f channels for other communication services, toward the simpler and more flexible and potentially rewarding approach of coordinated use of a broad-band single-channel repeater simultaneously by several earth-terminals. This mode of operation requires that earth-terminals equalize their transmitting powers by monitoring the spectrum from the satellite, rather than depending on AGC of separate i-f channels in the satellite to prevent a too-strong earth-signal from weakening other retransmissions. Also, this mode of operation provides flexi-

b. The Bell System, which formerly depended on radio for intercontinental phone circuits, has been investing heavily and profitably in long submarine cables; four in the past few years. The first trans-Atlantic phone cable provided thirty-six circuits (about 140 kc [kilocycle] bandwidth), cost about $30,000,000.00, and reportedly paid out in its first two years. A second trans-Atlantic cable soon will be placed in service at a reported cost of $40,000,000.00, presumably for a similar number of circuits. Tropospheric scatter radio chains are comparable in cost and are geographically constrained.
c. Comparing the proposed satellite system ($5,000,000.00 for 4500 kc bandwidth) with submarine cable, it could carry up to thirty times as much traffic at one-sixth the investment!

[2] 3. Converting "potential" into "actual" economic attractiveness will depend on acquiring communication traffic, most probably via cooperative agreement with one or more communication common carriers. General Telephone may be the best prospect (certainly a better one than the complacent Bell System) because it is trying to gain stature despite Bell's long-distance monopoly. The proposed satellite system could bypass Bell land-lines in linking General's east-coast and west-coast systems, in addition to giving it non-Bell circuits to Europe and other continents. General Telephone also could negotiate more efficiently with the communication services of other countries and even other domestic companies (Western Union, etc.) than [Hughes Aircraft] could; not being a common carrier. This and related market survey problems seemed too sensitive to be explored adequately by the engineers of this task force, even if time and suitable contracts had been available. General Telephone need not be the only potential partner, of course, for even a smaller common carrier might supply enough traffic to get started. As few as six circuits (30 kc out of the available 4500 kc) to Europe should justify a five-million-dollar investment in proportion to submarine telephone cables.

4. . . . (15 October [Interdepartmental Correspondence] from Lutz to Haeff, Jerrems) lists three questions which define the scope of the market survey believed to be desirable. To this list should be added a study of the relative costs and outage times for splicing a broken cable vs replacing a dead satellite repeater. As a preliminary estimate, keeping a launching in readiness on Jarvis Island should be less expensive than keeping a cable ship in readiness and a new satellite could be put up in hours, instead of the weeks required to locate and repair a cable-break.

5. Technical aspects of the proposed program have been evaluated in more detail, and with higher confidence in the conclusions, than was possible with the preceeding [sic] economic aspects. The crux of the technical attractiveness of this program (and an important economic consideration as well) lies in quick-reaction capability at low cost. By being able to keep the weight of a simple broad-band repeater payload below 25 lbs, it can be put in stationary orbit by an inexpensive (one-third million dollars) solid-fuel Scout booster. Everyone else (NASA, RCA, Space Electronics, Signal Corps) has viewed a stationary orbit repeater as a more sophisticated, hence heavier device, with attitude control to use high gain antenna *beams* on the satellite. More payload weight requires a larger *liquid*-fueled rocket and severe logistic problems in transporting or making liquid oxygen for an equatorial launch. The alternative of launching from the U.S. and "dog-legging" into an equatorial orbit increases guidance problems and requires Saturn thrusts. Thus, NASA and others consider the stationary orbit communications repeater as a high-cost program for 1965-70. This Task Force has convinced itself of the feasibility of puttin [sic] 25 lbs, or possibly 30 lbs, into a useful quasi-stationary orbit with a Scout booster, of achieving a 4500 kc bandwidth repeater within this weight and of doing this within a year of the date that full funding is provided.

Document I-4

Document Title: Memorandum from S.G. Lutz to A.V. Haeff, "Commercial Satellite Communication Project; Preliminary Report of Study Task Force," October 22, 1959.

Source: Hughes Space and Communications Company, Los Angeles, California (used with permission).

By 1959, work on communications satellite research and development was going on in several industrial firms besides Bell Laboratories. The Department of Defense had taken the lead in sponsoring research on active repeater satellites, while NASA concentrated its initial efforts on passive reflectors. In particular, the Department of Defense was supporting research on a complex satellite project called Advent, which intended to develop a satellite for use in geosynchronous orbit. An engineering team at Hughes Aircraft in mid-1959, led by Harold Rosen, devised a proposal for a much simpler geosynchronous satellite and asked the company to support its development. This memorandum reports to Hughes vice president for research, A.V. Haeff, the conclusions of an internal task force set up to assess the proposal of Rosen and his team, which also included Donald Williams and Thomas Hudspeth. (The appendices referred to in this memo are not included.) Over the following months, Hughes managers debated whether to provide support for the proposal from company funds or to seek government support for the project. Enough corporate funds were made available to keep the project going, but it was not until NASA contracted with Hughes to develop and demonstrate what became known as Syncom that the project became the foundation for the many geosynchronous satellites to follow.

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[1]

Hughes Aircraft Company
Interdepartmental Correspondence

To: A. V. Haeff **cc:** See Distribution **Date:** 22 October 1959

Subject: Commercial Satellite Communication Project; Preliminary Report of Study Task Force **From:** S. G. Lutz

1. It is the unanimous opinion of the Task Force working members* that the satellite communication system proposed by Dr. H. A. Rosen is technically feasible, is possible of realization within close to the estimated price and schedule, has great potential economic attractiveness and should not encounter too serious legal or political obstacles.

2. The Task Force has, of necessity, concentrated on technical aspects of the program and has not been able to make an adequate market survey. The phraseology, "great potential economic attractiveness[,]" is justified by the following:

   a. A rapidly increasing demand for new long-distance communication facilities is being created by: (1) Population increase, (2) Shrinkage of travel time via commercial jet aircraft, (3) Increasing foreign industrialization and international commerce, (4) Increasing military communication loads, and (5) Forthcoming decrease in HF [high-frequency] communication capability because of the declining sunspot cycle. Rather than being able to open more HF radio circuits to carry the increasing traffic, new circuits (cable, scatter or satellite) will be needed to pick up perhaps a third of the traffic now carried by HF circuits.

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* Task Force working members are: E. D. Felkel, S. G. Lutz, D. E. Miller, H. A. Rosen and J. H. Striebel.

Plastic sphere, 100 feet in diameter, of [the] type to be used in satellite transmission experiments. In orbit, thin plastic with aluminized surface will reflect microwaves.

In connection with this type of work, then, what are some of the specific problems on which we have worked, and what are some of the problems concerning which we need additional knowledge?

While we have a very good maser in the 6,000 mc range, there is still some room for improvement, and we need masers for other frequencies. A related problem is that some types of antennas tend to pick up noise from all directions, so we are adapting the horn-reflector type antenna, which does not have this defect. With such equipment, we have already made measurements of sky temperatures which check the theoretical curves shown on page 324. We believe that these antennas may also have many uses in radio astronomy.

We have made some studies of the effect of ultraviolet light on the properties of aluminized Mylar, and for this material we have investigated absorption at various wavelengths to tell us the temperature a satellite might attain in space.

Other obvious fields for additional work are those of propagation measurements, guidance, and the many components besides masers and antennas that must go into any experimental system. A very important need is highly reliable components for experiments with active satellite repeaters. We have inaugurated work on such components.

This need for further study should emphasize that today we have no proven answers to the problem of overseas broad-band radio communications. If we ever turn on our television sets and view a European event beamed by radio across the Atlantic, it may come to us over a system no one has even thought of yet. But in the meantime, to assure the possibility we must continue to pursue a vigorous and effective research program.

Number of Randomly Spaced Satellites Needed for Various Minimum Elevation Angles and Percentages of Interruption

Minimum Elevation Angle in Degrees	Percentage of Interruption 10%	5%	1%
0	9	12	19
3.25	11	14	21
7.25	12	15	24
12.60	17	22	33

Assumptions: Terminals in Newfoundland and Hebrides; Polar Orbits at 3000-mile height

The next obvious question is whether transmitters and antennas are available for such communication. Assuming an operating frequency of 2 kilomegacycles, a 40 db [decibel] signal-to-noise ratio, and 100-foot spherical reflectors at 3,000 miles, we have calculated that we would need antennas 150 feet in diameter and transmitter power of 100 kilowatts. Antennas of this size have been used, and the required power could be obtained by paralleling ten commercially available tubes. At present, however, we cannot be sure that the required type of satellite reflector would withstand the conditions of space and maintain its shape in orbit.

Need for Knowledge

At this stage the reader may feel that this is exoticism with a vengeance. We have perhaps raised more questions than those we have tried to answer. Aside from the problem of costs, which can hardly be handled definitively at this early date, the technical problems are extensive. But herein lies the point of this discussion—we need more fundamental knowledge of the possibilities before we can begin to think realistically of actual systems. And the only way we know of to get this knowledge is to continue our traditions of careful search, study of the problems, and measurement.

On March 19, T. Keith Glennan, Administrator of the National Aeronautics and Space Administration (NASA), announced plans to launch several satellite spheres next year. These experimental spheres, fabricated from an aluminized plastic, are to be 100 feet in diameter. The announcement also mentioned the plan to establish communications between an 85-foot tracking antenna at Goldstone, California, and communications facilities on the East Coast, including [329] Bell Laboratories equipment at Holmdel. The Goldstone antenna is operated by the Jet Propulsion Laboratory of Pasadena, California, which is owned by NASA and operated under contract to the NASA by the California Institute of Technology.

This view is somewhat optimistic, however, since we have so far ignored three sources of noise that could restrict the range of this type of communications: (l) The noise added by the receiving amplifier, (2) Cosmic noise, and (3) Atmospheric noise. Fortunately, the maser (RECORD, *July*, 1958) provides us with a microwave receiver that adds practically no noise to the received signal. Thus we can largely neglect the first of these three noise sources.

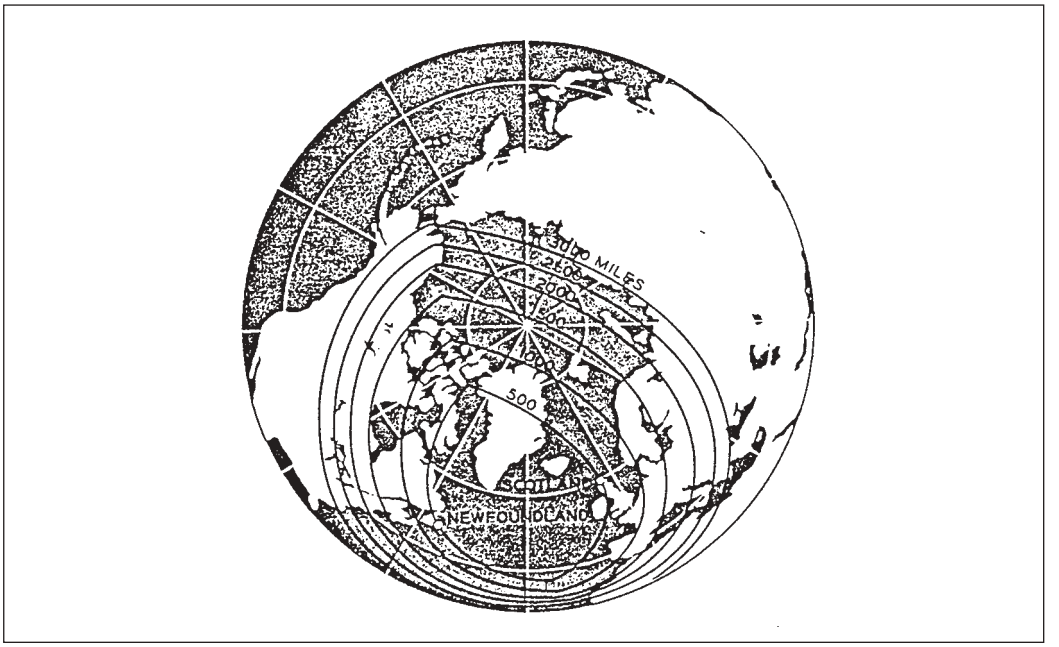
Another illustration [the graph at the beginning of this document] gives some pertinent data on the other two sources. In this graph, noise is described in terms of absolute temperature, ranging upward from 1° Kelvin on the ordinate, as related to frequency on the abscissa. The color region describes the range of the cosmic noise discovered by Jansky, and as we see from the graph, it becomes negligible at the higher frequencies.

The third source—atmospheric noise—is a more serious limitation. Even cold air at high altitudes is hot compared to absolute zero, so it radiates electromagnetic noise just as hot iron radiates light and heat. The radiation is small because the atmosphere is almost transparent. To evaluate the noise, we must consider how transparent the atmosphere is at a given frequency and also how much atmosphere an antenna "sees" as it follows a satellite.

In the graph, the bottom curve labeled 90 degrees illustrates that an antenna pointed straight up sees a minimum of atmosphere and therefore receives a minimum of atmospheric noise. From about 2 to 10 kilomegacycles this noise is fairly constant and corresponds to only about 2.5° K. As the antenna is rotated farther and farther toward the horizon, however, it must look through more and more atmosphere and receive correspondingly more noise. The zero curve at the top is the case where the antenna points horizontally; here it sees a very long atmospheric path, and the noise actually approaches the assumed atmospheric temperature (290° K) at very short wavelengths for which air is not very transparent to microwaves.

[328] Note, however, that the curves for the various angles are displaced downward toward the lower noise values as the angle above the horizon is increased. Even as close as 10 degrees above the horizon, an antenna will see only about 13° K of atmospheric noise. These curves make us feel that we can realize the advantages of the maser if we use signals from a satellite reflector only when it is 7 degrees or more above the horizon. This limitation in effect contracts the contour areas in the polar-projection map, which were drawn with the assumption that signals would be received right down to the horizon.

How serious is this limitation? Suppose we consider satellites 3,000 miles high and use them only when they are at least 7 degrees above the horizon. Average visibility per rotation will thus be less than the 22 percent listed in the first table, but if we put more and more satellites up, the result is an increase in the percentage of time that at least one satellite is visible. For 24 satellites, at least one satellite would be available to both Newfoundland and Scotland for 99 percent of the time. The interruptions would occur at predictable intervals, and would therefore be less serious than if they were random in time. The second table (*see below*) lists some other possibilities for different minimum angles and percentages of service interruptions.



Oval-shaped areas define regions in which polar-orbit satellites at various heights would be simultaneously visible to both terminals at Newfoundland and Scotland. The usable areas would be somewhat smaller, however, since transmission is difficult when [the] satellite is near the horizon.

Visibility Times at Various Heights of Orbit

	Height of Satellite Above Surface of Earth in Miles					
	500	1000	1500	2000	2500	3000
Time of one revolution (minutes)	100.4	118.0	136.6	155.0	175.2	195.2
Shortest visibility (minutes)	0	0	8.0	12.5	23.8	31.4
Longest visibility (minutes)	14.7	20.0	29.6	36.6	46.2	55.4
Average visibility (percent)	3.5	6.9	12.9	17.7	19.6	22.0

Assumptions: Terminals in Newfoundland and Hebrides; polar orbits; refraction effects ignored; and visibility from horizon to horizon.

The first Sputnik in October 1957 changed the picture radically, and we began to look at these possibilities much more seriously.

If satellite communication ever becomes a reality, it will be no exception to past Bell System experience. That is, it will necessarily be preceded by the established pattern of meticulous study and experimental work. At the moment, we do not have enough knowledge or experience to describe in detail a practicable system or to state exactly how it might be used. We can do little more than speculate on the various possibilities.

One proposal is to place satellites 22,400 miles above the equator. At this height, a satellite would rotate in step with the earth and seem always to hang in the same position in the sky. Such satellites would be "active" relay stations—that is, they would be equipped with receivers and transmitters, and probably with accurately pointed directive antennas. This is an apparently attractive proposal, but for the present it raises at least two serious questions: the problems of accurate rocketry to launch and orient such satellites are indeed formidable, and the problems of equipment life in such relay stations are, to put it mildly, severe.

A second proposal is to place active satellites in orbit only a few thousand miles above the earth. These would not be stationary in relation to the earth, but with a sufficient number of them, signals could be relayed from each whenever it is in a usable section of its orbit. With this second proposal, rocket accuracy is somewhat eased, but equipment life in a low-altitude relay station is as serious a question as in the case of the 22,400 mile satellite.

With low-altitude satellites, however, a transmitter and receiver on the satellite are not essential. Instead, one may put in orbit a group of passive reflectors. Large, high-power transmitters would then transmit to a satellite reflector, and signals would bounce from it and thus reach a distant receiver. The satellites would be aluminized plastic spheres—"balloons" perhaps 100 feet in diameter—with a high reflectivity to microwaves.

As an exercise to explore possibilities and problems, we have studied in some detail a theoretical system using passive satellites for transatlantic broad-band transmission. As shown in the illustration [of the passive-reflector satellite], the terminals were considered to be in Newfoundland and on an island in the Hebrides off Scotland. The satellites are to be imagined as traveling in polar orbits.

Regions of Visibility

On the polar projection shown below, closed contour lines are drawn for various heights of orbit. These define areas in which a single satellite would be simultaneously visible to both the Newfoundland and Scotland terminals. At a height of 2,000-miles, for example, a satellite would be visible to both terminals anywhere within the 2,000-mile contour, even along the outer edges of the area.

The first of the accompanying tables (*see below*) shows calculations relating to the orbit [327] heights. The shortest and longest visibility times in the second and third horizontal rows are of particular interest. For the l,000-mile height, as an example, the zero for shortest visibility time indicates that for some passes, a satellite would not be visible at all at both of the two terminals. A 3,000-mile satellite, however, would be visible at least 31.4 minutes, and as long as 55.4 minutes, for every revolution around the earth. On the average it would be visible 22 percent of the time. Thus, even with only one satellite, one might get quite long stretches of broadband communication.

observations indicated strong reflections from meteor trails, a verification of Skellett's and Goodall's early ideas.

However, ionospheric scattering proved disappointing for long-distance telephone circuits. For both turbulence scatter and meteor-trail scatter, the bandwidth is too narrow and transmission is too erratic. The more important region for the scatter technique proved to be the lower-altitude troposphere.

Kenneth Bullington did the pioneering work in this field. During 1950–1951, he collected data on and tested what we now know to be tropospheric scatter propagation, over paths 200 to 300 miles long. He pointed out the possibilities of this mode of transmission in historic papers published in the *Proceedings of the I.R.E.* in 1950 and 1953.

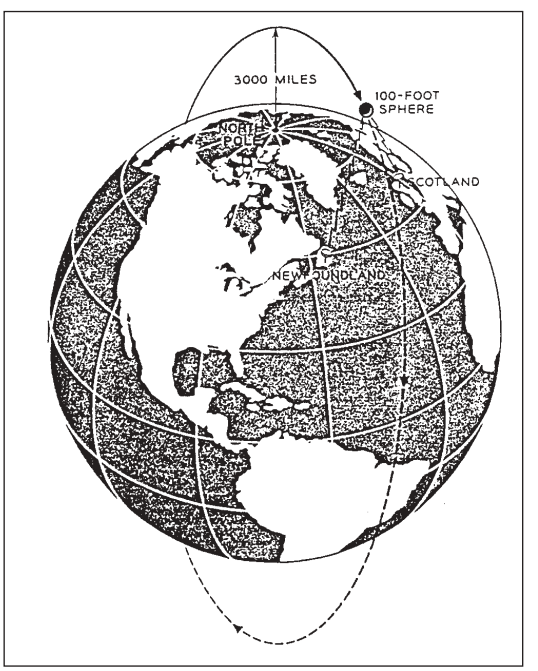
Beginning in 1955, further studies of scatter propagation were carried out over a path between a 60-foot scanning antenna at the Holmdel Laboratory and a transmitter on a farm in Pharsalia, New York, 171 miles away. The effects of antenna size, signal strength, depth and speed of fading, and angles of arrival were investigated. These data were compared with the predictions of a theory worked out by H. T. Friis, A. B. Crawford and D. C. Hogg. This theory supposes that the scattering is caused by a large number of randomly positioned but nearly horizontal discontinuities in dielectric constant in the first few miles above the earth's surface. The measurements fit the theoretical predictions very well in many respects. The knowledge acquired in these studies of tropospheric scatter is now widely used in designing scatter circuits.

Scatter Circuits in Operation

Scatter circuits designed by Bell Laboratories and installed by Western Electric are currently in operation over the DEW [Defense Early Warning] line in the far north and over the "White Alice" system in Alaska. In addition, a broad-band scatter system for commercial telephone and television service was established between Florida City and Havana in 1957. This Florida-Cuba circuit handles 36 telephone channels and has the capability of handling 120 or more.

If we now turn our attention to the problem of future broad-band radio transmission between North America and Europe, scatter circuits are an obvious suggestion. It might be possible, for example, to set up a series of relay stations via [326] Greenland, various North Atlantic islands, and Scotland. Our studies indicate, however, that this type of communications would be very expensive. Large antennas and high-power transmitters would have to be built and maintained at remote arctic locations. Further, the multipath nature of scatter transmission would probably result in a poor broad-band circuit by television standards, although several dozen telephone channels might be provided.

What, then, is another type of possible intercontinental radio communications? As early as 1954, we considered the use of artificial earth satellites as relays, and I published a technical paper on the subject. At that time, however, problems of launching such satellites were unexplored.



The geometry of a passive-reflector satellite in a polar orbit at an altitude of 3,000 miles, with terminals located in Newfoundland and Scotland.

a rapid variation in the direction from which signal components arrive at a receiving antenna and especially in the vertical angle of arrival.

Such extensive and accurate measurements made it clear that operating frequencies should be changed from time to time to suit the condition of the ionosphere. As a replacement for the early narrow-band antenna arrays, the simple rhombic antenna invented at Bell Laboratories permitted effective operation over the required wider band of frequencies. In following the more rapid variations in angle of arrival, the MUSA system—an array of rhombic antennas interconnected with phase-changing networks—made it possible for a receiver to track the observed changes in the vertical angle of arrival of the radio signal.

As a part of the careful studies of short-wave phenomena at Bell Laboratories from 1929 through 1931, K. G. Jansky investigated noise in the short-wave bands at the Holmdel Laboratory. In the course of these studies, he detected radio noise of extra-terrestrial origin—work which laid the basis of radio astronomy. In recognition of Mr. Jansky's discovery, the laboratory at the new National Radio Observatory at Green Bank, West Virginia, is to be named the Karl G. Jansky Laboratory.

Besides this short-wave work, higher frequencies were also explored, and much fundamental knowledge was gained. This was applied in providing a number of over-water circuits and in mobile radio. However, the next large-scale Bell System application of radio was found in the field of microwaves, which have frequencies of thousands of megacycles. G. C. Southworth started his microwave work as early as 1932, long before any use for such frequencies could be assured. H. T. Friis and his associates took up this work in 1938.

Here again we see how early scientific and exploratory work led to extensive measurements and studies, and to the development of a sound technical art. The knowledge so gained was invaluable to radar during World War II, and later made possible the experimental New York-Boston System in 1947 and the Transcontinental TD-2 Radio-Relay System in 1951.

Reliable Microwave Service

As in previous cases, there was a lot to learn. Studies of microwave paths proved the value of using highly directive antennas. These studies set a pattern in the Bell System of using very good, narrow-beam antennas that allow the use of low power and that minimize interference. All of this work showed that microwaves could provide very reliable service indeed.

We now approach more contemporary developments, and it is time to remind ourselves again that it is largely an illusion to think of such past achievements as commonplace. They were, and certain aspects of them still are, as challenging as anything we have in mind for the future.

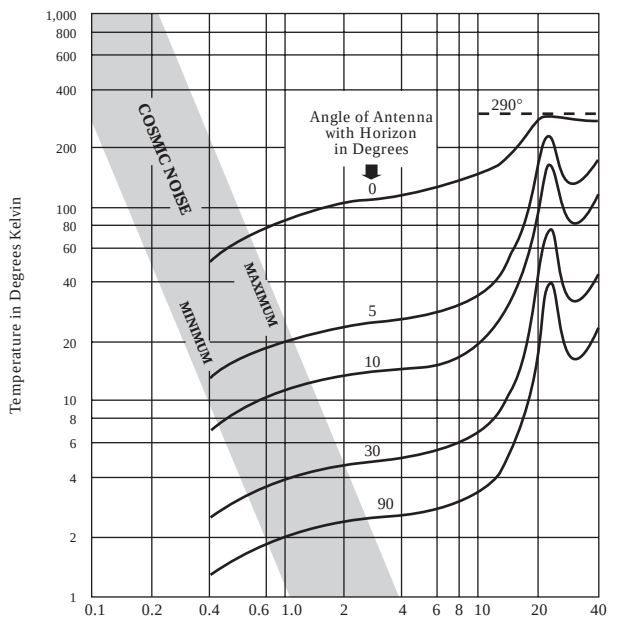
Current thinking in radio communications [325] still emphasizes the use of higher and higher frequencies, but direction of propagation is another important factor. Many intriguing problems and possibilities arise when we direct antennas toward the troposphere and the ionosphere, and toward satellites. Some of these problems were foreshadowed at Bell Laboratories as early as 1934 when A. M. Skellett and W. M. Goodall, in their studies of the ionosphere, looked for reflections from ionized meteor trails. The frequencies of 2 to 6 mc [megacycles] used in these studies were too low to give a strong signal, but statistical analysis of the data seemed to yield evidence for such reflections.

In other studies of the ionosphere, workers outside the Laboratories proposed in 1951 to use the turbulence of the ionosphere to achieve beyond-the-horizon scatter propagation. At a frequency of 50 mc, a 776-mile circuit was established between Cedar Rapids, Iowa, and Sterling, Virginia. Bell Laboratories monitored these signals, and with carefully designed antennas was able to receive teletypewriter messages during 1951 to 1954. In the course of this work, very high signal strengths were detected for very short periods. These

entific and engineering work and to show the value of the Bell System pattern of careful study, measurement and design.

Radio itself seemed exotic in an earlier day. Before the founding of Bell Laboratories in 1925, the A.T.&T. Co. and Western Electric contributed heavily to the technology of radio broadcasting. Even earlier, in 1915, A.T.&T. and Western made use of newly developed power vacuum tubes in demonstrating radio communication between Arlington, Virginia, and both Hawaii and Paris. This showed a potentiality for transoceanic communication which could not be overlooked. One result was the first use of radio for commercial telephone service, from the mainland in California to Catalina Island in 1920. The work also led directly to experiments in transatlantic telephony as early as 1923, and to the inauguration of commercial transatlantic telephone service in 1927.

[324]



Theoretical atmospheric noise (in degrees K) versus frequency as an ideal antenna points at various angles to the horizon. The color region indicates the expected range of cosmic noise.

In this early long-wave work, accurate measurements of field strengths were made. A form of modulation was adopted—in this case the first use on radio of the single-sideband technique—which was best suited to the nature of the medium and the needs of the system.

The value of this type of approach was again illustrated with short-wave radio, put into commercial service in 1928. A tricky sort of communication, short-wave propagation shows both long-term variations of signal strength and rapid fading. Careful measurements by Bell Laboratories workers showed that such fading has a multipath nature—that is, radio waves in bouncing different numbers of times between the earth and the ionosphere alternately add and subtract in the radio receiver. These measurements also showed

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Document I-3

Document title: John R. Pierce, "Exotic Radio Communications," *Bell Laboratories Records*, September 1959, pp. 323–329 (reprinted with permission).

Source: AT&T Archives, Warren, New Jersey.

In the 1950s, John R. Pierce and his research team at AT&T's Bell Laboratories began exploring the possibility of communicating via satellites. This review article, his second major one on the subject, examines the potential for using satellites in either geosynchronous orbit or in lower orbits to receive signals from the Earth and retransmit them to another location. Similar to his April 1955 article for Jet Propulsion, *which discussed in more technical terms some of the initial concepts for different types of communications satellites and orbital radio relays, this article describes some of the "state of the art" experiments that he and his team proposed to carry out using the large Echo 1 satellite to be orbited by NASA as a passive reflector of signals originating from the Earth. By 1960, Bell Labs had decided that the technical obstacles to a medium-altitude active repeater communications satellite could be solved, and AT&T consequently proposed the experimental Telstar program to the government.*

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[323] J. R. Pierce

Exotic Radio Communications

[original set in two columns of newspaper style text per page]

Pioneering work often seems exotic in its inception. Only a very few years ago, the idea of launching an artificial satellite seemed exotic, if not scatterbrained. But satellites have become almost commonplace. Today's exoticism is space flight by human beings, and we do not know what tomorrow's might be.

In the early part of this century, it would have taken an incorrigible visionary to foresee the present Bell System direct distance dialing network, undersea telephone cables, coaxial cable systems, and transcontinental microwave radio-relay routes. These all grew out of work which in its inception seemed far from any practical reality. It is an important part of Bell Laboratories activities to look far ahead—to study possible future communications services and thus build a fund of knowledge to draw upon if these services should become economically attractive.

In this article I shall deal primarily with some of the pioneering work at Bell Laboratories which may someday be important to the Bell System in providing broadband transoceanic radio communication. And to introduce this subject, I shall first briefly review some of our past accomplishments. My purpose is not merely to present a list of important radio research projects. Rather, I hope to illustrate the importance of good sci-

Conclusion

Briefly summarized, the advantages of the space station are as follows:—

(1) It is the only way in which true world coverage can be achieved for all possible types of service.

(2) It permits unrestricted use of a band at least 100,000 Mc/s wide, and with the use of beams an almost unlimited number of channels would be available.

(3) The power requirements are extremely small since the efficiency of "illumination" will be almost 100 percent. Moreover, the cost of the power would be very low.

(4) However great the initial expense, it would only be a fraction of that required for the world networks replaced, and the running costs would be incomparably less.

Appendix—Rocket Design

The development of rockets sufficiently powerful to reach "orbital" and even "escape" velocity is not only a matter of years. The following figures may be of interest in this connection.

The rocket has to acquire a final velocity of 8 km/sec. Allowing 2 km/sec. for navigational corrections and air resistance loss (this is legitimate as all space-rockets will be launched from very high country) gives a total velocity needed of 10 km/sec. The fundamental equation of rocket motion is[2]

$$V = v \log_e R$$

where V is the final velocity of the rocket, v the exhaust velocity and R the ratio of initial mass to final mass (payload plus structure). So far v has been about 2–2.5 km/sec for liquid fuel rockets but new designs and fuels will permit of considerably higher figures. (Oxy-hydrogen fuel has a theoretical exhaust velocity of 5.2 km/sec and more powerful combinations are known.) If we assume v to be 3.3 km/sec, R will be 20 to 1. However, owing to its finite acceleration, the rocket loses velocity as a result of gravitational retardation. If its acceleration (assumed constant) is a metres/sec.^{2}, then the necessary ratio R_g is increased to

$$R_g = R \frac{\alpha + g}{\alpha}$$

For an automatically controlled rocket a would be about 5g and so the necessary R would be 37 to 1. Such ratios cannot be realised with a single rocket but can be attained by "step-rockets,"[2] while very much higher ratios (up to 1,000 to 1) can be achieved by the principle of "cellular construction."[3]

Epilogue—Atomic Power

The advent of atomic power has at one bound brought space travel half a century nearer. It seems unlikely that we will have to wait as much as twenty years before atomic-powered rockets are developed, and such rockets could reach even the remoter planets with a fantastically small fuel/mass ratio—only a few percent. The equations developed in the appendix still hold, but v will be increased by a factor of about a thousand.

In view of these facts, it appears hardly worth while to expend much effort on the building of long-distance relay chains. Even the local networks which will soon be under construction may have a working life of only 20–30 years.

phere, a square metre normal to the solar radiation intercepts 1.35 kW of energy.[6] Solar engines have already been devised for terrestrial use and are an economic proposition in tropical countries. They employ mirrors to concentrate sunlight on the boiler of a low-pressure steam engine. Although this arrangement is not very efficient it could be made much more so in space where the operating components are in a vacuum, the radiation is intense and continuous, and the low-temperature end of the cycle could be not far from absolute zero. Thermo-electric and photo-electric developments may make it possible to utilize the solar energy more directly.

Though there is no limit to the size of the mirrors that could be built, one fifty metres in radius would intercept over 10,000 kW and at least a quarter of this energy should be available for use.

The station would be in continuous sunlight except for some weeks around the equinoxes, when it would enter the earth's shadow for a few minutes every day. Fig. 4 shows the state of affairs during the eclipse period. For [308] this calculation, it is legitimate to consider the earth as fixed and the sun as moving round it. The station would gaze the earth's shadow at A, on the last day in February. Every day, as it made its diurnal revolution, it would cut more deeply into the shadow, undergoing its period of maximum [Figure 4] eclipse on March 21st. On that day it would only be in darkness for 1 hour 9 minutes. From then onwards the period of eclipse would shorten, and after April 11th (B) the station would be in continuous sunlight again until the same thing happened six months later at the autumn equinox, between September 12th and October 14th. The total period of darkness would be about two days per year, and as the longest period of eclipse would be little more than an hour there should be no difficulty in storing enough power for an uninterrupted service.[7]

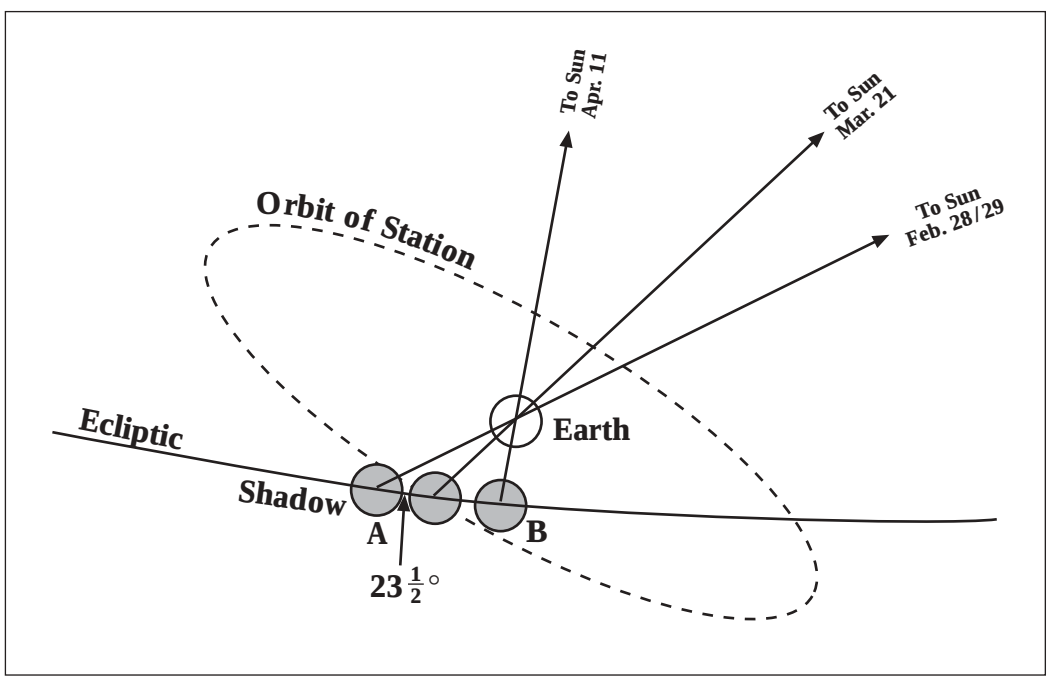

Figure 4. Solar radiation would be cut off for a short period each day at the equinoxes.

arrangement. The stations would be arranged approximately equidistantly around the earth, and the following longitudes appear to be suitable:—

30 E—Africa and Europe.
150 E—China and Oceana.
90 W—The Americas.

The stations in the chain would be linked by radio or optical beams, and thus any conceivable beam or broadcast service could be provided.

The technical problems involved in the design of such stations are extremely interesting,[3] but only a few can be gone into here. Batteries of parabolic reflectors would be provided, of apertures depending on the frequencies employed. Assuming the use of 3,000 Mc/s waves, mirrors about a metre across would beam almost all the power on to the earth. Larger reflectors could be used to illuminate single countries or regions for the more restricted services, with [307] consequent economy of power. On the higher frequencies it is not difficult to produce beams less than a degree in width, and, as mentioned before, there would be no physical limitations on the size of the mirrors. (From the space station, the disc of the earth would be a little over 17 degrees across). The same mirrors could be used for many different transmissions if precautions were taken to avoid cross modulation.

It is clear from the nature of the system that the power needed will be much less than that required for any other arrangement, since all the energy radiated can be uniformly distributed over the service area, and none is wasted. An approximate estimate of the power required for the broadcast service from a single station can be made as follows:—

The field strength in the equatorial plane of a $\lambda/2$ dipole in free space at a distance of d metres is

$e = 6.85 \frac{\sqrt{P}}{d}$ volts/metre, where P is the power radiated in watts.

Taking d as 42,000 km (effectively it would be less), we have $P = 37.6\, e^2$ watts. (e now in μV/metre.)

If we assume e to be 50 microvolts/metre, which is the F.C.C. standard for frequency modulation, P will be 94 kW [kilowatts]. This is the power required for a single dipole, and not an array which would concentrate all the power on the earth. Such an array would have a gain over a simple dipole of about 80. The power required for the broadcast service would thus be about 1.2 kW.[4]

Ridiculously small though it is, this figure is probably much too generous. Small parabolas about a foot in diameter would be used for receiving at the earth end and would give a very good signal/noise ratio. There would be very little interference, partly because of the frequency used and partly because the mirrors would be pointing towards the sky which could contain no other source of signal. A field strength of 10 microvolts/metre might well be ample, and this would require a transmitter output of only 50 watts.

When it is remembered that these figure relate to the broadcast service, the efficiency of the system will be realised. The point-to-point beam transmissions might need powers of only 10 watts or so. These figures, of course, would need correction for ionospheric and atmospheric absorption, but that would be quite small over most of the band. The slight falling off in field strength due to this cause towards the edge of the service area could be readily corrected by a non-uniform radiator.

The efficiency of the system is strikingly revealed when we consider that the London Television service required about 3 kW average power for an area less than fifty miles in radius.[5]

A second fundamental problem is the provision of electrical energy to run the large number of transmitters required for the different services. In space beyond the atmos-

arrays were used, the power requirements would be very small, as direct line of sight transmission would be used. There is the further important point that arrays on the earth, once set up, could remain fixed indefinitely.

Moreover, a transmission received from any point on the hemisphere could be broadcast to the whole of the visible face of the globe, and thus the requirements of all possible services would be met (Fig. 2).

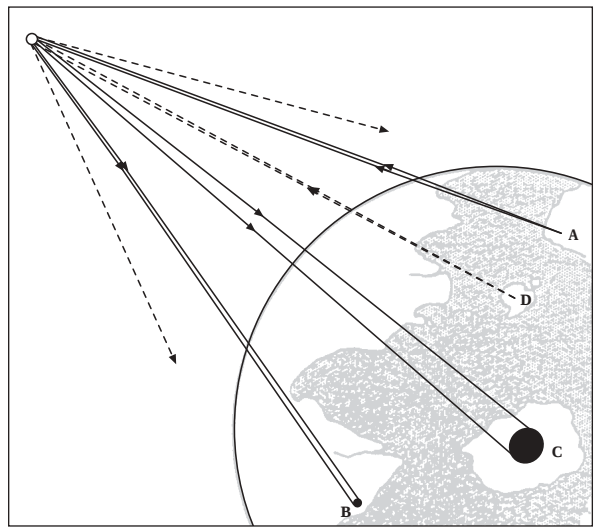

Figure 2. Typical extra-terrestrial relay services. Transmission from A being relayed to points B and area C; transmission from D being relayed to whole hemisphere.

It may be argued that we have as yet no direct evidence of radio waves passing between the surface [Figure 2] of the earth and outer space; all we can say with certainty is that the shorter wavelengths are not reflected back to earth. Direct evidence of field strength above the earth's atmosphere could be obtained by V2 rocket technique, and it is to be hoped that someone will do something about this soon as there must be quite a surplus stock somewhere! Alternatively, given sufficient transmitting power, we might obtain the necessary evidence by exploring for echoes from the moon. In the meantime we have visual evidence that frequencies at the optical end of the spectrum pass through with little absorption except at certain frequencies at which resonance effects occur. Medium high frequencies go through the E layer twice to be reflected from the F [Figure 3] layer and echoes have been received from meteors in or above the F layer. It seems fairly certain that frequencies from, say, 50 Mc/s to 100,000 Mc/s could be used without undue absorption in the atmosphere or the ionosphere.

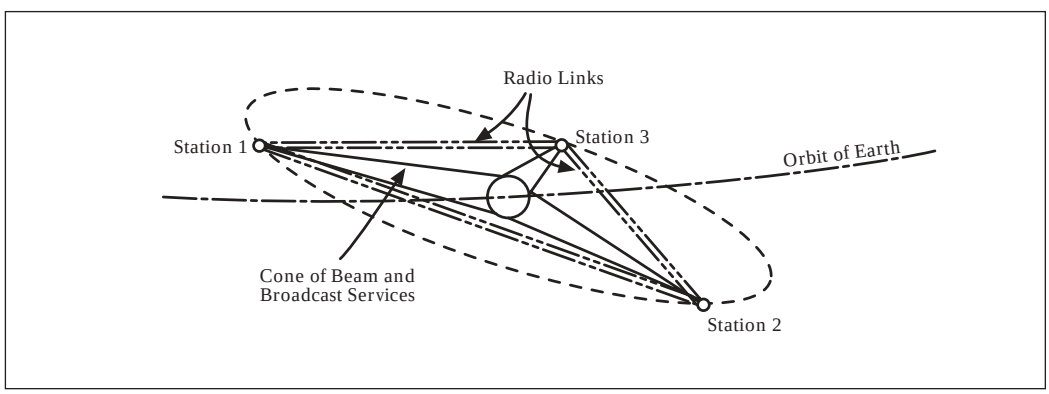

Figure 3. Three satellite stations would ensure complete coverage of the globe.

A single station could only provide coverage to half the globe, and for a world service three would be required, though more could be readily utilized. Fig. 3 shows the simplest

applies only to the closest possible orbit, one just outside the atmosphere, and the period of revolution would be about 90 minutes. As the radius of the orbit increases the velocity decreases, since gravity is diminishing and less centrifugal force is needed to balance it. Fig. 1 shows this graphically. The moon, of course, is a particular case and would lie on the curves of Fig. 1 if they were produced. The proposed German space-stations [Figure 1] would have a period of about four and a half hours.

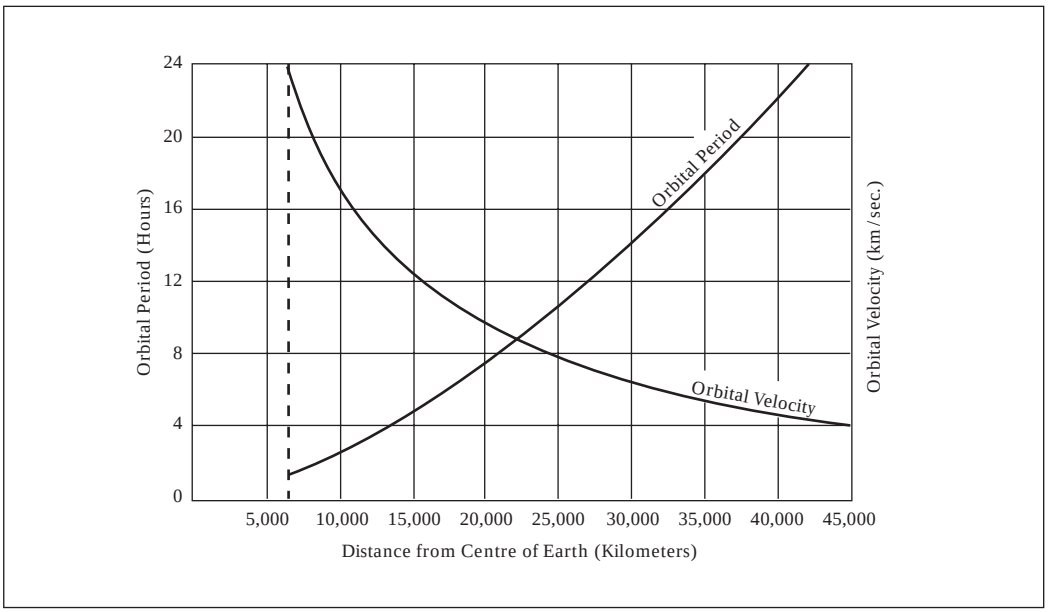

Figure 1. Variation of orbital period and velocity with distance from the center of the earth.

It will be observed that one orbit, with a radius of 42,000 km, has a period of exactly 24 hours. A body in such an orbit, if its plane coincide with that of the [306] earth's equator, would revolve with the earth and would thus be stationary above the same spot on the planet. It would remain fixed in the sky of a whole hemisphere and unlike all other heavenly bodies would neither rise nor set. A body in a smaller orbit would revolve more quickly than the earth and so would rise in the west, as indeed happens with the inner moon of Mars.

Using material ferried up by rockets, it would be possible to construct a "space-station" in such an orbit. The station could be provided with living quarters, laboratories and everything needed for the comfort of its crew, who would be relieved and provisioned by a regular rocket service. This project might be undertaken for purely scientific reasons as it would contribute enormously to our knowledge of astronomy, physics and meteorology. A good deal of literature has already been written on the subject.[2]

Although such an undertaking may seem fantastic, it requires for its fulfillment rockets only twice as fast as those already in the design stage. Since the gravitational stresses involved in the structure are negligible, only the very lightest materials would be necessary and the station could be as large as required.

Let us now suppose that such a station were built in this orbit. It could be provided with receiving and transmitting equipment (the problem of power will be discussed later) and could act as a repeater to relay transmissions between any two points on the hemisphere beneath, using any frequency which will penetrate the ionosphere. If directive

Document I-2

October 1945
Wireless World

[305]

Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?

By Arthur C. Clarke

[original set in three columns of newspaper style text per page]

Although it is possible, by a suitable choice of frequencies and routes, to provide telephony circuits between any two points or regions of the earth for a large part of the time, long-distance communication is greatly hampered by the peculiarities of the ionosphere, and there are even occasions when it may be impossible. A true broadcast service, giving constant field strength at all times over the whole globe would be invaluable, not to say indispensable, in a world society.

Unsatisfactory though the telephony and telegraph position is, that of television is far worse, since ionospheric transmission cannot be employed at all. The service area of a television station, even on a very good site, is only about a hundred miles across. To cover a small country such as Great Britain would require a network of transmitters, connected by coaxial lines, waveguides or VHF relay links. A recent theoretical study[1] has shown that such a system would require repeaters at intervals of fifty miles or less. A system of this kind could provide television coverage, at a very considerable cost, over the whole of a small country. It would be out of the question to provide a large continent with such a service, and only the main centres of population could be included in the network.

The problem is equally serious when an attempt is made to link television services in different parts of the globe. A relay chain several thousand miles long would cost millions, and transoceanic services would still be impossible. Similar considerations apply to the provision of wide-band frequency modulation and other services, such as high-speed facsimile[,] which are by their nature restricted to the ultra-high-frequencies.

Many may consider the solution proposed in this discussion too far-fetched to be taken very seriously. Such an altitude is unreasonable, as everything envisaged here is a logical extension of developments in the last ten years—in particular the perfection of the long-range rocket of which V2 was the prototype. While this article was being written, it was announced that the Germans were considering a similar project, which they believed possible within fifty to a hundred years.

Before proceeding further, it is necessary to discuss briefly certain fundamental laws of rocket propulsion and "astronautics." A rocket which achieved a sufficiently great speed in flight outside the earth's atmosphere would never return. This "orbital" velocity is 8 km per sec. (5 miles per sec.), and a rocket which attained it would become an artificial satellite, circling the world for ever with no expenditure of power—a second moon, in fact. The German transatlantic rocket A10 would have reached more than half this velocity.

It will be possible in a few more years to build radio controlled rockets which can be steered into such orbits beyond the limits of the atmosphere and left to broadcast scientific information back to the earth. A little later, manned rockets will be able to make similar flights with sufficient excess power to break the orbit and return to earth.

There are an infinite number of possible stable orbits, circular and elliptical, in which a rocket would remain if the initial conditions were correct. The velocity of 8 km/sec.

16. The receiving equipment at the earth end would consist of small parabolas perhaps a foot in diameter with dipole pickup. These would be sufficiently directive to prevent interference in the three doubly-illuminated zones. They would be aimed towards the station with the least zenithal distance and once adjusted need never be touched again. Mobile equipment would require automatic following which presents slight mechanical complications (a few valves and a servo motor) but no technical difficulties.

17. The efficiency of the system would be nearly 100%, since almost all the power would fall on the service area. A preliminary investigation shows that the world broadcast would require about ten kilowatts, while the beam relay services would require only fractions of a kilowatt. These powers are very small compared with present-day broadcasting stations, some of which radiate hundreds of kilowatts. All the power required for a large number of simultaneous services could be obtained from solar generators with mirrors about ten metres in radius, assuming an efficiency of about 40%. In addition, the conditions of vacuum make it easy to use large and fully demountable valves.

18. No communication development which can be imagined will render the chain of stations obsolete and since it fills what will eventually be an urgent need, its economic value will be enormous.

19. For completeness, other major uses of the station are listed below:—

a) Research.—Astrophysical, Physical, Electronic.

These applications are obvious. The space-station would be justified on these grounds alone, as there are many experiments which can only be conducted above the atmosphere.

b) Meteorological.

The station would be absolutely invaluable for weather forecasting as the movement of fronts, etc. would be visible from space.

c) Traffic.

This is looking a good deal further ahead, but ultimately the chain will be used extensively for controlling and checking, possibly by radar, the movement of ships approaching or leaving the earth. It will also play an extremely important role as the first link in the solar communication system.

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Assuming the use of a frequency of 3,000 megacycles, a [3] reflector only a few feet across would give a beam so directive that almost all the power would be concentrated on the earth. Arrays a metre or so in diameter could be used to illuminate single countries if a more restricted service was required.

11. The stations would be connected with each other by very-narrow-beam, low-power links, probably working in the optical spectrum or near it, so that beams less than a degree wide could be produced.

12. The system would provide the following services which cannot be realized in any other manner:

a) Simultaneous television broadcasts to the entire globe, including services to aircraft.

b) Relaying of programmes between distant parts of the planet.

13. In addition the stations would make redundant the network of relay towers covering the main areas of civilisation and representing investments of hundreds of millions of pounds. (Work on the first of these networks has already started.)

14. Figure II shows diagrammatically some of the specialised services that could be provided by the use of differing radiator systems.

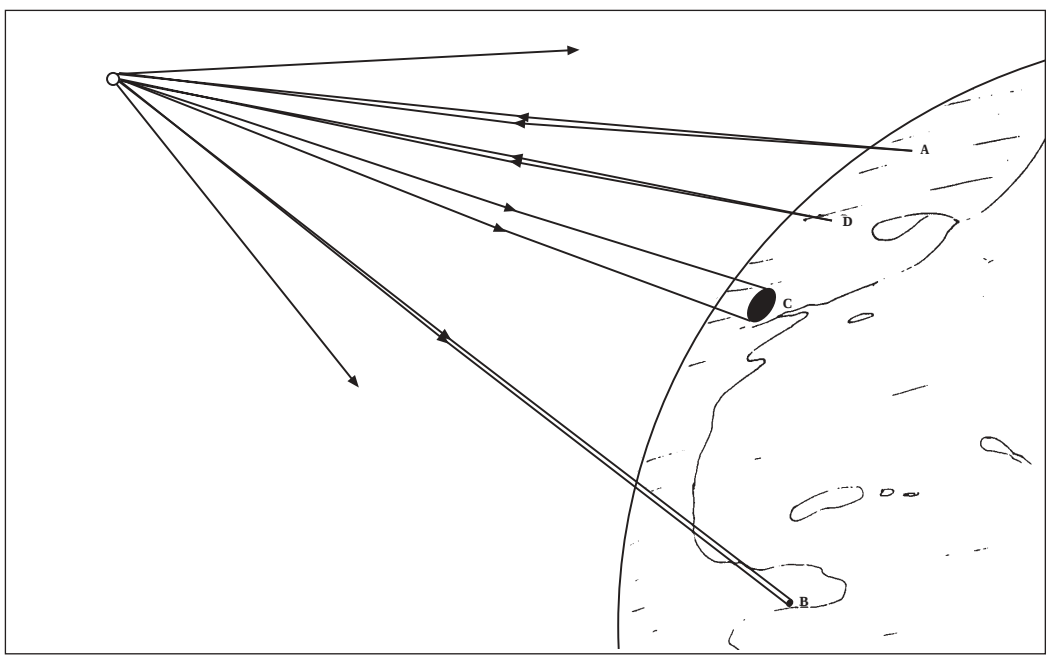

Figure II.

Programme from A being relayed to point B and area C.
Programme from D being relayed to whole hemisphere.

[4] 15. The numerous technical problems involved in this communication system cannot be discussed here but it can be stated that none of them present any difficulties even at the present time, thanks to the development of hyperfrequency engineering. It is hoped to discuss them in a later paper when security conditions permit.

7. In the near future, the large airliners which will fly great circle routes over oceans and uninhabited regions of the world will require television and allied services and there is no known [2] manner in which these can be provided.

8. All these problems can be solved by the use of a chain of space-stations with an orbital period of 24 hours, which would require them to be at a distance of 42,000 Km [kilometers] from the centre of the earth. (Fig 1.) There are a number of possible arrangements for such a chain but that shown is the simplest. The stations would lie in the earth's equatorial plane and would thus always remain fixed in the same spots in the sky, from the point of view of terrestrial observers. Unlike all other heavenly bodies they would never rise nor set. This would greatly simplify the use of directive receivers installed on the earth.

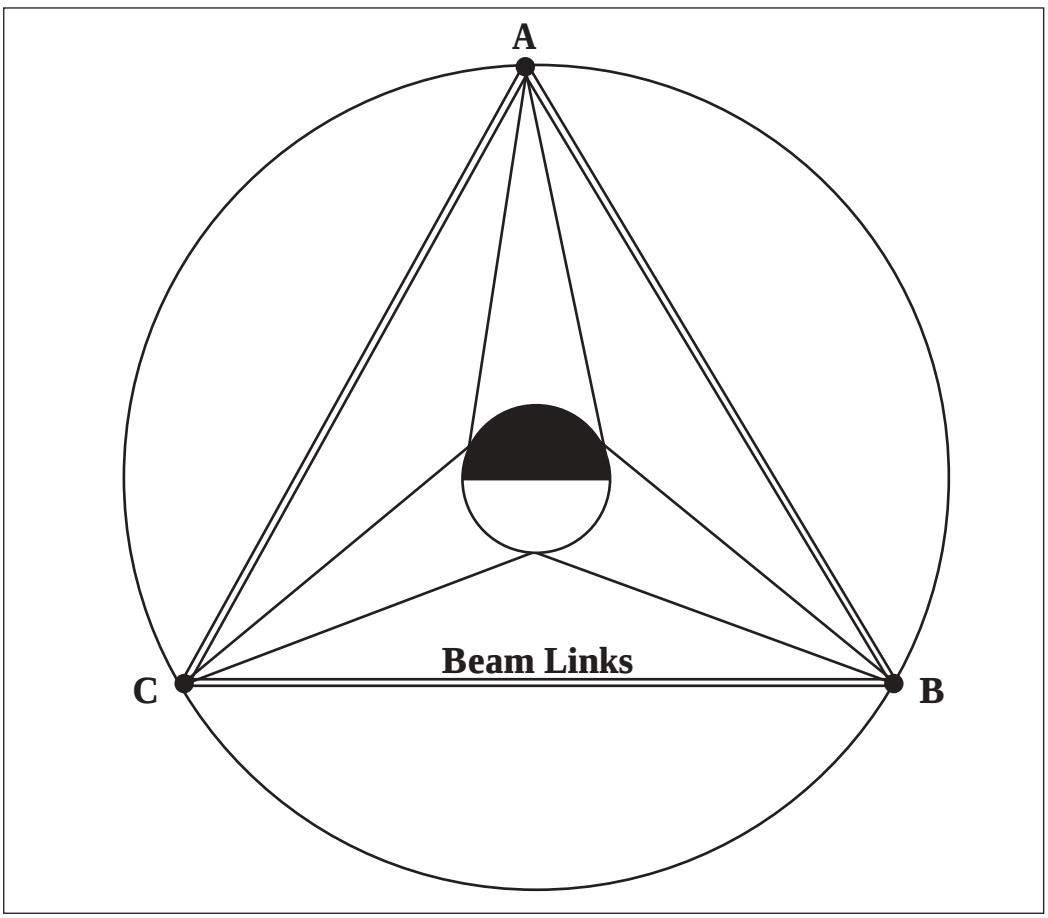

Figure 1.

9. The following longitudes are provisionally suggested for the stations to provide the best service to the inhabited portions of the globe, though all parts of the planet will be covered.

30 E—Africa and Europe.
150 E—China and Oceana.
90 W—The Americas.

10. Each station would broadcast programmes over about a third of the planet.

Document I-1

[no page number]

The Space-Station: Its Radio Applications

Arthur C. Clarke
25 May 1945

[1] 1. The Space-station was originally conceived as a refueling depot for ships leaving the Earth. As such it may fill an important though transient role in the conquest of space, during the period when chemical fuels are employed. Other uses, some of them rather fantastic, have been suggested for the space-station, notably by Hermann Noordung.[1] However, there is at least one purpose for which the station is ideally suited and indeed has no practical alternative. This is the provision of world-wide ultra-high-frequency radio services, including television.

2. In the following discussion the word "television" will be used exclusively but it must be understood to cover all services using the u.h.f. spectrum and higher. It is probable that television may be among the least important of these as technical developments occur. Other examples are frequency modulation, facsimile (capable of transmitting 100,000 pages an hour[2]), specialized scientific and business services, and navigational aids.

3. Owing to bandwidth considerations television is restricted to the frequency range above 50-Mc/sec [megacycles per second], and there is no doubt that very much higher frequencies will be used in the immediate future. The American Telephone and Telegraph Company are [sic] already building an experimental network using frequencies up to 12,000 megacycles.[3] Waves of such frequencies are transmitted along quasi-optical paths and accordingly receiver and transmitter must lie not far from the line of sight. Although refraction increases the range, it is fair to say that the service radius for a television station is under 50 miles. (The range of the London service was rather less than this.) *As long as radio continues to be used for communication, this limitation will remain, as it is a fundamental and not a technical restriction.*

4. Wide-band frequency-modulation, one of the most important of radio developments, comes in the same category. FM can give much better quality and freedom from interference than normal amplitude-modulation, and many hundreds of stations are being planned for the post-war years in America alone. The technical requirements of FM make it essential that only the direct signal be used, and ionospheric reflexions cannot be employed. The range of the service is thus limited by the curvature of the Earth, precisely as for television.

5. To provide services over a large area it is necessary to build numerous stations on high ground or with radiators on towers several hundred feet high. These stations have to be linked by landline or subsidiary radio circuits. Such a system is practicable in a small country such as Britain, but even here the expense will be enormous. It is quite prohibitive in the case of a large continent and it therefore seems likely that only highly populated communities will be able to have television services.

6. An even more serious problem arises when an attempt is made to link television systems in different parts of the globe. Theoretical studies[2] indicate that using a radio relay system, repeater stations will be necessary at intervals of less than fifty miles. These will take the form of towers several hundred feet high, carrying receivers, amplifiers and transmitters. To link regions several thousand miles apart will thus cost many millions of pounds, and the problem of trans-oceanic services remains insoluble.

technology has been moving in the opposite direction. The satellites' characteristics have been moving together in terms of satellite power, antenna beams, and on-board processing. Many of the latest Ka-band satellites, such as General Electric's GE Star. can actually offer fixed, mobile broadcast, and navigational services.

Equally significant is that these new satellite systems, because they can work to microterminals (fifty to sixty-five centimeters in diameter) and to handheld transceivers, can "bypass" conventional terrestrial networks. Thus, it can be said that satellite communications systems are now becoming a truly large, mass consumer business that are starting to rival terrestrial telecommunications systems.

Innovation has not been limited to the technological arena. Beginning with a single global telecommunications satellite entity, INTELSAT, there has been a proliferation of organizational forms for bringing the promise of communications satellites into reality. The 1984 decision in the United States to modify the traditional U.S. position that INTELSAT was the only authorized provider of global communications satellite services was a key to this development. [I-30] Both public and private forms of institutionalizing communications satellite services have emerged, as have several creative hybrid public-private organizations. Clearly, today, new private and competitive forms of satellite communications are becoming predominant as both INTELSAT and INMARSAT are spinning off new commercial entities to provide new forms of satellite services.

The ability to communicate words, images, and data instantaneously around the globe has fundamentally changed the character of international and intercultural relations. Through this application of space technology, a "global village" has truly come into being.

Document I-1

Document title: Arthur C. Clarke, "The Space-Station: Its Radio Applications," May 25, 1945.

Source: National Air and Space Museum Archives, Smithsonian Institution, Washington, D.C.

Document I-2

Document title: Arthur C. Clarke, "Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?," *Wireless World*, October 1945, pp. 305–308.

The Russian theorist Konstantin Tsiolkovsky was the first to note that a satellite orbiting 22,300 miles above the Earth's surface would travel at a speed that would make it appear to be stationary from Earth because its orbital velocity would be the same as the speed at which the Earth was rotating. In 1928, Herman Potôcnik, an Austrian Imperial Army officer, writing under the pseudonym Noordung, proposed a crewed space station in such a "geosynchronous" orbit, to be used for meteorology, reconnaissance, and Earth mapping. However, it was Arthur C. Clarke that first called widespread attention to the utility of the geosynchronous orbit for communications. In May 1945, Clarke, a physicist and at that time the secretary of the British Interplanetary Society, circulated six copies of his paper "The Space-Station: Its Radio Applications" to his society colleagues. (The paper was not actually published until 1968, when it appeared in the society's Spaceflight *magazine.) A second paper, written in June 1945, appeared in the October 1945 issue of* Wireless World.

Aerospace Corporation and various tactical communication and Defense Satellite Communications System (DSCS) spacecraft launched over the years. Because many of these military satellites were built by contractor firms that also constructed commercial satellites, there was often effective technology transfer within those firms.

Domestic Communications Satellite Systems

The first domestic satellite systems were deployed in the Soviet Union (Molniya in 1965) and Canada (Anik in 1971). A June 1972 decision by the FCC opened the way to the use of satellites for domestic communications within the United States, thus opening up a large new market for satellite telecommunications. [I-26] The ability of such systems to provide service to rural and remote areas and to relay television and other broadcast services to very small aperture antennas was quickly proven. Over the last fifteen years, these early successes have resulted in seventeen countries developing their own operational or experimental domestic satellite systems and placing satellites in the geosynchronous orbit.[20] In addition, approximately fifty countries are obtaining domestic communications satellite service through their participation (typically through the lease of transponders) in international and regional satellite systems.

The beginning of the evolution toward regional systems can be attributed to EUTELSAT, the European Telecommunications Satellite Organization. This organization started in its provisional form on June 30, 1977. This was followed by ARABSAT, which became operational in 1985, even though the idea was developed eight years earlier. After ARABSAT, the trend shifted away from public consortia closely modeled on a scaled-down version of INTELSAT. Newer systems used a privately owned—and more competitive—approach. ASTRA was established in the 1980s to provide low-power direct-broadcast service in Europe. PanAmSat began providing private transatlantic services in 1988. In Asia, Palapa in 1980 and later ASIASAT in 1990 began to offer certain forms of both regional and domestic service, with APSTAR following suit four years later.

Conclusion

In the last quarter century, tremendous progress has been made in space communications. New and expanded frequency bands have been operationally proven, and various uses of communications satellites have been successfully demonstrated. Consistent gains have been made in frequency reuse, spacecraft power, reliability, and lifetime. Improvements in Earth station delay and performance, digital modulation, and digital coding help complete a picture of total performance gains of more than 1,000 times in the last three decades. The range of space communications services has evolved from international and domestic fixed satellite services to mobile satellite services, broadcast satellite services, and even intersatellite links.

In the past, the distinction was quite clear between the satellite servers known as Fixed Satellite Service (FSS), Mobile Satellite Service (MSS), Broadcast Satellite Service (BSS), and Radio Determination Satellite Service (RDSS). These designations, as developed by the International Telecommunications Union (ITU), were used to allocate frequencies. Ironically, as the ITU has gone to more and more precise definitions of frequency allocations, such as aeronautical mobile, maritime mobile, and land mobile satellite services, the

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20. The seventeen countries that have launched one or more domestic communications satellite systems are: Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Luxembourg, Mexico, Spain, Sweden, the United States, the United Kingdom, and the Soviet Union.

This unique development of new space communications technologies in the 1970s and 1980s did not simply spring up spontaneously. Within NASA, a series of experimental satellites under the Applications Technology Satellite (ATS) program were developed and tested during the 1967–1976 period. These satellites expanded the technological reach of satellite communications in terms of higher frequency bands, new antenna size and performance, and satellite power and stabilization. The ATS program also helped demonstrate the new technology required to boost overall communications satellite performance. These experimental satellites not only demonstrated new technology, but provided valuable educational services to the Caribbean, the South Pacific, Brazil, and India, as well as to rural and remote parts of the United States. NASA joined with Canada in the Communications Technology Satellite (CTS) program; after its launch in 1976, CTS demonstrated new techniques of space telecommunications that could operate with very small terminals.

As the communications satellite industry matured into the only major successful commercial application of space, controversy arose during the 1970s over continuing a government-funded research and development program in support of that industry. Some in the Nixon administration argued that such a program constituted a subsidy to a particular segment of the private sector—a role the government should not play. NASA, faced with this argument and the need to adjust to a rapidly declining budget in the post-Apollo period, decided in 1972 to terminate its support of communications-related research and development. [I-27]

This decision remained controversial for a number of years; by the late 1970s, NASA was being urged to reenter the area. [I-28] The program that NASA proposed, the Advanced Communications Technology Satellite (ACTS), had a difficult time getting White House approval for most of the 1980s; congressional and some mixed industrial pressure finally led to the program's going forward. [I-29] After its launch in 1993, however, ACTS went on to demonstrate a variety of new techniques for enhancing the performance of communications satellites, especially with regard to operating in the new Ka band (thirty to 200 hertz) and on-board processing of signals so as to interconnect a very large number of spot beams (narrow, very-high-power beams), which boosted frequency reuse and increased satellite throughout capacity. However, it is hard to measure the significant impact. By the end of September 1996, the Federal Communications Commission (FCC) filing deadline, about fifteen new Ka-band satellite systems with a combined estimated value of approximately $50 billion have been proposed to provide high-data-rate multimedia video sources to North America and/or the world. If completely displayed, this would mean more than 1,200 new satellites in geosynchronous, medium, and low-Earth orbits.[19]

Furthermore, the development of the Tracking and Data Relay Satellite System (TDRSS) has led the way in such areas as intersatellite links and communications between low and geostationary orbits, satellite-switched time division multiple access techniques that allow multiple users to employ the same transponder, and combined fixed and mobile satellite communications. Today, the Orion Satellite System is operating intersatellite links, and many of the proposed new multimedia satellites will offer intersatellite link capabilities.

The experimental programs funded by the Department of Defense have also been contributors to technology development. In addition to Lincoln Laboratory's LES-1 to LES-9 experimental satellites, there have been numerous missions designed by the

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19. *Space 30: Thirty Year Overview of Space Applications and Exploration* (Washington, DC: Society of Satellite Professionals, 1989).

Table I–1
Technological Advances

Area of Development	*Measured Advance*	*Key New Technologies Developed*
1. Satellite Power	Power increased 80 times	• Sun-oriented solar cell array • High-efficiency solar cells • High-performance N_2H_2 batteries
2. Effective Use of Radio Frequencies	Radio frequencies available at 100 times greater	• Use of hybrid frequency bands • Frequency reuse by spatial separation • Spot-beam antennas • Frequency reuse by polarization discrimination
3. Satellite Lifetime	Increase in lifetime from 1.5 to 15 years	• Longer life batteries • Higher performance thrusters and propellants • Solid-state electronics • Enhanced satellite control techniques (including option for inclined orbit operation)
4. Digital Communication Techniques and Digital Circuit Multiplication and Compression Techniques	Up to 1,000-percent increase through use of TDMA and CDMA plus digital compression techniques	• Development of 155.5-megabyte TDMA • Digital speech interpolation • 32- and 16-kilobyte-per-second voice bringing two- to fourfold gain, respectively
5. On-Board Satellite Switching	Exact gain not easily measured; expanded use of spot-beam antennas—and thus expanded frequency reuse—optimized by on-board interconnection of beams and cross strapping	• Satellite-switched TDMA • Hybrid frequency connection between uplink and downlink • On-board switching fault detection and diagnostics
6. Earth Station Antennas	Decrease in costs of Earth stations four- to tenfold while decrease in size of antennas by factor of ten	• Use of solid state electronics • Elimination of most cryogenics • Enhanced low-cost construction materials and improved construction
7. Launch Vehicle Technology	Launch reliability increased to nearly 90 percent and lift capability by several thousand percent; cost-efficiency of launching, however, on a pre-pound basis, not changed significantly	• Enhanced rocket motor design with greater thrust • Enhanced guidance systems

satellite services, space research services, meteorological services, and Earth resource services. Throughout its history, however, INTELSAT has confined its activities to fixed satellite service public telecommunications for several reasons:

- These public telecommunications services were the most well-established, prevalent, and "desirable" services for its constituent members in terms of revenues.
- The special financial conditions and agreements needed to embark on "specialized" services posed a barrier to moving into these new areas.
- These other "new" services were largely unproven in terms of market viability.
- Other national, regional, or global ventures and institutional entities providing such services as maritime communications, regional communications, direct-broadcasting to home antennas, and remote sensing grew up over the years. Thus it was not easy for INTELSAT to expand as these organizations developed more specialized markets.

In the quarter of a century that followed the first commercial satellite operations, a remarkable array of technical developments has ensued. Key innovations have included: multidestination services among and between very small aperture antennas; the use of more frequency bands; three-axis stabilization, rather than satellites rotating about their vertical axis; and large, high-performance antennas on board the satellites themselves.

The last three decades of satellite technology development can be best shown perhaps by the evolution of the satellites of the INTELSAT system. During this period, many major technological advances occurred, including the seven shown in Table I–1. The cumulative result of these technological gains has been to produce fixed satellite designs that are overall approximately 1,000 times more cost-effective than the Early Bird satellite. In total, the last three decades have produced satellites that are at least eighty times more effective in terms of power, are 100 times more frequency efficient, and have more than ten times greater lifetimes. It is perhaps because fiber optic cables have achieved parallel developments in cost-efficiency on the Earth that the remarkable and sustained technological breakthroughs in satellite telecommunications are not more widely recognized or celebrated.

Most advances in communications satellite technology have originated within the United States; leading developers have been the scientists and engineers of such aerospace manufacturers as Ball Aerospace, Fairchild, Hughes Aircraft, Lockheed-Martin (now including General Electric, or GE, and RCA), TRW, and Ford Aerospace (now Space Systems/Loral). There have been many other contributors, such as NASA, the Department of Defense, the National Science Foundation, universities, and research laboratories such as Lincoln Laboratory, Johns Hopkins Advanced Physics Laboratories, Comsat Laboratories, and the Jet Propulsion Laboratory (JPL) and other NASA centers.[18] In the last decade in particular, the spread of satellite technology has become truly global. Major capabilities exist in Europe, Russia, Canada, and Japan, and more are emerging in India, China, Korea, Brazil, Israel, and Australia.

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18. See John H. McElroy, ed., *Space Science and Applications* (New York: IEEE Press, 1986), pp. 183–284. Although it is difficult to single out precisely and without omission all of the individuals who played the most important roles in communications satellite development over this period, some of the most important players were: Wernher von Braun, Richard Marsten, Robert Lovell, and Leonard Jaffe of NASA; Harold Rosen and Albert "Bud" Wheelon of Hughes Aircraft; Adolph Thiel of TRW; Jack Harrington of Lincoln Laboratory; Sigfried Rieger, Ernst Dietrich, Martin Votaw, and John Johnson of Comsat and INTELSAT; Joseph Campanella, Wilbur Pritchard, and Burton Edelson of Comsat Laboratories; Kenneth Rose of Ford Aerospace; Jack Kiegler of GE/RCA; William Pickering of JPL; J.O. Pastore of the U.S. Senate; Edward Welsh of the National Space Council; and John Pierce of AT&T's Bell Laboratories.

Twenty-Five Years of Communications Satellite Developments (1965–1990)

As the engineering and design of the world's first operational communications satellites proceeded, the nature of the institutional arrangements for global satellite communications became a topic of international discussion and dispute.[16] The United States initially thought in terms of a series of bilateral agreements between the United States and major users of international telecommunications. However, those on the other side of the Atlantic, developing a common position through the Committee on European Posts and Telecommunications (the association of European communications entities, most of which were government-owned monopolies), made it clear in February 1964 that a multilateral agreement was the only acceptable approach. The Europeans also were reluctant to hand all technical, operational, and policy control over to the United States, while the United States wished to preserve, as long as possible, its technological advantages in this new commercial sector. [I-21, I-23, I-24] The United States also wanted to ensure that the benefits of communicating via satellites were available to all countries, whatever their stage of economic development. [I-22]

The United States quickly dropped its insistence on bilateral arrangements and worked toward an acceptable multinational framework. Negotiations with Australia, Canada, Japan, and Europe lasted two years; their outcome hinged on several key issues. France preferred three separate regional satellite systems—one for Europe, one for the Americas, and one for Asia—but finally agreed to a single global system with a capital ceiling for a space segment investment of $500 million. This was a much higher initial investment than several other European countries were willing to accept. Japan and Australia played important roles in promoting compromise. They also promoted the use of geosynchronous satellites, because medium-altitude systems would have created gaps in coverage, with the largest gaps being in the Pacific Ocean region.[17] Perhaps the most important compromise between the United States and other countries was U.S. acceptance of the position that the initial agreement was only valid on an interim basis—after five years of experience with a U.S.-dominated organization, the agreement would be reopened in 1969 for review and potential revision. [I-25]

One of the key issues debated and reviewed in the 1962–1964 negotiations was what type of services INTELSAT should provide. Would it furnish all forms of public telecommunications services for both domestic and international service? The Interim Arrangements of 1964 and the Definitive Arrangements of 1971 that followed both specified that INTELSAT, with special approval, could provide a wide range of "specialized services" that included but were not limited to radio navigation services, broadcasting

16. Smith, *Communication via Satellite,* pp. 135–41.

17. It is a commonly held belief that the successful launch and operation of Early Bird in geosynchronous orbit effectively ended the debate about the "right orbit." In fact, ITT was selected to undertake a detailed study of medium-altitude satellites after the launch of Early Bird. Over the years, the issue of the "best" orbit for communications satellites has arisen again and again. Because of its northern latitude, not easily covered by satellites in geosynchronous orbit over the equator, the Soviet Union used highly elliptical orbits for its Molniya satellites. Most recently, the idea of creating a low-Earth-orbit grid of satellites interconnected by intersatellite links has been proposed by at least one potential land mobile communications satellite system operator. Despite the early nongeosynchronous systems, such as the Soviet Union's Molniya system and the Department of Defense's IDSCS, and despite the proposed new low- and medium-altitude communications satellite systems, use of the geosynchronous orbit is still predominant. Well over 95 percent of all communications satellites for domestic and international fixed satellite services, as well as for domestic, regional, and international fixed satellite services, plus those for military, mobile, and direct-broadcast satellite services, have been launched into geosynchronous orbit.

different versions of national legislation to create a framework for satellite communications emerged during 1961—and especially during 1962—within Congress. The bill of Senator Robert S. Kerr (D–OK) would have made space communications entirely private. From the opposite perspective, the bill of Senator Estes Kefauver (D–TN) would have made such communications entirely a governmental enterprise. Finally, the Kennedy administration's bill sought a compromise between private and public ownership and among various policy objectives. [I-16, I-17]

After months of debate and a filibuster led by liberal Democrats, complete with a cloture vote, the Communications Satellite Act of 1962 finally emerged. [I-18] This law called for the creation of a new entity to be known as the Communications Satellite Corporation (Comsat), with ownership divided fifty-fifty between the general public and telecommunications corporations, such as AT&T, International Telephone and Telegraph (ITT), RCA, and Western Union International.[13] Comsat's Board of Directors consisted of six representatives from the public stockholders, six representatives of the telecommunications industry, and three presidential appointees. Comsat was designated as the official representative of the United States for global satellite communications. Two years later, the corporation became the manager of the emerging global system known as the International Telecommunications Satellite Consortium (INTELSAT), which was formed on August 20, 1964.[14] [I-19]

Between the creation of Comsat as a new corporation on August 31, 1962, and the creation of INTELSAT, Comsat contracted with the Hughes Aircraft Company (the designer of Syncom 1, 2, and 3) to build an upgraded version of the Syncom satellite. This satellite was initially designated HS 303; it later became known officially as INTELSAT I. The world, however, came to know it by its popular name, "Early Bird." The satellite, which was the first operational geosynchronous communications satellite, weighed eighty-five pounds and was launched in April 1965. It had a lifetime of eighteen months and a capacity of 240 voice circuits or, alternatively, a black-and-white television channel. This transatlantic satellite, with three times the capacity of the largest submarine cable then available and the ability to provide real-time television transmission, captured the world's attention. Early Bird ushered in a new age of international television communications.[15] Also in 1965, the U.S. Department of Defense deployed a low-Earth-orbit satellite system known as the Initial Defense Satellite Communication System (IDSCS), while the Soviet Union deployed its first highly elliptical satellite system known as Molniya ("Lightning").

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13. It is interesting to note that John A. Johnson, General Counsel of NASA, was temporarily detailed to Senator Kerr's office to write draft legislation for the Communications Satellite Act, then later requested by the Kennedy administration to draft the version that actually became law (personal interview by the author with John A. Johnson, February 1984, INTELSAT Archives). See also J.O. Pastore, *The Story of Communications* (New York: MacFadden-Bertell, 1964), pp. 67–92.

14. Over the years, the Communications Satellite Act of 1962 was amended to allow telecommunications organizations to sell off their Comsat holdings, to restructure the Comsat Board of Directors, and to allow Comsat to be the official U.S. participant in the International Maritime Satellite Organization (INMARSAT), another consortium formed over a decade later. In most respects, Comsat's legislatively defined role has remained the same. Over time, however, through actions of the Federal Communications Commission (FCC), the U.S. executive branch, and the courts, Comsat has given up its ownership of Earth stations, entered the U.S. satellite communications market on a competitive basis with other corporations, and found its monopoly role in INTELSAT and INMARSAT questioned. These changes were largely the result of a changing regulatory environment within the U.S. government. During the Nixon, Carter, and Reagan administrations, there have been increasing efforts to move toward a deregulatory and competitive approach to most telecommunications activities that had traditionally been carried out by monopolies. Despite the erosion of the legislative and regulatory framework within which Comsat operated with respect to INTELSAT, which occurred between 1965 and 1990 (especially the loss of technical management of the INTELSAT global system between 1973 and 1979), Comsat remains one of the few monopolies left in the United States.

15. ICSC Document, ICSC-7-4E (April 1965), pp. 8–9.

ing on such a satellite, first with the company's own funds and since 1961 under contract to NASA. [I-4, I-5] This satellite, Syncom 2 (Syncom 1 suffered a system failure), was followed by a Syncom 3 mission that was even more successful in demonstrating the feasibility of high-capacity telecommunications operations in geosynchronous orbit.[10]

This lightning-like development was paralleled by progress with military satellites, particularly the Lincoln Experimental Satellite (LES) series from Lincoln Laboratory, which tested secure transponders for strategic communications from the National Command Authority. Together, these accomplishments set the stage for the practical exploitation of this exciting new technology.

The Creation of Comsat and INTELSAT (1962–1965)

The international civilian communications program soon evolved toward a global network of "stabilized" satellites in geosynchronous orbits a tenth of the way to the Moon. The civilian system began with an initial satellite over the Atlantic Ocean (1965), then the Pacific Ocean obtained service (1967), and finally global coverage was completed with Indian Ocean service (1969), just as Arthur C. Clarke had envisioned it twenty-four years earlier.

Although most critical technical choices had been made by 1965, the issue of how to institutionalize the civilian communications satellite system was far from clear-cut or easily decided. During 1961 and 1962, there was intense debate in the United States about public versus private ownership and operations. Political control and financing were also items of disagreement. Not surprisingly, these issues led to a major political debate in the United States.

The Eisenhower administration supported the development of satellite communications, but only if that development was based on private-sector initiatives.[11] [I-6, I-7] When John F. Kennedy took office in early 1961, however, he expressed a strong support for a leading government role in communications satellite development.[12] Achieving his objective, however, meant sorting out within the Kennedy administration the appropriate role of the government in communications satellite research and development, regulation, and ownership and operation. [I-8, I-9, I-10, I-11, I-12, I-13, I-15]

Once the administration had developed its position, it had to gain the assent of Congress. This was not a straightforward task; many in Congress had views on the issue that differed from the proposed White House policy. [I-14] The net result was that three

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10. Dunlap, *Communications in Space*, pp. 152–55.

11. On December 30, 1960, in one of his last speeches in office, President Eisenhower stated: "This nation has traditionally followed a policy of conducting international telephone, telegraph and other communication services through private enterprise subject to governmental control, licensing, and regulation. We have achieved communications facilities second to none among nations of the world. Accordingly, the government should aggressively encourage private enterprise in the establishment and operation of satellite relays for revenue producing services." *Public Papers of the Presidents of the United States: Dwight D. Eisenhower, 1960* (Washington, DC: U.S. Government Printing Office, 1979), p. 888.

12. The now-famous Kennedy speech of May 25, 1961, that established the goal of sending humans to the Moon and returning them to Earth also called for the establishment of a global satellite system for communications that would benefit all countries, promote world peace, and allow nondiscriminating access for all countries of the world. It called for a "constructive role for the U.N. in international space communications." *Public Papers of the Presidents of the United States, John F. Kennedy, 1961* (Washington, DC: U.S. Government Printing Office, 1962), pp. 529–31. Kennedy's position on communications satellites thus set the stage for the United Nations to act on this subject as well. In September 1961, the United Nations General Assembly adopted Resolution 1721, Section P, concerning the establishment of a global communications satellite system. Section P stated that "communications by means of satellite should be available to the millions of the world as soon as possible on a global and non-discriminating basis."

satellite field, suggested using the larger 100-foot-diameter Echo satellite to test transatlantic radio communications. [I-3] NASA accepted Pierce's suggestion, and the orbiting satellite was successfully used as a passive reflector (that is, there were no electronic systems to amplify the signal aboard the satellite) of an August 18 message from New Jersey to France. (Similar experiments had been conducted earlier using the Earth's Moon as a passive reflector.)

Although this and many other experiments using the passive Echo 1 and Echo 2 satellites (Echo 2 was launched in January 1964) were successful, in the late 1950s and early 1960s, industry and government attention increasingly focused on active communications satellites carrying on-board electronics that received a signal from the Earth, amplified it, and sent it back to the Earth. Such satellites had more predictable orbits than passive satellites; fewer were required to create a communications network; and signals relayed through active satellites required less expensive ground stations and had much higher capacity.[7]

The first artificial communications satellite that foreshadowed today's active satellite technology, Courier 1B, was designed and launched by the U.S. military in October 1960. It featured solar and battery power, an active antenna for transmission and reception, and electronic repeaters capable of frequency conversion from uplink to downlink signals. Despite the technological gains that Courier 1B represented, it still had a capability of only sixteen teletype channels. In short, it was little more than an experimental device. Submarine cables still had 100 times this capacity.

NASA, AT&T, and the Department of Defense, however, were by this time moving ahead with tremendous energy and quickly achieved impressive results. On July 10, 1962, only a year and a half after Courier 1B, a quantum leap in capability was achieved with the launch of Telstar, an AT&T-designed and -built experimental satellite with sufficient capacity to relay a television signal. Telstar was launched into a medium orbit with a 570-mile perigee; at this orbit, a number of satellites (about twelve to fifteen) would be required for an operational system. The success of the Telstar experiment immediately changed the world's view of the potential of this new technology. [I-20][8] Recognition grew that communications satellites could have three to four times the capacity of then-current submarine cables. Almost overnight, their commercial viability was advanced from remote to highly likely. Quickly thereafter, on December 14, 1962, the NASA-funded Relay 1 of the Radio Corporation of America (RCA) was launched into an orbit with a 660-mile perigee, demonstrating many of the same features as Telstar but with a longer lifetime in orbit. The technical feasibility of active communications satellites was thus clearly demonstrated by the second half of 1962.[9] The development of these early communications satellites represented the first steps toward the practical use of space and began a debate about whether such an enterprise should be public or private in nature.

Then, a satellite built by Hughes Aircraft, developed with both company and NASA funding and launched on December 14, 1963, demonstrated the final technical feature required for communications satellites to become commercially viable—stable and continuous operation in geosynchronous orbit. Beginning in 1959, Hughes had been work-

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7. John R. Pierce, *The Beginnings of Space Communications* (San Francisco, CA: San Francisco Press, 1968), p. 103; Arthur C. Clarke, *The Promise of Space* (New York: Harper and Row, 1968), pp. 100–101; Smith, *Communications via Satellite*, pp. 51–55.

8. It should be noted here that because the document about Project Telstar was produced in the second half of 1962, it appears in chronological order after this essay but is referenced out of order within the essay. Also note that the references to Documents I-14, I-22, and I-26 are out of order.

9. Leonard Jaffe, *Communications in Space* (New York: Holt, Reinhart and Winston, 1966), p. 86; Orrin E. Dunlap, Jr., *Communications in Space* (New York: Harper and Row, 1960), p. 151.

The Early Years of Concept and Experimentation (1945–1963)

In the decade that followed Clarke's article, increasingly powerful rockets were developed, largely in the context of the Cold War competition between the United States and the Soviet Union. The launch of Sputnik 1 by the Soviets in October 1957 triggered a number of U.S. space initiatives. The creation of the National Aeronautics and Space Administration (NASA) from the National Advisory Committee for Aeronautics (NACA) and the surge of funding for U.S. rocket programs, such as Vanguard, Thor, Atlas, and Titan, were immediate results. In the 1960 U.S. presidential election, the "Missile Gap" debates between John F. Kennedy and Richard M. Nixon set the stage for a strong U.S. space program for the 1960s, perhaps regardless of the election's outcome.[4] One issue under discussion at the time was whether space development would be almost exclusively a result of government activities or whether private enterprise would play a significant role.

The creation of communications satellite research and development programs within NASA and the Department of Defense in the late 1950s and early 1960s proved to be a highly effective means of establishing U.S. capability in this field; however, these government efforts were paralleled by private-sector communications satellite research and development activities. These communications satellite initiatives came at a key time in terms of the overall development of international communications. American Telephone and Telegraph (AT&T) and others kept private-enterprise interests alive with parallel research and development efforts of their own.

In the late 1950s and early 1960s, a number of new submarine telephone cables were being laid across the Atlantic and Pacific Oceans. These new cables replaced outmoded telegraph cables and stimulated the rapid growth of international telecommunications. The leaders of NASA, aerospace manufacturers, and telecommunications organizations all recognized that high-capacity communications satellites could also support the rapid growth of global communications. Only several years later did the idea emerge that communications satellites could also support regional or domestic telecommunications needs. [5]

Because of the U.S. lead in micro-electronics, the U.S. Signal Corps was able to launch the world's first communications satellite on an Atlas rocket soon after Sputnik. The first U.S. communications project was known as SCORE (Signal Communication by Orbital Relay Equipment), a broadcast-only satellite launched on December 18, 1958. SCORE lasted only twelve days and could only send to Earth a pre-recorded message from President Dwight D. Eisenhower: "Peace on earth, good will toward men."[6]

The first artificial satellite that actually relayed a real-time voice message from the Earth to orbit and back was Echo 1, launched on August 12, 1960. The Echo program was a successor to an International Geophysical Year effort to measure the density of the upper atmosphere by observing the orbit of a twelve-foot-diameter balloon-like satellite. In 1959 John Pierce, an AT&T scientist and one of the pioneers of the communications

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4. See John M. Logsdon, *The Decision to Go to the Moon: Project Apollo and the National Interest* (Cambridge, MA: MIT Press, 1970), and Walter A. McDougall, . . . *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985), for discussions of early U.S. space policy.

5. Joseph N. Pelton, *Global Communications Satellite Policy: Intelsat, Politics and Functionalism* (Mt. Airy, WA: Lomond Systems, 1974), pp. 44–102. The Soviet Union with its vast size and northern latitudes had to use a highly elliptical orbit for its communications satellites. This orbit required less rocket power to reach from Soviet launch sites than did geosynchronous orbit. The combination of internal need and ease of orbital access led the Soviet Union to initiate domestic communications satellite service much sooner than other countries.

6. *Ibid.*, pp. 46–48.

Chapter One

The History of Satellite Communications

by Joseph N. Pelton

Although the idea of using artificial Earth satellites to relay messages from one point on the Earth to another had been discussed in several places prior to 1945,[1] most accounts of the development of satellite communications begin by discussing Arthur Clarke's landmark works on the topic during that year. In two 1945 papers—one privately circulated and one published in *Wireless World*—Clarke discussed the special characteristics of geosynchronous orbit that would enable three satellites in that orbit to provide global communications.[2] [I-1, I-2] Clarke noted that in an orbit of 22,300 miles above the Earth, the velocity of a satellite exactly matched the velocity of the Earth's surface as the planet rotated about its axis; thus from the Earth, a satellite would appear to remain in a fixed position in the sky. In such an orbit, a satellite could "see" 40 percent of the equatorial plane. Clarke noted the benefits of such an orbital perspective, especially for telecommunications, because the curvature of the Earth's surface and atmospheric interference placed limits on ground-based transmissions. In addition, the use of satellites in geosynchronous orbit would make the design of a ground antenna simpler in terms of tracking and pointing mechanisms.

For these insights, Arthur C. Clarke is frequently called the "Father of Satellite Communications," and there have been ongoing efforts to officially designate the geosynchronous orbit as the "Clarke Orbit." Ironically, however, while a visionary in many respects, Clarke did not foresee how quickly communications satellites would become a reality. This is because he did not anticipate the invention of the transistor, which greatly reduced the necessary weight of a communications satellite and dramatically increased its reliability and lifetime. From the pre-transistor perspective of 1945, Clarke envisioned that communicating via satellite would in effect require a space station—an orbital platform weighing many tons with an on-board crew to replace burned-out vacuum tubes.[3] And while Clarke may not have been totally prescient, he can be credited with identifying a line of technological development that bore fruit in less than twenty years.

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1. Delbert D. Smith, *Communication via Satellite: A Vision in Retrospect* (Boston: A.W. Sijthoff, 1976), pp. 15–19.

2. The more frequently cited of Clarke's semi-annual papers is Arthur C. Clarke, "Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?," *Wireless World* 51 (October 1945): 305–08. A May 25, 1945, typed paper about geosynchronous satellites, "The Space Station: Its Radio Applications," was sent to members of the British Interplanetary Society and other addressees some five months before the more famous *Wireless World* article. This earlier paper was finally published in *Spaceflight* 10 (March 3, 1968): 85–86.

3. Personal interview by the author with Arthur C. Clarke, Sri Lanka, May 1984.

approved during the initial plenary meeting. Its members were Ireland, Norway, Panama, Philippines and Turkey. The Committee elected the representative of Turkey Chairman. The Committee found all credentials to be in order and its report was accepted without discussion by the Conference.

The Editorial Committee

The Editorial Committee was nominated by the Conference Chairman and approved by the plenary. Its members are Belgium, Canada, Colombia, France, Jamaica, Mexico, Spain, the United Kingdom, and the United States. There being no work to be done on final texts, the Editorial Committee did not meet or function at the first session of the Conference.

[18] The Steering Committee

Composition of the Steering Committee was provided for in the Conference Rules of Procedure as follows: Chairman—Conference Chairman (USA); members—the four regional Vice Chairmen (Netherlands, Venezuela, India and Algeria; but the Representative of The Netherlands left and was replaced by the Swiss Representative in the fourth week) and the Chairmen of the four Working Committees (Argentina, Japan, Australia and Italy). The Steering Committee met regularly throughout the first session, coordinating the program of the Conference. This Committee prepared the proposal adopted by the Conference to establish an intersessional Preparatory Committee (Annex G) which is discussed in detail in Section VII below.

VI. Plenary Session of the Conference

The Conference met in five plenary sessions. At the initial plenary the agenda was adopted, committees were formed, and conference officers were elected. There were four plenary sessions during the final week to receive and consider the Working Committee reports.

The opening session proceeded thorough the agenda as planned without any difficulties. Prior to adoption of the Conference Rules of Procedure, representatives from Italy, Nigeria and India sought assurances, which were given by the Conference Chairman, that the rules with regard to statements of observers would be interpreted liberally to ensure the fullest possible exchange of views. The United Kingdom suggested and was assured that maximum opportunity would be made available to achieve consensus on all matters.

Sweden introduced a comprehensive and novel set of draft definitive arrangements (Doc. 8). This draft was not given much direct attention by the Conference. The only other comprehensive draft agreements submitted were tabled by the United States at the end of the first week of the Conference (Doc. 10). These drafts were not discussed as such, but various articles were considered by the Conference Committees.

[19] At the four plenary sessions held during the final week, reports were received from the Working Committees and were discussed. Because of the number of unresolved issues and the general complexity of definitive arrangements, it became obvious that substantially more time would be required to develop final texts. It was decided, on the recommendation of the Steering Committee, to recess the Conference March 21, 1969 and to refer the Committee reports and all other relevant Conference documents to an intersessional Preparatory Committee for study and work. A proposal to provide for interim work was discussed at some length during the fourth plenary session and the Steering Committee was requested to revise the proposal to reflect the views expressed. A revised paper was submitted to the fifth and final plenary and was adopted unanimously without discussion (Annex G).

agreed that shares should be adjusted periodically, but left open whether adjustments would be based on past (U.S.) or projected use or some combination of the two. There was also a division of views on the question of circumstances under which a signatory could decline to accept an increased or decreased share.

It was agreed by all but a few members that there should be a utilization charge, partly as a means of compensating owners whose share is larger than their use prior to adjustment of shares. Working Group 1, which handled most of the Committee's work, recommended the cost of money plus about 2% as the basis of compensation for use of capital in determining utilization charges.

Committee III's second Working Group considered financial provisions relating to transition from the present agreements and possible withdrawals from [16] the organization. While the Working Group did not, and did not attempt to, reach final agreement, there was general agreement on the principles that should be applicable. It should not be too difficult to reach agreement in this area.

Working Group 3 agreed, with respect to financial access to the system by non-members, that the organization, in establishing space segment utilization charges for non-members[,] should take account of the fact that non-members have not borne any of the risks and obligations of membership. This would mean that a rate charged to non-members should take account of both the cost of the members' capital and the risk they have taken in investing in the system.

Committee IV—Other Operational Arrangements

Committee IV, which had two Working Groups, considered only procurement policy (Working Group A) and patent and data policy (Working Group B).

On procurement policies there developed three alternative approaches: (1) a relatively simple provision calling for international tenders and contractor selection on the basis of the best combination of price, quality and timely delivery; (2) retention of the existing interim arrangement provisions, which have allowed international spreading of contracts; and (3) the amplification of (1) above by addition of specific language encouraging international spreading of contracts with distribution roughly proportionate to relative investment percentages of members. There is, in fact, little actual difference in the probable practical effect of alternatives (2) and (3). The United States, and apparently a majority of those countries expressing themselves on this issue, favored alternative (1). The United Kingdom and Japan supported alternative (2) and France supported alternative (3). The proposed specific wording is set forth in the Committee's report (Doc. 12).
[17] With regard to patent and data policy, two alternatives emerged. The United States, the United Kingdom and others favored a provision which would leave to the discretion of the Governing Body the particular patent policies to be applied in each contract negotiation. Canada, Germany, India, France and others proposed a patent provision which would establish in the definitive arrangements a fixed non-exclusive license policy pursuant to which any INTELSAT contractor would get title to inventions and data developed under INTELSAT contracts, and the organization would take a non-exclusive license to use the information only in connection with space segments and would thus forego control over the contractor's use of the information. There was virtually unanimous agreement that to the extent INTELSAT obtains rights in inventions and data, they should be made available on a royalty-free basis for use in the INTELSAT space segment and on a reasonable royalty basis for other uses. The alternative patent and data policies are set forth in Com. IV/10 and 11.

The Credentials Committee

The Credentials Committee was nominated by the Conference Chairman and

the assembly should be the only competent parties to an arbitration proceeding. The majority of the delegations wanted to include in the intergovernmental agreement some mechanism for settling disputes among the governments[’] parties to that agreement. With respect to the selection of the panel members, the Working Group’s report, which was adopted by Committee II, stated that a majority favored selection of the panel by the Assembly without weighted voting. This was inconsistent with the U.S. position that the selection should be made by the board of governors. As for the scope of arbitrable disputes, the U.S. position that the scope should be confined to legal disputes received majority support, although some delegations favored a broader scope. The majority favored limiting the scope to legal disputes but using a different formulation from that proposed by the U.S.

Amendment Processes—The U.S. position that a proposed amendment to the operating agreement be approved by the board of governors was opposed by several delegates. Although there was general agreement that no amendment to the operating agreement should be made [14] without the consent of the parties to the intergovernmental agreement, differing views were expressed as to the manner in which that consent should be manifested.

Liability of the Signatories—This matter was discussed only in the full Committee. A significant issue was whether, if INTELSAT is given separate legal status, the signatories would or should enjoy limited liability for INTELSAT obligations. There was significant opinion that limited liability automatically followed from establishing INTELSAT with legal personality. The U.S., along with Australia and Sweden, felt that it would not. However, Sweden and a number of other delegations expressed the view that limited liability is an advantage which should be afforded the signatories. A second issue was whether exemption of the signatories to the operating agreement from inter se liability should extend beyond consequential damages arising from a breakdown in service. There was general agreement that the definitive arrangements should not impair member states’ responsibilities under the Treaty on Outer Space.

Withdrawal, Reservations, Definitions and Number of Agreements—Withdrawal was discussed only briefly in Committee II. No general agreement was discernible.

The matters of reservations and definitions were deferred until the final text of the agreement has been generally established. There appeared to be no opposition at this time to the U.S. position prohibiting reservations.

An overwhelming majority supported the U.S. position for two agreements, with some delegates reserving until more is known of the final text.

Committee III—Financial Arrangements

Committee III’s work program is shown in Annex E. Its report is Doc. 16.

[15] There was general agreement in the Committee that investment in the system should be related to use, as the U.S. had proposed, though some countries, principally the Arab group, favored applying the investment/use system only after allocating a base share of investment to each member. There was near agreement on a minimum share for each member, regardless of its use of the system, most delegations favoring 0.05%. However, many delegations thought members with lower use should not be required to accept this minimum.

The Committee divided three ways on the question of what types of use of the system should be counted in determining investment shares, about one-third of those countries that expressed views (including the U.S.) favoring all use of INTELSAT-financed facilities, one-third favoring international traffic only, and another group proposing to count international traffic and that domestic traffic that crosses international boundaries (or would do so if projected on the surface of the earth). The ideas of several delegations on this question clearly were related to the question of voting strength in the organization. It was

U.S. positions and, with the summary record of the Committee's discussion of the report, was transmitted to Committee I for consideration. However, the matter was not discussed in Committee I.

Com. II/9 (and 11) contains the report of this Working Group.

Working Group on Accession, Supersession and Buy-Out—

Entry Into Force—The U.S. position was that the definitive arrangements should enter into force upon final adherence by two-thirds of the present members who hold, or whose signatories to the Special Agreement hold, a substantial proportion (80% was suggested) of the investment quota under the Special Agreement. This position was adopted as the majority position by the Committee, but the exact percentage was left to be decided by the Plenary. The major point of contention concerned the financial criterion. Some delegates (Chile and Switzerland) strongly objected to a requirement which would enable the largest "shareholder" to block the entry into force of the new agreements. Only a small minority of delegations (Sweden, [12] France and Mexico) asserted that there must, as a matter of international law, be unanimous adherence by all prior members. The remainder appeared to accept adherence by a substantial majority as legally sufficient.

Transfer of Rights and Obligations—The Working Group produced two alternative draft articles. The first of these would transfer the rights and obligations of signatories to the interim Special Agreement to the signatories of the comparable part of the definitive arrangements, including transfer of ownership in undivided shares. The second approach transfers all rights and obligations of interim signatories to INTELSAT under the definitive arrangements. The two approaches are contrasted as appropriate, respectively, for a continued joint venture or the establishment of an organization with a legal personality.

Buy-Out—Committee II in its report formulated the following general legal principles for the buy-out of non-continuing members, leaving the mechanics to Committee III: (1) fair compensation with reasonable expedition; (2) for patents and data, either fair compensation or continued enjoyment; and (3) the amount of compensation to be settled by negotiation between the non-continuing member and INTELSAT. Failing an agreement, the non-continuing member could challenge any determination by the governing body before a neutral arbitral tribunal. Although there appeared to be no opposition to the principle of equitable compensation for non-continuing members, Chile and Sweden argued that a non-continuing member's share cannot be bought out without its consent.

Com. II/10 contains this Group's report.

Working Group on Other Matters—Com. II/15 and 16 are the reports of this Group.

Privileges and Immunities—This item was considered at some length in the full Committee as well as in the Working Group. The report of Committee II on this subject noted that a majority of the delegates favored including in the intergovernmental agreement two general provisions: the first would commit the host [13] state to conclude a headquarters agreement providing for appropriate privileges and immunities within the jurisdiction where the headquarters were located; the second would authorize the board of governors to negotiate with member states on an ad hoc basis those privileges and immunities appropriate for the proper functioning of INTELSAT. It was generally recognized that INTELSAT would obtain tax immunities where necessary, although provision for such immunities should not be specifically made in the intergovernmental agreement. Some delegates expressed the view that INTELSAT would have to have legal personality in order to be granted privileges and immunities under their domestic laws.

Settlement of Disputes—There were three major points of controversy: the proper parties to arbitration; the selection of the panel from which the third member (the president) of an arbitral tribunal is chosen; and, the scope of arbitrable disputes. The U.S. position was that the signatories to the operating agreement, the board of governors, and

complete internationalization of the Manager under a director general, felt that fixing a rigid time period in which this goal must be realized might interfere with the necessity of [e]nsuring efficient and effective management. Australia, Chile, Nigeria and Venezuela favored this approach. Some members of the Working Group who supported this view wanted it made clear that staff should be recruited on the basis of competence rather than on the basis of investment or geographical representation of countries.

A third view, expressed by the United States, specifically rejected the view that internationalization of the Manager should, in itself, be a primary goal or common aim. Efficient management should be the only goal of the organization regarding the structure of its management body. Internationalization of the organization should be addressed in the assembly and the governing body. Subsequently, the U.S. Delegation indicated that we could consider dividing the management function and creating an international administrative [10] management body to handle administrative, financial, and legal functions, with the operational manager continuing to handle other functions. The United States made it clear, however, that the concept of a director general interpositioned between the manager and the governing body was unacceptable.

Working Group C—The report of Working Group C (Com. I/94) deals with eligibility for INTELSAT membership and the question of relationships with non-member countries. The Working Group produced two draft articles, one on membership, which stipulates that only International Telecommunication[s] Union members are eligible for INTELSAT membership; and one setting forth principles of access to the system, which would make direct access to the space segment of the global system available to all signatories and other states, countries or areas not members of the organization. The Group unanimously supported the draft articles, with Tunisia, however, recording the view that the possibility of admitting non-ITU members to membership in INTELSAT should not be excluded. A few other members and several observers also spoke in favor of this view in meetings of the parent Committee, though a considerably larger number of members spoke in favor of ITU membership as a condition.

Committee I discussed the topics considered by its Working Groups before and after the Groups met. In addition, the topics of the rights and obligations of members and INTELSAT relationship with the ITU were discussed in the Committee, but these discussions did not go beyond a few expressions of views and these topics were not assigned to a Working Group. The Secretariat prepared and distributed a summary of the main points touched upon in these discussions (Com. I/107, Rev. 1).

Committee II—Legal and Procedural Questions

Committee II established three Working Groups. Its agenda is set forth in Annex D.

[11] Working Group on Legal Status—Legal status was examined at some length in both the Working Group and the full Committee. All of the other members of the Working Group (Brazil, Chile, Germany, the Philippines, Sweden, Switzerland, and the U.K.) opposed the U.S. position that INTELSAT should continue as a joint venture without legal personality. Instead they favored establishing INTELSAT as a legal entity distinct from the participants. The joint venture was described by the U.S. as a viable means of carrying out the activities and purposes of INTELSAT. The majority view urges that INTELSAT will be better able to contract, own property, sue or be sued, obtain privileges and immunities, and incur and dispose of liabilities appropriately if it is a separate legal personality. The United States position is that all these functions have been performed and can continue to be performed through a joint venture.

The report of the Working Group contains separate statements of the majority and

structure of the organization. The Working Group discussed and reported on the nature, composition and functions of the major organs of the organization including an assembly of members, a governing body and a manager. No draft articles were prepared although a number of proposed drafts were submitted to the group and are reflected in the report. The eighteen-country group attempted to identify and record alternative views on structure of the organization but did not attempt to negotiate or reconcile inconsistent or incompatible proposals.

There was unanimous support for creating an assembly, but the question arose as to its composition. Some thought the assembly should be exclusively a governmental body (i.e. participants would be under direct government control), and others suggested it be an assembly of telecommunication operating agencies or entities which are the signatories to the operating or special agreement. The United States, India and the United Kingdom, among others, proposed that the designation of delegations to the assembly be reserved as a matter of discretion of the individual member countries. An alternative solution proposed was to divide the assembly into [8] two assemblies, (1) an assembly of governments, meeting less regularly and concerning itself only with review of programs and progress and possible amendment of the intergovernmental agreement, and (2) an assembly of telecommunication operating entities, meeting more regularly, perhaps, annually, to oversee and consider the management and progress of the system.

There was considerable discussion on the powers of the assembly, and proposals range, in substance, from treating the assembly as the equivalent of a stockholders' meeting to giving the assembly direct responsibility and decision-making powers relating to operation of the system. The broadest support probably is for the relatively less operationally responsible assembly, and proponents of increased assembly powers are fewer as the powers assigned increase. There are two schools of thought on voting in the assembly. Nearly all of those speaking on the point favored one nation-one vote, in many cases, however, subject to the assumption that the assembly will have relatively limited powers. The United States position was to combine one nation-one vote with a weighted vote reflecting relative levels of investment of the members.

There was unanimous opinion in the Committee favoring establishment of a governing body equivalent to the present Interim Communications Satellite Committee (ICUS) of INTELSAT. It was unanimously agreed that representatives to this body should be from the telecommunication operating entities involved. There was a consensus that the size of the body should be limited in the interest of efficiency and effectiveness, although all agreed that equitable arrangements should be made for representation from smaller member countries and all geographical areas. There was no consensus on how to achieve these goals. There also was no specific agreement on functions of the governing body, but it appeared to be intended by most delegations that its functions would be similar in nature and scope to those now performed by the ICUS. Voting in the governing body was discussed without [9] conclusions. There is general agreement that voting should be weighted to reflect relative investment in or use of the system, but there appears to be substantial support for the view that no single country or small group of countries (2 or 3) should be able to impose or block (veto) a decision of the governing body. (The U.S. currently has an effective veto power under the interim arrangements.)

The Working Group reported three principal views on the management arrangements for the future organization and the proponents and supporters of each view proclaimed their desire to ensure efficient, competent management.

The proponents of the first view maintained that the definitive arrangements should establish a firm goal of full internationalization of the management, under a director general, within a specific period of time. This view was supported by Belgium, France, India, Switzerland, the United Kingdom, Canada and Germany, among others.

The proponents of the second view, while not excluding the possibility of partial or

Conference was done in the Committees, with plenary meetings held only at the beginning and near the end of the session.

V. Work of the Committees

Committee I—Structure and Functions

Committee I's work program, including nine specific topics, is set forth in Annex C. To facilitate its work, the Committee formed three working groups, each of which prepared a report, which was reviewed and accepted by the Committee and forwarded to a plenary meeting for consideration.

Working Group A—The report of Working Group A (Com. I/84, Rev. 1) deals with the purposes and objectives of INTELSAT and the scope of INTELSAT's activities. The Working Group developed a draft Preamble for the definitive arrangements, a draft [6] article on "Objectives and Purposes" and a draft article on "Scope of Activities." These draft articles were adopted unanimously by the ten-country Working Group, subject to notes and reservations set forth in the report.

The Preamble is substantially similar to the Preamble of the 1964 intergovernmental Agreement and represents, in substance, the points which the U.S. Delegation sought to have included. France, supported by Syria, Switzerland, Belgium, and Sweden, reserved on the question of the use of the word "single" in the phrase "single global system," arguing that the term is ambiguous, ignores the presence of other communication satellite systems in the world, and, therefore, should be eliminated.

The objectives and purposes of the organization as proposed in the draft article include the creation of a global organization to establish a single global commercial communication satellite system (France reserving again on "single") "intended primarily to provide international public telecommunication services on a commercial basis of high quality and reliability, and sufficient to provide such services to all areas of the world." This statement of objectives and purposes is consistent with U.S. views.

The Working Group submitted a proposed article on the organization's authorized scope of activities. The draft article states that INTELSAT: shall provide the space segment for international public telecommunications services; shall make its global satellite facilities available for domestic public telecommunications services on a non-discriminatory basis if this would not affect adversely the provision of facilities for international public services; may provide facilities in the global space segment for specialized service, presumably domestic or international in scope, if this would be both technically and economically acceptable and does not affect adversely the provision of international public services; may provide separate satellites for domestic public telecommunications services; and may provide separate satellites for specialized telecommunications services, presumably both domestic and international in scope, if this would [7] be both technically and economically acceptable and does not affect adversely the provision of international public services.

Although the Working Group agreed on this text, there are still several areas of less than complete agreement. The status and relative priority of domestic traffic is a matter of particular concern to Denmark, Pakistan, Portugal, the United Kingdom and the United States, all of which have geographically separated areas between which communication satellite traffic is or may be contemplated. (The U.S. concern, however, relates to all domestic traffic.) In connection with "specialized" telecommunication services, France, among others, expressed concern that INTELSAT may be entering into areas or types of service better left to other organizations or to national governments to provide. As drafted, the article was acceptable to the United States.

Working Group B—The report of Working Group B (Com. I/111) deals with the

States, Vatican City State, Venezuela, Republic of Viet Nam, Yemen Arab Republic. Only Iraq was not represented.

Observers were sent from the following twenty-nine non-member countries: Afghanistan, Barbados, Bolivia, Bulgaria, Cambodia, Cameroon, Congo (K), Costa Rica, [4] Czechoslovakia, Ecuador, Finland, Ghana, Hungary, Ivory Coast, Liberia, Maldive Islands, Mauritania, Mauritius, Mongolia, Paraguay, Poland, Romania, Senegal, Somalia Republic, Southern Yemen, Union of Soviet Socialist Republics, Uruguay, Yugoslavia, Zambia. In addition, observers attended from the United Nations and the International Telecommunication[s] Union. Thus a total of ninety[-]eight delegations attended the first session of the Conference.

A complete list of participants is attached as Annex A, including a list of the United States Delegation.

Among the non-member observer countries, a substantial number spoke during various meetings of the Conference. Particularly the USSR, Poland, Romania and some of the African observer delegations presented substantive comments and views on questions being considered by the Working Committees of the Conference.

IV. Organization of the Conference

The United States, as host Government, provided the secretariat and physical facilities for the Conference. The conference facilities in the State Department Building were used. In addition, the main auditorium of the Pan American Health Organization Building was used for several committee meetings. Administrative and secretariat support from the Office of International Conferences was outstanding throughout the Conference and won deserved praise from many delegations at the final plenary session. In addition, the Federal Communications Commission, the Office of the Director of Telecommunications Management, and the Communications Satellite Corporation made available secretarial and administrative support staff and equipment which contributed further to the efficiency of the overall operation.

The Conference was formally opened by the Acting Secretary of State, Elliot L. Richardson. The names of the elected Conference officers and Committee Chairmen and Vice Chairmen are set forth in Annex B. All Conference officers and Committee Chairmen and Vice Chairmen were unanimously elected and there were no objections to the [5] composition of any of the Conference Committees. The established Working Committees of the Conference and their subject matter were the following:

Committee I	Structure and Functions of INTELSAT Consortium, with particular regard to questions of membership, scope of services, organizational structure including structure of major organs, their functions and voting.
Committee II	Legal and Procedural Questions, including definitions, legal status, entry into force, duration, amendment, withdrawal, settlement of disputes.
Committee III	Financial Arrangements.
Committee IV	Other Operational Arrangements, including procurement policy, inventions and data, technical and operational matters.

All four of these Committees were constituted as committees of the whole, i.e. open to participation by all member country delegations, and all committee sessions, though not the sessions of working groups, were open to observers. Most of the work of the

the first Agreement and the Communications Satellite Corporation (ComSat), the telecommunications entity designated by the U.S. Government, is a signatory of the second (Special) Agreement. Pursuant to these two Agreements, opened for signature on August 20, 1964, the cooperating member countries brought into existence the International Telecommunications Satellite Consortium (INTELSAT), which now has 68 member countries.

Pursuant to Article IX of the Interim Agreement, the governing body of INTELSAT—the Interim Communications Satellite Committee (ICUS)—produced a report containing the Committee's recommendations, and other shades of opinion, on definitive arrangements for the organization. This report was issued to all INTELSAT member Governments on December 31, 1968.

Under other terms of Article IX the United States was obligated to convene a plenipotentiary conference to consider the ICUS Report within 90 days of the date it was issued. In compliance with this obligation, the United States convened the Plenipotentiary Conference on Definitive Arrangements for the International Telecommunications Satellite Consortium in Washington on February 24, 1969. After four weeks of work, the Conference recessed its first session on March 21, 1969. This report covers that session.

II. Agenda of the Conference

As adopted, the agenda provided for:

1. Election of the Chairman
2. Adoption of the Agenda
[3] 3. Adoption of Conference Rules of Procedure
4. Election of other Officers
5. Organization of the Conference
   - A. Credentials Committee
   - B. Editorial Committee
   - C. Working Committees
6. Report of the Credentials Committee
7. Consideration of the report and recommendations of the Interim Communications Satellite Committee and of definitive arrangements for the International Telecommunications Satellite Consortium
8. Signing of definitive arrangements

The Conference followed this agenda, completing items 1–6, including adoption unanimously of the rules of procedure, established its work program, and proceeded in working committees to consider the wide variety of proposals contained in the ICUS report, as well as other proposals introduced during the Conference. It did not complete consideration of item 7, the substantive business of the Conference, and, of course, did not reach item 8, signing of agreements.

III. Participation

Sixty-seven of the sixty-eight members of INTELSAT registered at the Conference. They were Algeria, Argentina, Australia, Austria, Belgium, Brazil, Canada, Ceylon, Chile, China, Colombia, Denmark, Ethiopia, France, Federal Republic of Germany, Greece, Guatemala, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Lebanon, Libya, Liechtenstein, Luxembourg, Malaysia, Mexico, Monaco, Morocco, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Panama, Peru, Philippines, Portugal, Saudi Arabia, Singapore, Republic of South Africa, Spain, Sudan, Sweden, Switzerland, Syrian Arab Republic, United Republic of Tanzania, Thailand, Tunisia, Turkey, Uganda, United Arab Republic, United Kingdom, United

Report of the United States Delegation to the Plenipotentiary Conference on Definitive Arrangements for the International Telecommunications Satellite Consortium

(First Session)
Washington, D.C.
February 24–March 21, 1969

Submitted to the Secretary of State:

Leonard H. Marks, Ambassador
Chairman, United States Delegation
April 10, 1969

Summary

The purpose of the Conference is to establish definitive arrangements for the International Telecommunications Satellite Consortium (INTELSAT). During the period February 24 to March 21, 1969, 96 interested member and non-member countries exchanged views on general aspects and specific details of proposed definitive arrangements. No final decisions were taken by the Conference, which stands recessed until November 18, 1969, at which time it is expected that draft definitive arrangements will be considered by the reconvened Conference. In the interim, an intersessional Preparatory Committee is being formed to develop the draft definitive arrangements.

The Conference provided the first occasion since the interim arrangements were signed in 1964 for governments in their sovereign capacity to examine the organization collectively. Hence it is not surprising that political factors influenced the positions taken by many delegations. However, the avoidance of the extraneous political issues often raised at international conferences is notable. There have been no challenges to credentials and no polemics on issues outside the business of the Conference.

The Conference worked in its first session through four working committees and in plenary session. The various Committee reports produced have been referred to the intersessional Preparatory Committee and will provide a basis for that Committee's work.

I. Background

Following a series of successful communication satellite experiments by Government and industry in the United States in the period 1958–1963, the United States undertook, pursuant to the terms and mandates of the Communications Satellite Act of 1962, to establish, in conjunction and in cooperation with other countries, a single global commercial communication satellite system. After several months of international bilateral and multilateral negotiation [2] in 1963–64, the Government of the United States convened a Plenipotentiary Conference at Washington, D.C. in July 1964, at which texts of two agreements were initialed by 19 participating Governments. The first is the intergovernmental Agreement Establishing Interim Arrangements for a Global Commercial Communications Satellite System, in which the parties agreed to establish a global communication satellite system in cooperation with one another. A related Special Agreement, signed by Governments or telecommunications entities designated by member Governments, contains details relating to operation, financial aspects, procurement, control and maintenance of the global satellite system. The U.S. Government is a party to

terminal has now been delayed for over a year in an attempt to compromise the conflicting interests between the international telegraph carriers, the Communications Satellite Corporation, and our domestic common carriers. By 1968 a second communications satellite terminal will be needed in Hawaii and another one on the West Coast. Both of these stations should be under construction now. They are not. A major factor in the delay has been the general disorder in the U.S. international communications structure and the continuing pattern of conflict between the carriers.

C. Confusion and Conflict Resulting from the Foreign Interests of U.S. International Common Carriers

The need for communications satellite earth stations in foreign countries where U.S. international common carriers have business interests has created dissension among these carriers and had a very serious impact on the U.S. image overseas. In the Philippines, controversy between U.S. common carriers concerning responsibility for assisting in the organization of communications satellite activities and the construction of an earth terminal resulted in a long period of stalemate and confusion. The ultimate decision on the part of the Philippine Government was to sharply reduce the activity of U.S. carriers within the Philippines.

A similar situation has developed in Central and South America where certain of our international carriers are fighting a rear guard action against loss of their operating franchises. These conflicts and controversies are delaying the construction of satellite earth terminals in direct opposition to the announced United States policy to promote a rapid growth of satellite communications capability so as to strengthen bonds within this hemisphere.

Document I-25

Document title: Leonard H. Marks, Ambassador, Chairman, "Report of the United States Delegation to the Plenipotentiary Conference on Definitive Arrangements for the International Telecommunications Satellite Consortium (First Session), Washington, D.C., February 24–March 21, 1969," April 10, 1969.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

The 1964 Interim Agreement that created INTELSAT specified that after five years a conference would be called to develop a definitive agreement for the organization. Accordingly, a Plenipotentiary Conference on Definitive Arrangements for the International Telecommunications Satellite Consortium convened in Washington, D.C., on February 24, 1969. The report of the U.S. delegation on the first session of that conference detailed the many areas of disagreement that would have to be resolved before a definitive agreement was possible. It took several years of difficult negotiations before that objective was achieved. The definitive agreements for INTELSAT went into effect on May 21, 1971.

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[1]

A. Technology Gap

Many foreign nations feel that they were forced to accept the 1964 communications satellite agreements on U.S. terms as a result of deficiencies in their own space research and development capabilities.

[8] These nations are working as hard as [bolded passages were highlighted with a marker in the original] **possible to improve their technical position to give them options to strengthen their position and insure more equitable participation in the INTELSAT organization after 1969.** [note in margin, arrow pointing to, and emphasizing, the following sentence] The manner in which the U.S. shares its technology impacts directly on this issue. We are eager to share technology with those nations firmly committed to INTELSAT. **We do not, however, find it in the U.S. interest to provide the tools with which a foreign nation can circumvent the INTELSAT agreements by contributing to the establishment of competing regional systems.**

B. Leadership in INTELSAT Administration and Management

At present the U.S., through the Communications Satellite Corporation, serves as Chairman of the Interim Communications Satellite Committee, provides the Manager for all technical operations of INTELSAT, and has [bolded passages were highlighted with a marker in the original] **a controlling voting interest of 54 percent** in most decisions of the Consortium. Many foreign nations feel that this is an unacceptable domination of INTELSAT by the U.S. We are already experiencing pressure within the Consortium to reduce the influence of the U.S. and to strip COMSAT of its administrative and technical control. This will undoubtedly be an important point in the 1969 renegotiations.

A GENERAL DISORDER OF U.S. INTERNATIONAL COMMUNICATIONS

A. Inadequate Responsiveness to Communications Needs of the U.S. Government

The serious conflicts of interest that have existed in recent years among U.S. international communications common carriers have been greatly increased by the advent of communications satellites. This situation has resulted in increased controversy and delay in meeting new Government requirements. A recent Department of Defense requirement for communication service to Japan, Thailand, and the Philippines to provide support for operations in Vietnam has resulted in many conflicting filings with the Federal Communications Commission. This conflict and others like it have raised serious doubts within Government agencies concerning the ability of the U.S. international common carriers, placed as they are in a constant conflict of interest, to provide assured and rapid response to new or emergency communications requirements of the Government.

Such uncertainties create a growing incentive for the Government to reverse previous trends toward increased use of international common carriers and to turn instead to greater dependency upon and use of [9] Government owned communications satellite systems. Since the U.S. Government is by far the largest single user of international commercial communications channels, loss of any portion of this business by the carriers could have a serious adverse effect on all the international carriers, but particularly on the viability of international satellite communications.

B. Delays in U.S. Earth Station Construction

The continual controversy and divided system responsibility in U.S. international communications have also adversely affected and delayed construction of an adequate U.S. earth terminal complex to keep pace with the growing communications capacity of the space segment. On the East Coast of the U.S. the system needs two full scale operating terminals. One terminal is in operation but the authorization to construct the second

A merger of the five U.S. international carriers is becoming increasingly vital. If it does not take place soon some of the wiser heads in the industry see no way of preventing Government ownership as a way of bringing order out of chaos.

B. Patent Problems

The INTELSAT organization's patent provisions are already a problem that promises to become increasingly acute. Some U.S. aerospace firms are balking at a requirement that INTELSAT be given patent rights to all patents used on INTELSAT contracts.

C. TV and Educational TV Interests

The proposals of the Ford Foundation, American Broadcasting Company, and others to create a domestic TV distribution system via communications satellites have confronted the FCC with problems that are fraught with economic, policy, legal, and technical issues which overlap and impact upon our international agreements.

These domestic issues are raising serious apprehensions among our foreign partners that the U.S. intends to place domestic interests and pressures ahead of better world communications. And, of course, the Soviet Union has repeatedly criticized INTELSAT as a rich man's club being run for the primary benefit of the United States.

[7] THE "LIMITED OBJECTIVES" SYNDROME

A. Inadequate Research and Development

Communications satellites are still in a very early stage of development from the viewpoint of both technology and utilization. In order to achieve the goals established by the Communications Satellite Act of 1962, a substantial acceleration of research and development program is needed.

A primary task is to produce advanced multiple access capabilities to serve low traffic density terminals of the developing nations. We also need more stable space platforms, better pointing accuracy in our antennas, and improved primary power sources for the space vehicles.

[bolded passages were highlighted with a marker in the original] **Although COMSAT is seeking to construct a major research and development facility, they are encountering strong opposition from our European partners.** Such a research center would tend to be competitive to foreign manufacturing interests. Certain U.S. aerospace firms have opposed the COMSAT research and development center for the same reason. COMSAT is certain to run into serious trouble unless they adopt a carefully planned philosophy acceptable to their foreign partners and U.S. industry.

B. Conflict as to the Proper Pace of System Implementation

COMSAT has pushed ahead faster than desired by some of the European partners in order to create an operating system with worldwide coverage prior to 1969. A successful system will be the best possible insurance of our continuing the present favorable pattern of international agreements. Within INTELSAT, however, there is an element which feels that the global system should proceed more slowly so that the gap in aerospace technology between the U.S. and other countries can be closed prior to major deployment of the system. There is also a reluctance among those nations who are large owners of telephone cable systems to divert traffic to satellites so long as channels are available in the cables.

FEAR OF U.S. DOMINATION

tions is certain to impede the growth of these terrestrial microwave services. It is also clear that the unrestricted installation of earth stations for domestic purposes will preempt space required to expand the international system. Despite technological advances there is an ultimate limitation to the amount of communication which can be carried in this frequency band.

[5] The solution to this problem lies in the development of new exclusive frequency bands for satellite communications. The course of action is feasible but will require additional research and development and a few years of time—but it will make it possible to exploit satellite communications to its fullest potential.

C. U.S. Space Systems Manufacturers

At present the aerospace industries of the U.S. enjoy a significant technological lead over all foreign competitors in the field of communications satellites. The concept of a single global system prevents rapid, albeit wasteful, proliferation of the space segment hardware and restricts the market to supplying the INTELSAT organization. [bolded passages were highlighted with a marker in the original] **A greater market potential could be created more rapidly through the development of independent national systems or proliferation of regional systems. The aerospace industry thus seeks a proliferation of systems.**

While this approach may produce a short run profit for the aerospace industry, it will produce a long run harvest of international telecommunications chaos and ill will. We cannot afford to be cast in the role of sponsoring these misguided attempts to implement inefficient and unnecessary communications satellite systems that do not have the traffic base to make their operations viable or to achieve the economies of scale possible in a single global system. In this case, the short term commercial interests of our aerospace manufacturers are in conflict with the national and international objectives of creating an effective global system to introduce a new era in world telecommunications and better serve all mankind.

D. National Ambitions of Foreign Governments

Several foreign nations, [bolded passages were highlighted with a marker in the original] **notably France,** feel that they must develop their own communications satellite capability as rapidly as possible to reinforce national prestige.

An important motive for individual nationalistic control of communications satellites stems from a desire [bolded passages were highlighted with a marker in the original, note in margin: "#1"] **to continue to exercise cultural and political leadership in traditional areas of influence without intervention by an international body such as INTELSAT.** [note in margin: "#2"] **Equally important is their desire to create a viable option which can be used as a negotiating point in the 1969 discussions.** [note in margin: "Symphonie"]

[6] THE IMPACT OF U.S. DOMESTIC COMMUNICATIONS ISSUES

A. The Ownership of International Earth Stations

The recent FCC decision to share ground station ownership 50-50 between COMSAT and the communications common carriers has not yet reduced conflict or speeded progress as had been hoped. COMSAT's investment capital potential has been cut in half but the record carriers still want more.

As more and more international traffic shifts communications to satellites, the rate base position of the international carriers will become progressively worse. Further, dividing ownership among COMSAT and the five international carriers seriously jeopardizes the profit position of COMSAT as well. So long as we have the present irrational arrangement of international common carriers, the situation is certain to continue to get worse.

2. The impact of U.S. domestic communications issues;
3. The "limited objectives" syndrome;
4. Fear of U.S. domination;
5. The general disorder of U.S. international communications.

INTERESTS THAT CONFLICT WITH THE GLOBAL SYSTEM

A. [bolded passages were highlighted with a marker in the original] **International Carriers**

These organizations, including both the United States and foreign carriers, **view the INTELSAT system as a direct competitor to the established cable and high frequency radio routes.** Long established spheres of influence and methods of operation are also threatened. With a single global communication satellite system, opportunity for national control of international communications routing, ability to charge transit fees and apply other restrictive practices will be lost. Many of the foreign carriers feel that their earnings would be greater and their control maintained if traffic is transmitted over cable and high frequency radio systems where their ownership may be as high as 50 percent in contrast to their 1 to 5 percent ownership which is typical in INTELSAT. Some Administrations in Europe frankly admit using the profits of their international telecommunications traffic to subsidize their domestic costs for both telecommunications and postal services. Some Administrations also feel that where cable and high frequency radio are no longer viable, their interests would be better served through the creation of regionally oriented satellite systems where their ownership share could be increased.

Another arrangement preferred by U.S. record carriers and some foreign Administrations over the present COMSAT-INTELSAT arrangement would be a completely non-profit space segment structure which would be [4] supported by the various nations on the basis of use. Administrations would derive income from earth station charges which could be handled much like cable charges without the added complication of providing income and profits to the space segment owners. The only major impediment in the way of this arrangement is COMSAT. Other nations are not faced with this dilemma. All sophisticated Administrations can be assumed to be thoroughly aware that the U.S. poses the only impediment to this kind of structuring.

Some of the international record carriers are also concerned that the INTELSAT organization will spawn greater sophistication in the less developed nations and encourage them to assume a more prominent role in their internal communications systems as well as the satellite earth terminals used as gateways for international traffic.

In the past, international carriers have often dominated completely communications within a developing nation through control of international communication facilities.

B. Domestic Common Carriers

While our domestic common carriers recognize the need for single ownership and management of international communications systems and for compatibility between international and domestic systems, they are in conflict with certain of COMSAT's proposals for early domestic communications satellite service. A key question affecting domestic service stems from the present international agreements which provide for shared frequencies between terrestrial microwave systems and space services.

In the frequency bands assigned to satellite communications, we also operate a profusion of domestic terrestrial microwave relay systems which involve a capital investment over $2 billion. This is over twice the total capital invested in international telecommunications by all the nations of the world. These terrestrial microwave systems are continuing to expand rapidly. It is clear that the installation of numbers of domestic satellite earth sta-

quality of services and charges for such services.

THE INTERNATIONAL AGREEMENT OF AUGUST 20, 1964—55 NATIONS

Desiring to establish a single global commercial communication satellite system as part of an improved global communications network which will provide expanded telecommunications services to all areas of the world and which will contribute to world peace and understanding;
[2] Determined, to this end, to provide, through the most advanced technology available, for the benefit of all nations of the world, the most efficient and economical service possible consistent with the best and most equitable use of the radio spectrum.

BASIS

The single global system is truly a revolutionary concept. It is also intrinsically sound from the viewpoint of supporting the policy objectives established by the Congress and confirmed in our international agreements.

USE OF COMMUNICATIONS SATELLITE TECHNOLOGY TO CONTRIBUTE TO WORLD PEACE AND UNDERSTANDING, IMPROVED WORLD TRADE, AND COMMERCE

The integrity of the global system is vital to our primary goal of using satellite technology to promote world peace and understanding, and to our corollary goals of improved world trade, commerce, and better understanding between nations. We must nurture this global system concept, [bolded passages were highlighted with a marker in the original] **for if we allow it to deteriorate into a series of isolated regional networks we may forever lose the golden opportunity which satellite technology provides for creating a world community in which communications flow freely between nations.**

SPECIAL ATTENTION TO THE COMMUNICATIONS NEEDS OF LESS DEVELOPED COUNTRIES

The single commercial communications satellite system provides the broadly based structure to meeting the demands of the smaller nations. Further, it provides a framework in which the United States can work effectively to promote communications satellite technology designed to aid the developing nations.

EFFECTIVE USE OF THE FREQUENCY SPECTRUM

The demands for communications satellite service already promise to overtax the capability of the frequency spectrum. Only through the economies of scale and engineering efficiency of a truly global system will all of the nations of the world be able to gain equal benefits from communications satellite technology.

[3] THE HAZARDS AHEAD

These are fundamental problems in the field of satellite communications which have national importance and which can profoundly affect the economic, social, and political objectives of this Nation. These problems arise from many sources but may be generally categorized as follows:

1. Interests that conflict with the global system;

I am bending every effort to clarify this situation and achieve unified government action to overcome the growing obstacles. Among my proposals are the following:

a. Give *first priority* to development of INTELSAT and the international system. This is in conformance with U.S. policy and statute.
b. Emphasize the great advantages of the single global system. [bolded passages were highlighted with a marker in the original] **(There is *no* regional need which the single global system cannot meet with better service at lower cost, with better spectrum conservation.)**

[ii] c. Provide greater U.S. aid to developing nations in getting earth stations.
d. Develop as rapidly as possible the practical use of the higher (and less used) frequency bands for exclusive use of large domestic satellite systems. Service to be available in 4–5 years.
e. Use the INTELSAT system for early U.S. domestic service growth and ETV [educational television] experiments.
f. Avoid FCC or Congressional action to constitute a separate U.S. domestic satellite system for the immediate future.
g. Accelerate the development of low cost earth stations.
h. Accelerate the development of more efficient multiple access systems to reduce the cost of communication to both rich and poor nations.

[1] A GLOBAL SYSTEM OF SATELLITE COMMUNICATIONS
— THE HAZARDS AHEAD —

THE U.S. COMMITMENT TO A SINGLE GLOBAL SYSTEM

BACKGROUND

The foundation of our communications satellite policy has been embodied in the concept of a single global system to which all nations could have equal access, and through which international communications could flow free of artificial constraints held over from the colonial traditions of past centuries. The concept stems both from the policy objectives established by the Congress and from our international agreements.

THE COMMUNICATIONS SATELLITE ACT OF 1962

Declaration of Policy and Purpose

Sec. 102. (a) The Congress hereby declares that it is the policy of the United States to establish, in conjunction and in cooperation with other countries, as expeditiously as practicable a commercial communications satellite system, as part of an improved global communications network, which will be responsive to public needs and national objectives, which will serve the communication needs of the United States and other countries, and which will contribute to world peace and understanding.

(b) The new and expanded telecommunications services are to be made available as promptly as possible and are to be extended to provide global coverage at the earliest practicable date. In effectuating this program, care and attention will be directed toward providing such services to economically less developed countries and areas as well as those more highly developed, toward efficient and economical use of the electromagnetic frequency spectrum, and toward the reflection of the benefits of this new technology in both

tems. Diversion of Government traffic from the carriers will further jeopardize the future viability of ComSat and the global system.

j. [bolded passages were highlighted with a marker in the original] **Communication satellites are in such an early stage** of their technological and systems development that present systems should soon be made obsolete by the new developments. **But research and development efforts by ComSat and NASA are inadequate to push progress fast enough.** I am increasing the efforts of my office to push for faster progress.

The national policy established by the President and Congress is to give first priority to the successful achievement of a single international global system at the earliest time. It is a sound policy which makes paramount the objectives of world peace and understanding. The importance of the single global system to achieve these objectives cannot be overemphasized. Executive Branch departments are working diligently to reduce the hazards and obtain the objectives sought by the Communications Satellite Act, but success is far from certain yet. The trend appears to be toward progressively more serious obstacles. Further discussion of these obstacles is contained in the attachment.

In a subsequent report I will set forth the steps being taken by my office and other government agencies to cope with these hazards. Some of my proposals for Government actions are included in the attached summary.

J. D. O'Connell

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[i]

A Global System of Satellite Communications — The Hazards Ahead —

SUMMARY

The hazards to the future success of the International Consortium (INTELSAT) and ComSat appear to be increasing and becoming more serious. Knowledgeable students of the situation are privately expressing the thought that [bolded passages were highlighted with a marker in the original] **it is entirely possible that INTELSAT may fall apart in favor of a series of regional systems.**

If this were to occur it would mean:

- A massive setback in future growth and easy access in international telecommunications.
- The loss of the soundest, simplest, lowest cost system of international telecommunication which can make the largest contribution to world peace and understanding.
- A reversion to reactionary concepts of rich nation domination of zones of communication influence, increased length and lower quality of transmission paths, and higher consumer costs.
- A very serious prestige loss to the United States.
- Financial loss to the shareholders of ComSat.

The most serious threats to INTELSAT and ComSat which are described in the following pages have not yet reached critical or unmanageable stage. But over optimism, lack of vigorous action, or actions which aggravate these trends can cause these problems to rapidly get beyond control.

ACTIONS UNDER WAY

The White House
Washington

February 8, 1967

MEMORANDUM FOR THE PRESIDENT

I submit a proposed draft of the President's 1966 report to the Congress as required by the Communications Satellite Act of 1962. This report emphasizes positive accomplishments. It does not describe the hazards which INTELSAT and ComSat face. Some of these hazards are:

a. Actions of certain international record carriers indicate that they consider it to be in their corporate interest to emasculate INTELSAT, the single global system, and ComSat.

b. Certain major aerospace manufacturers both here and abroad deprecate the value of INTELSAT and the single global system. They favor many proliferating domestic and regional systems. Obviously these would provide a larger market for their products.

c. [bolded passages were highlighted with a marker in the original] **France has been promoting within Europe a regional communications satellite system which will compete with INTELSAT,** and **will probably join the Soviet Molnya** [sic: Molniya] **system.**

d. ComSat's studies conclude that there is more business and earnings in the domestic communications field than can be derived from international traffic. This conflict of interest has been demonstrated in recent FCC filings where ComSat has failed to take a clear-cut position as the servant of the international INTELSAT joint venture.

e. Certain members of INTELSAT who derive a favorable balance of payments under present arrangements are not supporting the U.S. policy of actively encouraging the establishment of satellite communications facilities for the developing nations. This has resulted in inadequate progress toward the design of low cost earth terminals and satellite systems—concepts which are needed to promote early effective and economical use in the developing nations.

f. [bolded passages were highlighted with a marker in the original] **Major continental European nations are critical of the "excessively dominant"** position of the United States in the decisions of the International Consortium. **Actions to reduce U.S. dominance and to obtain a manager other than ComSat are expected during the 1969 negotiations to extend the existing Interim Agreement or consummate a more permanent one.**

[2] g. Action by the United States to embark upon separate domestic or regional enterprises prior to 1969 will have a serious negative impact on the single global system, the International Consortium, the 1969 renegotiations, and ComSat's future as Manager for INTELSAT.

h. The recent FCC action to adopt a 50-50 shared ground station ownership formula between ComSat and the communications common carriers has not reduced conflict as had been hoped. ComSat's investment capital potential has been cut in half but the record carriers still want more. A merger of ComSat with the six other U.S. international carriers is becoming increasingly vital.

i. The general disorder of U.S. international telecommunications has been and is a serious obstacle to progress in commercial communication satellites and is a threat to their future. It is also creating increasing pressure to reverse the trend toward greater Government use of the international common carriers and causing serious consideration of programs to step up the capacity of the Government's own communication satellite sys-

telegram are as follows:

(A) Policy directive has not hindered desirable scientific and technological cooperation in any practical way except in the area of communications satellite technology. However, the existence of this policy has undoubtedly colored European views as to the disinterested nature of US offers of cooperation.

(B) Scientific or industry dissatisfaction has not been reflected as irritant on political lines since 1964 negotiations. Political interest may reappear prior to 1969 negotiations.

(C) The divergencies of view among British interests on communications satellite technology were analyzed in Embassy's A-1084 of Nov. 4. To summarize briefly, the GPO is fundamentally concerned with efficient economic communications and less involved in political and industrial considerations. The GPO strongly supports the concept of a single global system. The foreign office is anxious to abtain [sic] political cohesion in Europe and will seek European consensus even [4] at some compromise of domestic ambitions. Industry primary interest is to secure larger share of INTELSAT procurement and will support vigorously any proposal, either for a single system or an independent system, which will improve its competitive position, vis-à-vis US industry. The Ministry of Defense (MOD) is not taking a more active role in the communications satellite question due to participation in IDCSP and possibly ADCSP. Any MOD support for independent European initiative will depend largely on its experience with joint US/UK military projects.

(D) If British are assured of US commitment to genuine cooperative effort in communications satellite technology, we believe they would be prepared to give the required assurances. Clarification on the role of regional and national systems (e.g. ABC proposal for US national TV relay system) would be required. Also Europeans may wish to launch experimental satellites using US launchers. Embassy judgement here is not based on specific comments from industry or government but from the interpretation of expressions of opinion by the Foreign Office, GPO and industry contacts over the past year or so. Bruce

BT

Document I-24

Document title: Memorandum from J.D. O'Connell for the President, February 8, 1967, with attached: "A Global System of Satellite Communications: The Hazards Ahead," February 8, 1967.

Source: Lyndon B. Johnson Presidential Library, Austin, Texas (used with permission).

General James D. O'Connell, the individual responsible for promoting the U.S. policy objective of creating a single global system of satellite communications based on INTELSAT, saw many hazards ahead. This memorandum sketches his perceptions of the challenges to achieving this policy objective.

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[1] MEMORANDUM

under current circumstances is improbable.

3. Therefore, on a cost benefit analysis the costs to the US of sharing technology with Europe in terms of Western leadership, markets, etc., are not likely to be great. On the other hand, the benefits could be considerable. The principal gain would be psychological. US initiatives would be regarded as an act of good will—a cooperative gesture from a friend and ally—which would further strengthen Atlantic bonds. It would encourage US/Europe scientific and industrial cooperation and neutralize any tendency to turn to the USSR in frustration. It would tend to still those voices which charge that US policies are directed to establishing and maintaining absolute domination in all advanced areas of technology.

4. To a lesser degree US technological cooperation, to the extent that it would assist Europe to maintain a reasonably competitive position, will increase specialization and trade for the benegit [sic] of both sides.

5. Turning now to the specific case of communication satellite technology, much of the above reasoning applies. The advantages to the US of relaxing its objectives is for a substantial US share in a single global communications satellite system. Such psychological factors could well be important. The ambitions of European industry in obtaining a larger share of the INTELSAT contracts are well known. Both industry and government regard communications satellites as the one sector of space investment which promises an early commercial return. Informed Europeans are aware that current US policies prevent European industry from obtaining the know-how which they feel would permit them to compete for and obtain such contracts. Much of the recent publicity in Europe released by industry supporting the concept of regional communications satellite systems, allegedly complementary with the global system, is believed primarily designed to provide Europe a greater share of the market for satellites and other elements of the commercial system. The European Conference on Satellite Communications (CETS) is meeting in The Hague later this month with the specific objective of improving European capabilities in satellite technology. Certainly regional systems will be examined as one means of achieving this objective. While France may favor regional systems as an end in themselves, it is believed most countries are basically concerned with industrial aspects and are [3] quite content with [a] single system concept so long as they obtain [a] fair slice of the equipment cake. Thus, if Europeans feel that the US policies and predominance in a single global system will continue to frustrate what they feel to be their quite legitimate aspirations on production, they may well seek to negotiate an agreement at the 1969 Conference which would permit the establishment of regional systems.

6. It is recognized that there is fear that the relaxation of restrictions on transfer of satellite technology will give Europeans the tools to establish separate systems. In our view this fear is exaggerated. First of all, as mentioned above, the general European objective is to achieve adequate competence to bid for INTELSAT and possibly IDCSP [Initial Defense Communications Satellite Program] contracts, and not to establish independent systems per se. This is particularly true of the British. Second, the possibility appears remote that the Europeans could launch an independent system by 1969. Aside from the question of satellite development, Europe will not have launch capability until well into the 1970's.

7. To conclude on this point, an offer to share communications technology with Europe would gain a measure of good will and serve to alleviate European suspicions of US intentions. This should improve the US negotiating posture in 1969. On the other hand the danger to US objectives in such a move would, in practical terms, be negligible since the Europeans would be unable to use such technology over the short term to launch an independent system.

8. Answers to the specific questions posed in the final paragraph of reference

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[Abbreviations in margin: "E, SS, G, SP, SC, L H, EUR, EA, P, USIA, NSC, INR, CIA, NSA, DOD, ACDA, SCI STR, MC, GDP, OC, COM, DTM, FCC, NSF, OST, RSR"]

CONFIDENTIAL LONDON 3872

Transfer of U.S. Communications Satellite Technology

REF: STATE 76929, LONDON'S A-1084 OF NOV. 4, 1966
NSA

1. US policy on the dissemination of information on communications satellite technology has an impact not only on US objectives regarding a permanent single global communications satellite system but also on technology as it relates to European well being. It is the Embassy's premise that an economically strong, technologically advanced and politically cohesive Europe is in the US national interest. Economic strength and technological competence go hand in hand. This is not to say that technological parity in every field is necessary for strong economies but reasonable competence in most advanced sectors appears to be a sine qua non for long term competitiveness even though comparative advantage may lie with one country or another from time to time. This is particularly true in an environment of reduced trade barriers which exposes the industrial sector to keen international competition.

2. In this context it is clear that communications satellite technology encompasses a very narrow slice of technology. The acquisition of greater competence in this field is likely to have only a marginal impact, in practical terms, on narrowing the over-all technological gap. By the same token US initiatives in other single sectors of technology, treated individually, will have minimal effect on the over-all position. However, concentrated cooperative efforts by the US across the board in all possible areas might lead to a significant improvement in Europe's position vis-à-vis the US (and the USSR). But, given the extent of us investment in R&D in the advanced sectors, it is unlikely that Europe under any circumstances could [2] eliminate the gap in the foreseeable future. Any substantial narrowing of the gap will require a major increase in European investment in R&D which

Service for Less-Developed Nations

In carrying out his responsibilities under the Communications Satellite Act of 1962, the President has directed that the United States Government take active steps to encourage the construction of earth-station links to the worldwide communications satellite system in selected less-developed countries. Emphasis in this effort is to be on encouraging the selected countries to construct these stations out of their own resources, stressing the many benefits of direct access to the global communications satellites.

The Special Assistant to the President for Telecommunications/Director of Telecommunications Management has been designated by the President as the agent for coordinating this project.

The State Department and AID are to determine (a) the countries to be included in this program and (b) U.S. Government actions, if any, for encouraging the accelerated construction of earth stations and related facilities in these countries. In cases involving possible U.S. technical or financial assistance, the President has directed that no special funds should be requested. All funding of such projects is to be handled out of current AID FY 1966 appropriations or out of the regular FY 1967 funds.

[2] The Department of State is to report its findings to the President, through the Special Assistant to the President for Telecommunications/Director of Telecommunications Management, by July 1, 1966.

The President has directed that the Executive Agent and Manager of the National Communications System [NCS] and U.S. Government agencies operating facilities outside the NCS utilize the global communications satellite system in handling traffic whenever possible and where national security requirements will not be compromised, consistent with sound cost-efficiency and other management considerations.

A Working Group is to be established, in accordance with the President's instruction, to study the possibilities of using the communications satellite system to advance information exchange and educational purposes, in line with his desire that the United States play a greater role in international education efforts, particularly in less-developed countries.

[hand-signed: "Bromley Smith"]

Document I-23

Document title: David Bruce, U.S. Ambassador to the United Kingdom, to the Secretary of State, "Transfer of U.S. Communications Satellite Technology," Telegraphic Message, November 9, 1966.

Source: Record Group 59, General Records of the Department of State, Archives II, National Archives and Record Administration, College Park, Maryland.

European governments and industry knew that the United States was following a restrictive policy regarding the transfer of technology; this became a source of irritation as the United States attempted to increase the intensity of its space cooperation with Europe and as the 1969 negotiations for definitive INTELSAT arrangements approached. This diplomatic cable from the U.S. embassy in London reflects a foreign policy perspective—that the restrictive policy outlined in NSAM 338 (Document I-21) was not in the best overall interest of the nation. Others in Washington and overseas, concerned with international space policy, shared this perspective and urged that the 1965 policy directive be revised. Their arguments were partially successful, and a slightly less restrictive version of NSAM 338 was issued in mid-1967.

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[1] INCOMING TELEGRAM *Department of State*

cations satellite system rather than to develop independent systems and accommodate their needs within the U.S. system (with additional costs normally to be borne by the participants). Recognized needs should be restricted to those, similar to ours, which are vital to the national security of selected allied nations and which cannot be met by commercial facilities.

5. Withhold provision of assistance to any foreign nation in the field of communications satellites which could significantly promote, stimulate or encourage proliferation of communications satellite systems.

6. Provide technology and assistance in the field of communications satellites to foreign nations: (a) only if such nations are to participate in the U.S. national defense communications satellite system and then only to the extent required for that participant to be effective; or (b) only for use in connection with the single global commercial communications satellite system in accordance with the provisions of the Interim Agreement and Special Agreement of August 20, 1964; and only if there exist appropriate assurances that such technology or assistance will not be transmitted or transferred to a third nation without prior U.S. authorization.

The policies expressed above will be kept under review by the Special Assistant to the President for Telecommunications/Director of Telecommunications Management and the agencies and departments concerned.

Document I-22

Document title: National Security Action Memorandum No. 342, "U.S. Assistance in the Early Establishment of Communications Satellite Service for Less-Developed Nations," March 4, 1966.

Source: Record Group 273, Records of the National Security Council, Archives II, National Archives and Record Administration, College Park, Maryland.

One of President Kennedy's objectives from the start of his involvement with communications satellites was to make sure that any system developed was truly global, served poorer countries, and linked centers of economic activity. Lyndon Johnson's administration continued this policy and issued this directive to emphasize its importance.

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[1] March 4, 1966

NATIONAL SECURITY ACTION MEMORANDUM NO. 342

TO: The Secretary of State
The Secretary of Defense
The Secretary of Commerce
The Secretary of Health, Education and Welfare
The Administrator, National Aeronautics and Space Administration
The Chairman, Federal Communications Commission
The Administrator, Agency for International Development
The Director, United States Information Agency
The Special Assistant to the President for Telecommunications and Director of Telecommunications Management

SUBJECT: U.S. Assistance in the Early Establishment of Communications Satellite

communications satellite capability should require satisfactory assurance that the assistance furnished will be used only within the framework of agreements and arrangements to which the United States is a participant and will not be transmitted or transferred to a third nation without prior U.S. authorization. No agreement [handwritten highlighting in the margin through the end of this paragraph] should be concluded with any nation until information has been made known to other allied nations concerning the U.S. willingness to cooperate in meeting other nations' national security needs which are similar to ours.

7. U.S. firms are required to comply with Munitions Control licensing procedure prior to communication satellite or related technology, transferring equipment or components as embraced by the United States Munitions List, [handwritten underlining] <u>including booster technology and launch services,</u> to foreign nations or firms.

8. U.S. firms are also required to comply with the Department of Commerce's export licensing requirements prior to communicating or transferring to foreign nations or firms certain other relevant technology, equipment or components, not covered by the U.S. Munitions List.

9. All transactions approved under paragraphs 7 and 8 involving technology and assistance pertaining to complete communications satellites or a significant portion thereof, and to provision of launching services or launch vehicles for communications satellites should be conditioned upon express (written) assurances to this government by the foreign nation(s). The assurances should be that technology and assistance obtained will be used only within the framework of the existing international consortium agreements for a single global system or the framework of such special agreements as are referred to in paragraph 6 above and will not be transmitted or transferred to a third nation without prior U.S. authorization.

[page 5] 10.The principles and policy set forth in this document should be reviewed and updated as communications satellite system developments progress and definitive requirements are determined and after the global commercial communications satellite system has been established and is in substantial use.

<u>POLICY:</u>

Therefore, in keeping with the above, it is the United States policy to:

1. Promote the prompt establishment and successful operation of a single global common carrier and public service communications satellite system in cooperation with other nations as part of an improved global communications network which will provide expanded telecommunications services and which will contribute to world peace and understanding.

2. Avoid measures which would adversely affect either the continued expansion of participation in the existing international agreement for a single global commercial communications satellite system or acceptability of the basic premises of the present agreements on a permanent basis.

3. Make use of commercial communications facilities for general governmental purposes wherever commercial circuits of the type and quality needed to meet government requirements can be made available on a timely basis and in accordance with applicable tariff or, in the absence of Federal Communications Commission jurisdiction, at reasonable cost. Establish and maintain separate satellite communications facilities including ground terminals with capacity limited to that necessary to meet those unique and vital national security needs which cannot be met by commercial facilities. The capacity of these separate facilities shall at all times be limited to that essential to meet such unique needs.

[page 6] 4. Encourage selected allied nations to use the U.S. national defense communi-

tiated by the Communications Satellite Act of 1962 and now joined by forty-six nations.

The communications satellite activities of U.S. Government agencies, including the Department of Defense and the National Aeronautics and Space Administration, have an important bearing on the U.S. support of the objectives of the Communications Satellite Act of 1962. These activities may contribute to the dissemination of scientific and technical knowledge of the subject to foreign countries which might be used to the detriment of U.S. policy in this field.

A policy to guide government agencies in the dissemination of satellite technology and in the provision of assistance which is consistent with the overall policies enunciated above is necessary. Such policy should be sufficiently comprehensive to give due regard to the specific requirements of national security.

For the purposes of this policy statement it is intended that restrictions upon transfer of technology and provision of assistance [handwritten underlining] refer to detailed engineering drawings, production techniques and equipment, and manufacturing or fabrication process pertaining to complete communications satellites or a significant portion thereof, and to provision of launching services or launch vehicles for communications satellites. It is not intended that this policy statement apply to surface terminals or limit dissemination of information concerning [page 3] systems concepts, description of spacecraft and normal scientific and technical publications of a professional character. Furthermore, it is not intended that this statement shall limit the dissemination of information required to be disclosed under the provisions of the Special Agreement of August 20, 1964, pertaining to the establishment of a global commercial communications satellite system.

Specific principles to guide United States arrangements for assistance to other countries in the development of communications satellite capabilities are:

1. The United States should conform fully with the 1964 Agreements Establishing Interim Arrangements for a Global Commercial Communications Satellite System.

2. The United States *should refrain* from providing assistance to other countries which would significantly promote, stimulate or encourage proliferation of communications satellite systems.

3. The United States *should not* consider requests for launch services or other assistance in the development of communications satellites for commercial purposes except for [handwritten underlining] use in connection with the single global system established under the 1964 Agreements.

4. The United States should recognize the vital national security needs of other allied nations which can be met by satellite communications and which cannot be met by the commercial system. For example, the United Kingdom has indicated its need for highly reliable satellite communications from England to Australia and to other Far East terminals.

5. The United States aim is to encourage selected allied nations to use the U.S. national defense communications satellite system rather than to develop independent systems and to accommodate allied needs within the U.S. system (with additional costs normally to be borne by the participants). Recognized needs should be restricted to those, similar to ours, which are vital to the national security of the selected allied nations and which cannot be met by commercial facilities. To accommodate the needs within the U.S. national defense system it may prove necessary to include one or more satellites, synchronous or otherwise, [page 4] whether of the same or different design. In this case, such satellite(s) should be designed to be electronically interoperable with the satellites of the basic U.S. national defense communications satellite system in order to permit mutual usage.

6. Agreements for direct assistance to allies which may significantly promote their

Director, Bureau of the Budget
Executive Secretary, National Aeronautics and Space Council
Special Assistant to the President for Science and Technology
President, Communications Satellite Corporation

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[attachment, no page number] August 25, 1965

POLICY CONCERNING U.S. ASSISTANCE IN THE DEVELOPMENT OF FOREIGN COMMUNICATIONS SATELLITE CAPABILITIES

GENERAL:

It is the policy of the United States to support the development of a [handwritten underlining] single global commercial communications satellite system to provide common carrier and public service communications. The intent of the United States to exploit space technology for the service of all mankind, and to promote its use in support of peace, understanding and world order has been stated clearly in legislation and in Administration speeches and official releases. The U.S. Government is committed to use global commercial communications facilities for general governmental communications purposes wherever commercial circuits of the type and quality needed to meet government requirements can be made available on a timely basis and in accordance with applicable tariff or, in the absence of Federal Communications Commission jurisdiction, at reasonable cost. Separate satellite communications facilities including surface terminals may be established and maintained by the U.S. Government to meet those unique and vital national security needs which cannot be met by commercial facilities. The capacity of these separate facilities shall at all times be limited to that essential to meet such unique needs. These policies underlie the spirit and the letter of the Communications Satellite Act of 1962, its legislative history and the position of the United States in the negotiations leading to the signing of agreements establishing interim arrangements for a global commercial communications satellite system.

Provisions for the establishment of the global commercial communications satellite system and a U.S. national defense communications satellite system consistent with these policies have now advanced to the point where it is desirable to amplify and interpret these policies [page 2] in order to guide United States relations with other countries in the development of communications satellite capabilities, particularly with respect to providing technology and assistance therefor.

No Foreign Dissemination

DISCUSSION:

Most major countries of the world other than the United States provide international public communications services through governmental agencies or chartered chosen instrument corporations partially or wholly owned by the government. Assistance to any of these foreign governments in the development of communications satellite systems can potentially develop competitors seeking to divert traffic from the single global system being developed by the international consortium established as a result of U.S. actions ini-

Document title: Memorandum from J. D. O'Connell, Special Assistant to the President for Telecommunications and Director of the Office of Telecommunications Management, to the Secretary of State, Secretary of Defense, Secretary of Commerce, Administrator, National Aeronautics and Space Administration, and Chairman, Federal Communications Commission, "Policy Concerning U.S. Assistance in the Development of Foreign Communications Satellite Capabilities," September 17, 1965, with attached: National Security Action Memorandum 338.

Source: Record Group 273, Records of the National Security Council, Archives II, National Archives and Record Administration, College Park, Maryland.

An interim International Telecommunications Satellite Organization (INTELSAT) was created in 1964 with the understanding that after five years there would be negotiations to create a more permanent organizational structure for international telecommunications via satellite. Comsat was the manager of the interim INTELSAT system, and its structure institutionalized U.S. dominance of the organization's operations and hardware procurement. The United States hoped to maintain that dominant position for as long as possible. The White House appointed a Special Assistant to the President, General James O'Connell, to further that objective. This national security directive reflects O'Connell's efforts to restrict U.S. assistance to other countries that desired to develop their own communications satellite capability.

[no pagination]

September 17, 1965

MEMORANDUM TO: Secretary of State
Secretary of Defense
Secretary of Commerce
Administrator, National Aeronautics and Space Administration
Chairman, Federal Communications Commission

SUBJECT: Policy Concerning U.S. Assistance in the Development of Foreign Communications Satellite Capabilities

The attached policy statement concerning U.S. assistance in the development of foreign communications satellite capabilities is promulgated in accordance with the approval of the President, as noted in [handwritten underlining] National Security Action Memorandum 338, dated September 15, 1965. This statement was transmitted to the President by my memorandum dated August 25, 1965.

As noted in NSAM 338, my office will keep the subject policy under constant review. The cooperation and suggestions of the departments and agencies concerned are invited.

[hand-signed "J. D. O'Connell"]
Special Assistant to the President
for Telecommunications and
Director of Telecommunications Management

Information copies:

INTRODUCTION

The feasibility of communicating by satellites was demonstrated by NASA's Project Echo in 1960 and also by Projects Courier and Score. In March 1959, Messrs. J. R. Pierce and R. Kompfner of Bell Telephone Laboratories, Incorporated wrote a paper showing the feasibility of an active broadband satellite communications repeater. This started Project Telstar.

Objectives

In general terms, the Telstar Communications Experiment is intended to advance the entire area of communications by satellite. Specifically, the experiment is intended to do five things.

1. The first objective is to test an actual broadband communications satellite. The Telstar satellite was originally intended for experiments in telephony, data transmission, and single-channel television. While not primarily designed for two-way telephony, the system could provide 60 simultaneous conversations.
2. A second objective is to test the reliability of electronics equipment in the satellite under the stress of launch and the environment of space.
3. A third objective is to provide measurements of radiation levels in space; this function is completely separate from the communications experiments.
4. A fourth objective is to provide additional knowledge about the best technique for tracking accurately a moving satellite.
5. A fifth objective is to provide a real-life test for the ground-station equipment. . . .

[117] **SECTION 5—CONCLUSIONS**

FUTURE TELSTAR PROGRAM

The results which have been discussed represent the current picture of what we have learned in the field of satellite communications. A considerable amount of data has been gathered on transmission phenomena and propagation. In this area it has been most gratifying to find that transmission at 4 and 6 kmc is exactly according to theory, and there has been no fading or multipath effects that have been observed. The transmission of a variety of signals has indicated that the performance of the link can be completely specified by the standard transmission parameters.

The area where further information would be helpful is that of environment. Here, it is important that we be able to characterize the levels and types of radiation, the incidence and distribution of micrometeoroids and the behavior of the earth's magnetic field. The reliability of components in a space environment will have an important bearing on the economics of satellite communications.

On the ground station, continued effort is being expended to simplify and minimize the equipment required. This is especially true in the area of satellite tracking. The tracking at Andover has been excellent—with no loss of signal level being attributable to tracking error. However, in future systems, it would appear that greater advantage can be derived from autotrack and that programmed tracking can be considerably simplified.

To summarize: The future Telstar Program will consist of:

1. Further transmission tests to confirm and refine the data already gathered.
2. Continued observation of radiation effects, temperature and spin axis orientation.
3. Evaluation of satellite performance to obtain a measure of component reliability.

Document I-21

aspects of space communication in which international cooperation will be required. . . .” [T]his implied invitation to expand the agenda of the EARC beyond consideration of radio frequency allocations and is currently a controversial issue in the U.S. The Bureau of International Organization Affairs (IO) has had the primary responsibility for preparation and coordination of positions for the U.N. discussions and is currently very interested in implementation of U.N. Res. 1721 as regards the ITU. Deputy Assistant Secretary Gardner of IO plans to participate in current meetings of the Administrative Council of the ITU at Geneva at which Mr. Francis Colt de Wolf of TRC represents the U.S.

In summary, the principal issues involving the Department as regards space communications at present are (1) development of the U.S. position as regards the appropriate role of the ITU in this area in relation to our obligations under the U.N. Resolution; (2) development of the U.S. positions to be taken at the ITU Extraordinary Administrative Radio Conference planned for 1963, in Geneva; [page 6] (3) determination of the manner in which to approach other interested administrations in the development of the international communication satellite system (as distinct from the U.S. position itself) and (4) how US/USSR joint efforts in the development of communication satellites could be moved forward in accordance with the Kennedy-Khrushchev exchange of letters.

In addition to the communication satellite report, attached also is a statement of the Department’s position presented by Under Secretary McGhee before the Subcommittee on Anti-trust and Monopoly of the Senate Committee on the Judiciary on March 30, 1962.

Document I-20

Document title: Project Telstar, “Preliminary Report, Telstar I, July–September 1962,” Bell Telephone Laboratories, Inc., 1962.

Source: AT&T Archives, Warren, New Jersey (used with permission).

Telstar I was built and paid for by American Telephone and Telegraph Company, which wanted to investigate the viability of a communications system that used a constellation of medium-altitude satellites. When Telstar I was launched on July 10, 1962, it became the first real-time active communications satellite and broadcast live television between the United States and England and France. This was a considerable advance over previous experiments, which had involved only voice and data communications using store and forward satellites such as Signal Communication by Orbiting Relay Equipment (SCORE) and Courier. It demonstrated the attractiveness of satellites compared to undersea cables for transatlantic communications. But it also demonstrated the limitations of a medium-altitude satellite, which only stayed in view of a ground station for a brief amount of time. Telstar I had a four-month life span. The following are excerpts of two of the sections of Telstar I’s preliminary report.

PROJECT TELSTAR

Preliminary Report
Telstar I

JULY – SEPTEMBER 1962

PREPARED BY
BELL TELEPHONE LABORATORIES, INC.

[3] **SECTION 1—OBJECTIVES AND EQUIPMENT DESIGN**

some non-carriers to the restriction in ownership on the basis that this would form an undesirable monopoly and this view prevailed in the Executive Branch during the fall of 1961. The Space Council coordinated a draft bill which was forwarded by the President to the Congress and introduced as S.2814 on February 7, 1962. . . . It would have provided for two classes of stock, one of which could be purchased by the general public and the other by the carriers. A third point of view was expressed by a rather small group of Congressmen in favor of Government ownership of the system. Congressman William Fitts Ryan represented this group and introduced H.R. 9907 in support of this view.

Although specific legislation was not introduced until January 1962, hearings had been held before various Congressional committees beginning with that before the House Committee on Science and Astronautics in May 1961. The Department testified before this Committee and since then has testified before the Senate Commerce Subcommittee on Communications, the Senate Small Business Subcommittee on Monopoly, the Senate Committee on Aeronautical and Space Sciences, the Senate Judiciary Subcommittee on Anti-trust and Monopoly, the Senate Commerce Committee and the Subcommittee on Communications of the House Committee on Interstate and Foreign Commerce. The principal witnesses for the Department were Under Secretary George McGhee and Philip Farley, Special Assistant to the Secretary for Atomic Energy and Outer Space (S/AE). Primary responsibility in the Department for space communications had been delegated to S/AE although representatives of E usually accompanied the witnesses from the Department when they testified, and S/AE consulted TRC when ITU matters were involved. It is understood, however, that with the planned dissolution of S/AE, primary responsibility will be transferred to E.

The foregoing discussion has related primarily to domestic developments. They are basic to, and influence greatly, international developments, however. In addition to preparation of positions for the CCIR Los Angeles and ITU Geneva Conferences, the Department is actively concerned now with preparation for the projected ITU Extraordinary Administrative Radio Conference on Space Radiocommunications expected to be held in Geneva in the fall of 1963. Frequency proposals have tentatively been agreed in the FCC/IRAC and circulated by the Department to missions in all ITU Member countries as "Preliminary Views of the U.S. on the Allocation of Radio Frequencies for Space Radiocommunication." . . . Response to this effect is just beginning to be significant.

[page 5] The U.S. was host to an international meeting of Study Group IV (on Space) of the CCIR in Washington in March 1962. In review and amplification of the Los Angeles actions, further scientific and technical recommendations were adopted on various space communication problems.

On March 7, 1962, the President sent a letter to Mr. Khrushchev to which the latter replied on March 20 concerning cooperation in outer space. Related talks were initiated in New York on March 27 between Deputy Director Hugh Dryden of NASA and Mr. Blagonravov of the USSR. Communication satellite cooperation was specifically considered and it is expected that this will lead to further contact between the two administrations in this particular area.

Perhaps the most significant and current international problem in this area is the relation of space communications to other space questions before the United Nations, particularly involving the U.N. Committee on the Peaceful Uses of Outer Space. After nearly two years of dormancy, at least partially due to the refusal of the U.S.S.R. to participate, the Committee was reactivated and given a new lease on life in November 1961. On December 20, 1961 the General Assembly adopted unanimously U.N. Res. 1721 (XVI) dealing with space. . . . Section D of that resolution involves communication satellites and designates the ITU as the responsible agency in this area. After noting plans for the 1963 extraordinary conference it recommends "that the ITU consider at this conference those

ment on April 25, 1961 to the 1958 Space Act which, among other things, made the Vice President Chairman of the Council. On July 24, 1961, President Kennedy issued a new communication satellite policy prepared by the Council. It is the current basic policy in the field and will be found on pages 45 and 46 of . . . "Communication Satellites: Technical, Economic and International Developments."* It confirmed the policy of ownership and operations to be in private hands and Government responsibility to encourage research developments, provide launching facilities and exercise regulatory functions including the obligation to "examine with other countries the most constructive role for the United Nations, including the ITU (International Telecommunications Union) in international space communications. Foreign participation in the system would be provided "through ownership or otherwise." The Space Council has the responsibility for policy coordination and for making recommendations to the President concerning actions needed "to achieve full and prompt compliance with the policy."

The TCC Space Communication Subcommittee had, in April, formulated an initial draft statement of policy and on June 1, 1961, this was circulated on an Official Use Only basis to the TCC Members noting that, because related studies were being conducted in other areas of the Executive Branch, the Department did not propose further consideration of the matter at the time. It is, however, desirable to summarize its conclusions:

[page 3] 1. The development of communication satellites should be a national objective and immediate action was required.
2. It should be accomplished by joint efforts of Government and private enterprise.
3. The new system should supplement, not replace, existing systems.
4. It should be privately owned and Government regulated.
5. Existing and future common carriers should have non-discriminatory access to the system.
6. Other nations should participate in the civil system.
7. The civil system should meet all Government needs normally provided by privately owned communication systems.
8. They should not be subject to special space law.
9. The International Telecommunication Union should serve as the principal international organization in this field.
10. Interim installation of key message centers is desirable pending establishment of direct circuits.
11. The possibility of global TV and radio relay via communication satellites should be emphasized.

Also on June 5, 1961 the FCC met with the commercial communications carriers in furtherance of its Docket 14024 regarding the form of ownership which might be appropriate to an international communication satellite system. An Ad Hoc Committee was formed which reported in October . . . in favor of a joint venture non-profit corporation with ownership limited to the carriers, access by all carriers needing the service, and participation by foreign carriers "by ownership or otherwise" as provided in the President's policy of July 24.

On January 11, 1962 Senator Robert Kerr, Chairman of the Senate Space Committee, introduced a bill, S.2650 . . . in the Senate providing for private ownership and leaving to the FCC (which had stated its preference for ownership limited to the carriers) the approval of the owners.

[page 4] Considerable opposition had been expressed by the Department of Justice and

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* It may be of interest to note that this document was prepared under the direction of Mr. MacQuivery of TD who was detailed from the Department to the Senate Space Committee [rest of the sentence is illegible].

Role of the Department of State in Space Communication Development

One of the earliest instances of the Department's participation in space communication problems was in the preparation for and participation in the 1958 Los Angeles Assembly of the International Radio Consultative Committee (CCIR) at which significant technical recommendations were formulated, particularly with regard to problems of radio frequency selection and use by such systems. During this time and immediately following that meeting, those concerned with regulatory problems also assisted the Department in formulating U.S. proposals for the 1959 Geneva International Radio Conference. These proposals were substantially non-controversial, although they did elicit lively discussions at the Conference and required some special meetings in Washington during the Conference in order to resolve certain differences involving radio astronomy. These were of such concern that the Science Advisor to the President became involved at one point. The issue related to the recognition of space research as compared with radio astronomy in the international table of frequency allocations. A reasonably satisfactory solution was developed in which the Department played a major role in bringing the opposing views together.

Following the Geneva Conference the Department was immediately involved in policy development plans with various agencies. It worked with NASA in clearing frequencies with foreign countries in connection with tracking satellites, with the FCC and Interdepartment Radio Advisory Committee (IRAC) in space frequency use planning, and with the Senate Committee on Aeronautical and Space Sciences in the issuance on March 19, 1960 of a study of "Radio Frequency Control in Space Telecommunications" by Dr. Edward Wenk, Jr. The private companies, especially AT&T, were becoming interested in the potentialities of relay by satellite. [handwritten underlining] In fact, the pace became so rapid that it was necessary on September 30, 1960 for the Telecommunication Coordinating Committee (TCC), advisory to the Department, to request those companies known to be active not to "make any commitments to foreign entities pending further advice as to the promulgation of relevant policies which will guide and govern such activities." It [handwritten underlining] then set up a committee to develop such policies under the chairmanship of FCC Commissioner T.A.M. Craven. Membership on this committee included those involved in other groups also developing various aspects of space communication policy nor necessarily directly related to international affairs. For example, the IRAC/FCC began developing coordinated views on the radio frequencies needed for operational (as distinct from research) use of space. On December 4, 1960, the [page 2, handwritten underlining] Senate Space Committee issued a second report on "Policy Planning for Space Telecommunications" largely based on replies from Executive Branch Agencies to inquiries from the Committee based on questions posed in the March report.

Meanwhile, the AT&T had replied on October 21, 1960 to the FCC for authority to operate a communications satellite system.

On December 31, 1960, President Eisenhower issued a communication satellite policy statement urging that the Government aggressively encourage private enterprise in the establishment and operation of a revenue producing system and directing the National Aeronautics and Space Administration to cooperate closely with the FCC in facilitating this objective. In January 1961 the FCC licensed ITT and AT&T for communication satellite experiments.

The National Aeronautics and Space Council was reactivated as a result of an amend-

interest; and (iii) an evaluation of the capital structure of the corporation so as to assure the Congress that such structure is consistent with the most efficient and economical operation of the corporation.

Approved August 31, 1962, 9:51 a.m.

Document I-19

Document title: Edward A. Bolster, Department of State, to Mr. Johnson, Memorandum, "Space Communication," May 3, 1962, with attached: "Role of the Department of State in Space Communication Development."

Source: Record Group 59, General Records of the Department of State, Archives II, National Archives and Records Administration, College Park, Maryland.

As the debate over the organization and ownership of the U.S. communications satellite system heated up in mid-1962, the question of the relationship of that system to the rest of the world's communications entities was also beginning to be addressed. This internal State Department memorandum summarizes, for an official of the Department's Economic Bureau (organizational code "E"), the state of affairs in May 1962.

Memorandum

TO: E - Mr. Johnson DATE: May 3, 1962

FROM: TRC - Edward A. Bolster

SUBJECT: Space Communication

The attached material summarizes the Department's interest and responsibilities in the space communications field. As you know, Phil Farley's office (Special Assistant for Atomic Energy and Outer Space) is to be abolished soon; responsibility within the Department for communication satellite matters will probably be transferred to E. I suggest that you obtain Mr. Farley's comments on this subject within the next few days, since he will be leaving in the near future for his assignment in Paris.

Dr. Irvin Stewart, Director of Telecommunications Management, wishes to meet with you as soon as possible to discuss your mutual interest in certain aspects of communications policy. I suggest that you arrange such a meeting soon and that we brief you orally in advance.

You will recall that Senator Pastore told Under Secretary McGhee that he would like to meet with you at your convenience to discuss the Department's handling of communications policy matters.

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[attachment, page 1]

other communications common carriers shall be deemed to be a common carrier activity fully subject to the Communications Act. Whenever the application of the provisions of this Act shall be inconsistent with the application of the provisions of the Communications Act, the provisions of this Act shall govern.

NOTICE OF FOREIGN BUSINESS NEGOTIATIONS

SEC. 402. Whenever the corporation shall enter into business negotiations with respect to facilities, operations, or services authorized by this Act with any international or foreign entity, it shall notify the Department of State of the negotiations, and the Department of State shall advise the corporation of relevant foreign policy considerations. Throughout such negotiations the corporation shall keep the Department of State informed with respect to such considerations. The corporation may request the Department of State to assist in the negotiations, and that Department shall render such assistance as may be appropriate.

SANCTIONS

SEC. 403. (a) If the corporation created pursuant to this Act shall engage in or adhere to any action, practices, or policies inconsistent with the policy and purposes declared in section 102 of this Act, or if the corporation or any other person shall violate any provision of this Act, or shall obstruct or interfere with any activities authorized by this Act, or shall refuse, fail, or neglect to discharge his duties and responsibilities under this Act, or shall threaten any such violation, obstruction, interference, refusal, failure, or neglect, the district court of the United States for any district in which such corporation or other person resides, or may be found shall have jurisdiction, except as otherwise prohibited by law, upon petition of the Attorney General of the United States, to grant such equitable relief as may be necessary or appropriate to prevent or terminate such conduct or threat.

(b) Nothing contained in this section shall be construed as relieving any person of any punishment, liability, or sanction which may be imposed otherwise than under this Act.

(c) It shall be the duty of the corporation and all communications common carriers to comply, insofar as applicable, with all provisions of this Act and all rules and regulations promulgated thereunder.

REPORTS TO THE CONGRESS

SEC. 404. (a) The President shall transmit to the Congress in January of each year a report which shall include a comprehensive description of the activities and accomplishments during the preceding calendar year under the national program referred to in section 201 (a) (1), together with an evaluation of such activities and accomplishments in terms of the attainment of the objectives of this Act and any recommendations for additional legislative or other action which the President may consider necessary or desirable for the attainment of such objectives.

[9] (b) The corporation shall transmit to the President and the Congress, annually and at such other times as it deems desirable, a comprehensive and detailed report of its operations, activities, and accomplishments under this Act.

(c) The Commission shall transmit to the Congress, annually and at such other times as it deems desirable, (i) a report of its activities and actions on anticompetitive practices as they apply to the communications satellite programs; (ii) an evaluation of such activities and actions taken by it within the scope of its authority with a view to recommending such additional legislation which the Commission may consider necessary in the public

U.S.C. 310) [citation in margin: "48 Stat. 108"].

(e) The requirement of section 45 (b) of the District of Columbia Business Corporation Act (D.C. Code, sec. 29-920 (b)) as to the percentage of stock which a stockholder must hold in order to have the rights of inspection and copying set forth in that subsection shall not be applicable in the case of holders of the stock of the corporation, and they may exercise such rights without regard to the percentage of stock they hold.

(f) Upon application to the Commission by any authorized carrier and after notice and hearing, the Commission may compel any other authorized carrier which owns shares of stock in the corporation to transfer to the applicant, for a fair and reasonable consideration, a number of such shares as the Commission determines will advance the public interest and the purposes of this Act. In its determination with respect to ownership of shares of stock in the corporation, the Commission, whenever consistent with the public interest, shall promote the widest possible distribution of stock among the authorized carriers.

PURPOSES AND POWERS OF THE CORPORATION

SEC. 305. (a) In order to achieve the objectives and to carry out the purposes of this Act, the corporation is authorized to—

(1) plan, initiate, construct, own, manage, and operate itself or in conjunction with foreign governments or business entities a commercial communications satellite system;

(2) furnish, for hire, channels of communication to United States communications common carriers and to other authorized entities, foreign and domestic; and

(3) own and operate satellite terminal stations when licensed by the Commission under section 201 (c) (7).

(b) Included in the activities authorized to the corporation for accomplishment of the purposes indicated in subsection (a) of this section, are, among others not specifically named—

(1) to conduct or contract for research and development related to its mission;

(2) to acquire the physical facilities, equipment and devices necessary to its operations, including communications satellites and associated equipment and facilities, whether by construction, purchase, or gift;

(3) to purchase satellite launching and related services from the United States Government;

(4) to contract with authorized users, including the United States Government, for the services of the communications satellite system; and

(5) to develop plans for the technical specifications of all elements of the communications satellite system.

(c) To carry out the foregoing purposes, the corporation shall have the usual powers conferred upon a stock corporation by the District of Columbia Business Corporation Act [citation in margin: "68 Stat. 17; D.C. Code 29-901"].

[8] TITLE IV—MISCELLANEOUS

APPLICABILITY OF COMMUNICATIONS ACT OF 1934

SEC. 401. The corporation shall be deemed to be a common carrier within the meaning of section 3 (h) of the Communications Act of 1934, as amended, and as such shall be fully subject to the provisions of title II and title III of that Act [citation in margin: "48 Stat. 1066; 47 USC 153; 48 Stat. 1070; Ante, p. 64; 47 USC 201-222, 301-397"]. The provision of satellite terminal station facilities by one communication common carrier to one or more

Code, sec. 29-911 (d)) [citation in margin: "68 Stat. 191"].

(b) The corporation shall have a president, and such other officers as may be named and appointed by the board, at rates of compensation fixed by the board, and serving at the pleasure of the board. No individual other than a citizen of the United States may be an officer of the corporation. No officer of the corporation shall receive any salary from any source other than the corporation during the period of his employment by the corporation.

FINANCING OF THE CORPORATION

SEC 304. (a) The corporation is authorized to issue and have outstanding, in such amounts as it shall determine, shares of capital stock, without par value, which shall carry voting rights and be eligible for dividends. The shares of such stock initially offered shall be sold at a price not in excess of $100 for each share and in a manner to encourage the widest distribution to the American public. Subject to the provisions of subsections (b) and (d) of this section, shares of stock offered under this subsection may be issued to and held by any person.

(b) (1) For the purposes of this section the term "authorized carrier" [note in margin: "Authorized carrier"] shall mean a communications common carrier which is specifically authorized or which is a member of a class of carriers authorized by the Commission to own shares of stock in the corporation upon a finding that such ownership will be consistent with the public interest, convenience, and necessity.

(2) Only those communications common carriers which are authorized carriers shall own shares of stock in the corporation at any time, and no other communications common carrier shall own shares either directly or indirectly through subsidiaries or affiliated companies, nominees, or any persons subject to its direction or control. Fifty per centum of the shares of stock authorized for issuance at any time by the corporation shall be reserved for purchase by authorized carriers and such carriers shall in the aggregate be entitled to make purchases of the reserved shares in a total number not exceeding the total number of the nonreserved shares of any issue purchased by other persons. At no time after the initial issue is completed shall the aggregate of the shares of voting stock of the corporation owned by authorized carriers directly or indirectly through subsidiaries or affiliated companies, nominees, or any persons subject to their direction or control exceed 50 per centum of such shares issued and outstanding.

(3) At no time shall any stockholder who is not an authorized carrier, or any syndicate or affiliated group of such stockholders, own more than 10 per centum of the shares of voting stock of the corporation issued and outstanding.

(c) The corporation is authorized to issue, in addition to the stock authorized by subsection (a) of this section, nonvoting securities, bonds, debentures, and other certificates of indebtedness as it may determine. Such nonvoting securities, bonds, debentures, or other certificates of indebtedness of the corporation as a communications common carrier may own shall be eligible for inclusion in the rate base of the carrier to the extent allowed by the Commission. The voting [7] stock of the corporation shall not be eligible for inclusion in the rate base of the carrier.

(d) Not more than an aggregate of 20 per centum of the shares of stock of the corporation authorized by subsection (a) of this section which are held by holders other than authorized carriers may be held by persons of the classes described in paragraphs (1), (2), (3), (4), and (5) of section 310 (a) of the Communications Act of 1934, as amended (47

or appropriate for or consistent with carrying out the purposes and objectives of this Act by the corporation;

(9) [e]nsure that no substantial additions are made by the corporation or carriers with respect to facilities of the system or satellite terminal stations unless such additions are required by the public interest, convenience, and necessity;

(10) require, in accordance with the procedural requirements of section 214 of the Communications Act of 1934, as amended [citation in margin: "57 Stat. 11; 47 USC 214"], that additions be made by the corporation or carriers with respect to facilities of the system or satellite terminal stations where such additions would serve the public interest, convenience, and necessity; and

(11) make rules and regulations to carry out the provisions of this Act.

TITLE III—CREATION OF A COMMUNICATIONS SATELLITE CORPORATION

CREATION OF CORPORATION

SEC. 301. There is hereby authorized to be created a communications satellite corporation for profit which will not be an agency or establishment of the United States Government. The corporation shall be subject to the provisions of this Act and, to the extent consistent with this Act, to the District of Columbia Business Corporation Act. The right to repeal, alter, or amend this Act at any time is expressly reserved [citation in margin: "68 Stat. 177; D.C. Code 29-901"].

PROCESS OF ORGANIZATION

SEC 302. The President of the United States shall appoint incorporators, by and with the advice and consent of the Senate, who shall serve as the initial board of directors until the first annual meeting of stockholders or until their successors are elected and qualified. Such incorporators shall arrange for an initial stock offering and take whatever other actions are necessary to establish the corporation, including the filing of articles of incorporation, as approved by the President.

DIRECTORS AND OFFICERS

SEC. 303. (a) The corporation shall have a board of directors consisting of individuals who are citizens of the United States, of whom one shall be elected annually by the board to serve as chairman. Three members of the board shall be appointed by the President of the United States, by and with the advice and consent of the Senate, effective the date on which the other members are elected, and for terms of three years or until their successors have been appointed and qualified, except that the first three members of the board so appointed shall continue in office for terms of one, two, and three years, respectively, and any member so appointed to fill a vacancy shall be appointed only for the unexpired term of the director whom he succeeds. Six members of the board shall be elected annually by those stockholders who are communications common carriers and six shall be elected annually by the other stockholders of the corporation. No stockholder who is a communications common carrier and no trustee for such a stockholder shall vote, either directly or indirectly, through the votes of subsidiaries or affiliated companies, nominees, or any persons subject to [6] his direction or control, for more than three candidates for membership on the board. Subject to such limitation, the articles of incorporation to be filed by the incorporators designated under section 302 shall provide for cumulative voting under section 27 (d) of the District of Columbia Business Corporation Act (D.C.

Commission; and

[4] (6) to the extent feasible, furnish other services, on a reimbursable basis, to the corporation in connection with the establishment and operation of the system.

(c) the Federal Communications Commission, in its administration of the provisions of the Communications Act of 1934, as amended, and as supplemented by this Act, shall [citation in margin: "48 Stat. 1064; 47 USC 609"]—

(1) [e]nsure effective competition, including the use of competitive bidding where appropriate, in the procurement by the corporation and communications common carriers of apparatus, equipment, and services required for the establishment and operation of the communications satellite system and satellite terminal stations; and the Commission shall consult with the Small Business Administration and solicit its recommendations on measures and procedures which will [e]nsure that small business concerns are given an equitable opportunity to share in the procurement program of the corporation for property and services, including but not limited to research, development, construction, maintenance, and repair;

(2) [e]nsure that all present and future authorized carriers shall have nondiscriminatory use of, and equitable access to, the communications satellite system and satellite terminal stations under just and reasonable charges, classifications, practices, regulations, and other terms and conditions and regulate the manner in which available facilities of the system and stations are allocated among such users thereof;

(3) in any case where the Secretary of State, after obtaining the advice of the Administration as to technical feasibility, has advised that commercial communication to a particular foreign point by means of the communications satellite system and satellite terminal stations should be established in the national interest, institute forthwith appropriate proceedings under section 214 (d) of the Communications Act of 1934, as amended [citation in margin: "57 Stat. 12; 47 USC 214"], to require the establishment of such communication by the corporation and the appropriate common carrier or carriers;

(4) [e]nsure that facilities of the communications satellite system and satellite terminal stations are technically compatible and interconnected operationally with each other and with existing communications facilities;

(5) prescribe such accounting regulations and systems and engage in such ratemaking procedures as will [e]nsure that any economies made possible by a communications satellite system are appropriately reflected in rates for public communication services;

(6) approve technical characteristics of the operational communications satellite system to be employed by the corporation and of the satellite terminal stations;

(7) grant appropriate authorizations for the construction and operation of each satellite terminal station, either to the corporation or to one or more authorized carriers or to the corporation and one or more such carriers jointly, as will best serve the public interest, convenience, and necessity. In determining the public interest, convenience, and necessity the Commission shall authorize the construction and operation of such stations by communications common carriers or the corporation, without preference to either;

(8) authorize the corporation to issue any shares of capital stock, except the initial issue of capital stock referred to in section 304 (a), or to borrow any moneys, or to assume any [5] obligation in respect of the securities of any other person, upon a finding that such issuance, borrowing, or assumption is compatible with the public interest, convenience, and necessity and is necessary

1934, as amended, to provide services by means of communications satellites;
(8) the term "corporation" means the corporation authorized by title III of this Act.
(9) the term "Administration" means the National Aeronautics and Space Administration; and
(10) the term "Commission" means the Federal Communications Commission.

[3] TITLE II—FEDERAL COORDINATION, PLANNING, AND REGULATION

IMPLEMENTATION OF POLICY

SEC. 201. In order to achieve the objectives and to carry out the purposes of this Act—
(a) the President shall—
(1) aid in the planning and development and foster the execution of a national program for the establishment and operation, as expeditiously as possible, of a commercial communications satellite system;
(2) provide for continuous review of all phases of the development and operation of such a system, including the activities of a communications satellite corporation authorized under title III of this Act;
(3) coordinate the activities of governmental agencies with responsibilities in the field of telecommunication, so as to [e]nsure that there is full and effective compliance at all times with the policies set forth in this Act;
(4) exercise such supervision over relationships of the corporation with foreign governments or entities or with international bodies as may be appropriate to assure that such relationships shall be consistent with the national interest and foreign policy of the United States;
(5) [e]nsure that timely arrangements are made under which there can be foreign participation in the establishment and use of a communications satellite system;
(6) take all necessary steps to [e]nsure the availability and appropriate utilization of the communications satellite system for general governmental purposes except where a separate communications satellite system is required to meet unique governmental needs, or is otherwise required in the national interest; and
(7) so exercise his authority as to help attain coordinated and efficient use of the electromagnetic spectrum and the technical compatibility of the system with existing communications facilities both in the United States and abroad.
(b) the National Aeronautics and Space Administration shall—
(1) advise the Commission on technical characteristics of the communications satellite system;
(2) cooperate with the corporation in research and development to the extent deemed appropriate by the Administration in the public interest;
(3) assist the corporation in the conduct of its research and development program by furnishing to the corporation, when requested, on a reimbursable basis, such satellite launching and associated services as the Administration deems necessary for the most expeditious and economical development of the communications satellite system;
(4) consult with the corporation with respect to the technical characteristics of the communications satellite system;
(5) furnish to the corporation, on request and on a reimbursable basis, satellite launching and associated services required for the establishment operation, and maintenance of the communications satellite system approved by the

vices utilized by the system; that the corporation created under this Act be so organized and operated as to maintain and strengthen competition in the provision of communications services to the public; and that the activities of the corporation created under this Act and or the persons or companies participating in the ownership of the corporation shall be consistent with the Federal antitrust laws.

(d) It is not the intent of Congress by this Act to preclude the use of the communications satellite system for domestic communication services where consistent with the provisions of this Act nor to preclude the creation of additional communications satellite systems, if required to meet unique governmental needs or if otherwise required in the national interest.

DEFINITIONS

SEC. 103. As used in this Act, and unless the context otherwise requires-

(1) the term "communications satellite system" refers to a system of communications satellites in space whose purpose is to relay telecommunication information between satellite terminal stations, [2] together with such associated equipment and facilities for tracking, guidance, control, and command functions as are not part of the generalized launching, tracking, control, and command facilities for all space purposes;

(2) the term "satellite terminal station" refers to a complex of communication equipment located on the earth's surface, operationally connected with one or more terrestrial communication systems, and capable of transmitting telecommunications to or receiving telecommunications from a communications satellite system.

(3) the term "communications satellite" means an earth satellite which is intentionally used to relay telecommunication information;

(4) the term "associated equipment and facilities" refers to facilities other than satellite terminal stations and communications satellites, to be constructed and operated for the primary purpose of a communications satellite system, whether for administration and management, for research and development, or for direct support of space operations;

(5) the term "research and development" refers to the conception, design, and first creation of experimental or prototype operational devices for the operation of a communications satellite system, including the assembly of separate components into a working whole, as distinguished from the term "production," which relates to the construction of such devices to fixed specifications compatible with repetitive duplication for operational applications;

(6) the term "telecommunication" means any transmission emission or reception of signs, signals, writings, images, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems;

(7) the term "communications common carrier" has the same meaning as the term "common carrier" has when used in the Communications Act of 1934, as amended, and in addition includes, but only for purposes of sections 303 and 304 [citation in margin: "48 Stat. 1064; 47 USC 609"], any individual, partnership, association, joint-stock company, trust, corporation, or other entity which owns or controls, directly or indirectly, or is under direct or indirect common control with, any such carrier; and the term "authorized carrier," except otherwise provided for purposes of section 304 by section 304 (b) (1), means a communications common carrier which has been authorized by the Federal Communications Commission under the Communications Act of

your bill and some of the major aspects of the proposed legislation.

[hand-signed] E.C. Welsh

Attachment

Document I-18

[1]

Public Law 87-624
87th Congress, H.R. 11040
August 31, 1962

An Act

76 STAT. 419

To provide for the establishment, ownership, operation, and regulation of a commercial communications satellite system, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I—SHORT TITLE, DECLARATION OF POLICY AND DEFINITIONS

SHORT TITLE

SEC. 101. This act may be cited as the "Communications Satellite Communications Act of 1962" [citation in margin: "Communication Satellite Act of 1962"].

DECLARATION OF POLICY AND PURPOSE

SEC. 102. (a) The Congress hereby declares that it is the policy of the United States to establish, in conjunction and in cooperation with other countries, as expeditiously practicable a commercial communications satellite system, as part of an improved global communications network, which will be responsive to public needs and national objectives, which will serve the communication needs of the United States and other countries, and which will contribute to world peace and understanding.

(b) The new and expanded telecommunication services are to be made available as promptly as possible and are to be extended to provide global coverage at the earliest practicable date. In effectuating this program, care and attention will be directed toward providing such services to economically less developed countries and areas as well as those more highly developed, toward efficient and economical use of the electromagnetic frequency spectrum, and toward the reflection of the benefits of this new technology in both quality of services and charges for such services.

(c) In order to facilitate this development and to provide for the widest possible participation by private enterprises United States participation in the global system shall be in the form of a private corporation, subject to appropriate governmental regulation. It is the intent of Congress that all authorized users shall have nondiscriminatory access to the system; that maximum competition be maintained in the provision of equipment and ser-

Committee on Science and Astronautics shall be notified when all steps necessary to the organization of the Corporation have been completed, including approval of the proposed Corporation by-laws by the Commission. Sec. 402 will take effect thirty days after the date of such notification.

(c) If the organization of the Corporation has not been completed within three months after the date of enactment of this Act, the President shall make an interim report to the Senate Committee on Aeronautical and Space Sciences and the House Committee on Science and Astronautics on the status of such organization.

Document I-17

[1]
Executive Secretary April 11, 1962

Memorandum to the President

It is understood that Chairman Oren Harris of the House Interstate and Foreign Commerce Committee is scheduled to see you tomorrow. If so, he may want to discuss the Communications Satellite legislation, which is before his committee. He has completed his hearings and is hoping to mark up the bill very soon.

Your bill was introduced in the Senate as S. 2814. It was introduced by Congressman Harris in the House as H.R. 10115. Harris also introduced your bill as modified by the Senate Space Committee. That bill is H.R. 11040, and is currently the one primarily being considered by Chairman Harris.

Harris has been most cooperative in this matter, as illustrated by his invitation to Nick Katzenbach and me to help iron out various questions with him and his staff yesterday. He indicated that he wanted to make the minimum number of changes in the bill and thought it important to act quickly so that efforts by others to obtain Government ownership of the system would not have time to block action this session. This same view is, I believe, held by Senator Kerr and his Space Committee, and Senator Pastore and the Interstate and Foreign Commerce Committee in the Senate.

Our meeting with Chairman Harris was also attended by Newt Minow, who stated that the majority of the FCC, including himself, believed they could "live with and make work" the bill as it now stands. Some clarifying language of various minor points is being worked out by the staff of the Commerce Committee and staff of the Justice Department.

It is suggested that emphasis might well be made on the following:

1. That broad-based ownership is the important principle, and that the provision in H.R. 11040 (50% of stock ownership by the public, and 50% by authorized carriers) is satisfactory.
2. That the new corporation should be authorized to own ground stations, without preventing individual carriers from also [2] owning such terminals, and that it would be best if the legislation left the decision as to ground station ownership up to a finding of public interest, convenience, and necessity on the part of the FCC, without any language in the bill which would prejudice or influence the FCC's decision in any individual case.
3. That legislation should not be delayed any longer than absolutely necessary.
4. That it makes no difference whether the new legislation becomes a separate statute (which you had proposed) or takes the form of amendment to the Communications Act or to the Space Act, and that this is a matter for the Congress to determine.

Attached for possible reference is my recent testimony on the major changes made in

program in the field of space telecommunications with that of the Corporation so as to give maximum assurance of rapid and continuous scientific and technological progress.

(b) The costs of the launch vehicles and launching and related services furnished by the Administration under subparagraphs (a) (1) and (a) (2) above shall be reimbursed by the Corporation as a credit to current appropriations of the Administration.

(c) The Administration is also authorized to furnish other services, on a reimbursable basis, upon the request of the Corporation and as required for the successful development and operation of the communications satellite system.

(d) The Corporation shall consult with the Administration, and coordinate its research program, as provided in subparagraphs (a) (3) and (a) (4) above.

RELATIONSHIP BETWEEN THE CORPORATION AND THE FEDERAL COMMUNICATIONS COMMISSION

Sec. 405. (a) In regulating the Corporation as a communications common carrier under the Communications Act of 1934, as amended, the Commission shall [e]nsure—

(1) that the communications satellite system established by the Corporation is technically compatible with and operationally interconnected with existing communications facilities;

(2) that the rate structure established for the communications services offered by the Corporation will provide a fair return on the capital invested in the Corporation; and

(3) that there will be nondiscriminatory use of and equitable access to the system by present and future authorized communications carriers.

[4] (b) The Commission is also authorized to—

(1) determine which United States communications common carriers shall be eligible to participate in the ownership of the Corporation;

(2) approve the by-laws of the Corporation, or alterations thereto;

(3) require the Corporation to employ competitive bidding in the acquisition of equipment used in the system, to the maximum extent feasible, so as to preserve effective competition;

(4) require the Corporation to provide communications services in areas of the world where it may be uneconomical, so as to make the system global in coverage as soon as technically feasible; and

(5) require the Corporation to provide opportunities for foreign participation, through ownership or otherwise, in the system, on an equitable basis, and on reasonable terms.

COMPLETION OF ORGANIZATION OF THE CORPORATION

Sec. 406. (a) The President is authorized to take all steps necessary to organize the Corporation described in Sec. 402 hereof, including but not limited to the following:

(1) obtaining a determination by the Commission as to which communications common carriers shall be eligible to participate in the ownership of the Corporation;

(2) obtaining commitments from such eligible common carriers as to the amounts they will invest in the Corporation; and

(3) receiving nominations to the Board of Directors of the Corporation, as provided for in Sec. 402 (f) hereof.

(b) The Senate Committee on Aeronautical and Space Sciences and the House

Directors appointed by each carrier or affiliated group of carriers having an ownership interest in the Corporation and two additional Directors designated jointly by United States carriers who are authorized by the Commission to provide communications services via satellite but who do not acquire an ownership interest in the Corporation. The Board of Directors shall choose, or elect by majority vote, the principal officers of the Corporation. Each Director shall have one vote in all matters determined by the Board of Directors.

(g) Financing of Corporation.

(1) The total authorized capital stock of the Corporation shall be 500 million dollars, consisting of five thousand shares of the value of $100,000.00 each. Such stock shall be of one class, shall be nonassessable, and shall be issued only for cash fully paid. Stock held by owning carriers shall not be transferable, except with the approval of the Commission, and then only to other communications common carriers determined by the Commission to be eligible to participate in the ownership of the Corporation.

(2) The minimum amount of stock which shall be held by an owning carrier shall be five shares.

POWERS OF CORPORATION

Sec. 403. The Corporation shall have perpetual succession, and shall have power to do any and all things necessary and proper to carry out the object and purposes of the Corporation, including, without limitation thereto, the following—

(a) to acquire, hold, own, mortgage, lease, and dispose of real and personal property, of every class and description and without limitation as to place;

(b) to lease channels to authorized users of the communications satellite system;

(c) to conduct research and development;

(d) to enter into, make and perform contracts and agreements of every kind and description with any person, firm, association, corporation, municipality, county, state, body politic, or government or colony or dependency thereof.

(e) to sue and be sued;

(f) to accept unconditional gifts of services, money or property, and legacies and devises;

(g) to adopt and alter a corporate seal and, subject to prior approval of the Commission, by-laws not inconsistent with the laws of the United States or of any State;

(h) to establish and maintain offices and facilities for the conduct of the affairs of the Corporation in the District of Columbia and in the several states and territories of the United States, and in foreign countries; and

(i) to purchase, hold, sell, and transfer the shares of its own capital stock.

[3]

RELATIONSHIP BETWEEN THE CORPORATION AND THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Sec. 404. (a) The Administration shall be responsible for—

(1) furnishing launch vehicles required for the communications satellite system on a schedule which will facilitate the economical and efficient development and operation of the system;

(2) launching the satellites, and furnishing launch-crew and associated services;

(3) consulting with the Corporation on the technical specifications for satellites and earth terminal station, and on the number and location of such stations; and

(4) to the greatest extent practicable, coordinating its research and development

In the end, the administration bill was not significantly altered and eventually became the basis for the Communications Satellite Act of 1962.

Document I-16

[1] (AUTOMATIC RELEASE IN A. M.'S OF TUESDAY, NOVEMBER 28, 1961)

FROM THE OFFICE OF SENATOR ROBERT S. KERR

DRAFT

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

That the National Aeronautics and Space Act of 1958, as amended (42 USC 2451-2476), is amended by adding thereto a Title IV, to read as follows:

TITLE IV—SPACE COMMUNICATIONS

DECLARATION OF POLICY

Sec. 401. The Congress hereby declares that it is the policy of the United States to provide leadership in the establishment of a world-wide communications system involving the use of space satellites at the earliest practicable time, to provide for ownership of the United States portion of the system, and to invite all nations to participate in the system in the interest of world peace and closer brotherhood among peoples throughout the world.

CREATION OF SATELLITE COMMUNICATIONS CORPORATION

Sec. 402. (a) The provisions of this Section shall take effect as provided in Sec. 406 of this Act.

(b) There is hereby created a corporation, to be known as the Satellite Communications Corporation (hereafter referred to as the "Corporation"), whose object and purposes shall be to develop, construct, operate, manage, and promote the use of a communications satellite system in the public interest, and to foster research and development in the field of space telecommunications.

(c) Organization and Operation. The Corporation shall be organized and operated as a communications common carriers' carrier, and shall own the United States portion of the communications satellite system, consisting of the satellites, the earth terminals, and associated ground control and tracking facilities. The Corporation. shall make the facilities of the system available on a nondiscriminatory and equitable basis, at rates to be established by the Federal Communications Commission (hereafter called the "Commission"), to all United States carriers authorized by the Commission to provide communications services via satellite.

(d) Foreign Participation. The Corporation shall also provide opportunities for foreign participation in the communications satellite system, through ownership or otherwise, on an equitable basis and on reasonable terms

(e) Ownership of Corporation. Ownership interests in the Corporation shall be limited to United States communications common carriers who are determined by the Commission to be eligible to participate in such ownership.

[2] (f) Officers of Corporation. There shall be a Board of Directors consisting of two

cies are dissatisfied with the report of the FCC Ad Hoc Industry Committee; and substantial Congressional and press concern continues over AT&T's potential stranglehold over communication satellites. The Task Force will have recommendations ready in December. Senator Kerr is preparing his own legislative recommendations, so the entire matter will undoubtedly come to a head during the coming Congressional session.

Frederick G. Dutton

Document I-16

Document title: Senator Robert S. Kerr, "Amendment to the National Aeronautics and Space Act of 1958, Space Communications," November 28, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

Document I-17

Document title: E.C. Welsh, Executive Secretary, National Aeronautics and Space Council, Executive Office of the President, Memorandum to the President, April 11, 1962.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

Document I-18

Document title: "Communications Satellite Act of 1962," Public Law 87-624, 76 Stat. 419, signed by the President on August 31, 1962.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

By the spring of 1962, the Kennedy administration had decided its preference regarding what kind of communications satellite organization should be developed. There were some in Congress, however, who wanted public ownership of any such organization, while others argued for totally private control. While the congressional debate was going on, Telstar was launched and successfully operated by AT&T. This further strengthened the case for private-sector operation of international satellite communications. In addition to the administration bill mentioned in the memorandum to President Kennedy from Edward C. Welsh, Executive Secretary for the National Aeronautics and Space Council, there were fifteen other legislative proposals concerning the same subject. These advocated alternatives included government ownership, limited private ownership similar to the administration bill, and open ownership not limited to the international carriers.

John Johnson, NASA's general counsel, was first asked to draft Senator Robert Kerr's bill for a communications satellite corporation and then asked to draft the Kennedy administration's bill for the same proposal. Kerr's bill provided for an entirely privately run corporation, regulated by the government. It represented the more conservative side of the argument over ownership and control. Kerr chaired the Senate Committee on Aeronautical and Space Sciences and served primarily as an advocate for the administration's bill rather than his own. Estes Kefauver represented the other side of the debate and introduced a bill calling for total government ownership. He led the opposition to the administration bill on the Senate floor, first through the addition of a number of amendments and then by a filibuster. The Senate finally moved for cloture for the first time since 1927 to end the debate.

any system of ownership to meet. We believe that if careful thought is given to how or, indeed, whether, these tests can be met, not only will the public interest be served, but the rapid development of this new gift of science will mo[v]e ahead unhindered by a premature struggle over its fruits.

Sincerely yours,

Hubert H. Humphrey
Estes Kefauver
Wayne Morse

Joseph P. Addabbo
Thomas L. Ashley
Edward P. Boland
James A. Burke
James A. Byrne
Emanuel Celler
Merwin Coad
Jeffery Cohelan
Leonard Farbstein
Kenneth J. Gray
Chet Holifield
Elmer J. Holland
Lester Holtzman
Robert W. Kastenmeier
Eugene J. Keogh
Frank Kowalski
Thomas J. Lane
Richard E. Lankford
Roland V. Libonati
Clem Miller
Joseph M. Montoya
John E. Moss
Abraham J. Multer
M. Blaine Peterson
Henry S. Reuss
Ralph J. Rivers
James Roosevelt
William Fitts Ryan
John F. Shelley
B. F. Sisk
Herman Toll
Al Ullman

Document I-15

Document title: Frederick G. Dutton, Assistant to the President, Memorandum for the President, November 13, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

In October 1961, the FCC Ad Hoc Carrier (or Industry) Committee Report proposed that a nonprofit corporation be established to develop and operate the communications satellite system. This corporation would lease circuits to authorized carriers, which would own the satellites as well as their ground stations. The corporation would be run by a board of directors, including representatives of AT&T, ITT, RCA, and Western Union and three public directors appointed by the president. The committee's report resulted in immediate controversy, as noted in Frederick Dutton's memorandum to President Kennedy. ITT, RCA, and Western Union all expressed concern that AT&T would dominate such a corporation, while representatives of other aerospace and electronic manufacturers were unhappy that they would be excluded from participating in such a revolutionary field. Some members of Congress expressed concern that such a corporation involving all of the international carriers would constitute a monopoly. The issue was not settled until the passage of the Communications Satellite Act on August 31, 1962.

November 13, 1961

Memorandum for the President

As a matter of information, you should be aware that the proper kind of entity to own and operate communication satellites is becoming an increasing source of controversy. I have brought together a Task Force of representatives from the interested Federal agencies with the Chairman, Ed Welsh, as Executive Director of the Space Council, to prepare recommendations consistent with your policy statement in this field. The Executive agen-

of the Bell Telephone System. Only by insisting upon the widest participant by all interested communications and aerospace manufacturers and operators can there by any hope that such a monopoly can be forestalled in this new and vital field.

The antitrust laws prohibit monopolization of any part of the domestic or foreign commerce of the United States. They also prohibit the acquisition, ownership, control, or operation by an interstate or foreign wire carrier of any station or any system for radio communications or signals between any place in any state in the United States and any place in any foreign country, if the purpose is, and/or the effect thereof may be, to substantially lessen competition or to restrain commerce between any place in any state in the United States and any place in any foreign country, or unlawfully to create monopoly in any line of commerce. In these circumstances, any plan which does not meet *both* the conditions we have specified would, in our considered judgment, be in direct violation of the antitrust laws and would require special legislation by the Congress. No executive order or decree of any agency can override the antitrust laws.

[4] Nor is there any logical or rational basis for excluding U.S. domestic communications common carriers from ownership in the system while granting companies which have no interest and virtually no investment in international communications service opportunity to participate in the system's ownership, particularly since the space satellite could provide domestic as well as international communications services.

Furthermore, it is clear that the space satellite communications system will be vastly different from the conventional common carrier type of operation. Thus there is no justification for excluding communications and aerospace manufacturers, particularly when the record clearly demonstrates that a number of these organizations have a far greater contribution to make in expert technology than any of the ten "communications carriers."

The question of monopoly is only one of many complicated questions involved in the decision as to what kind of an ownership system will best meet the public interest. The ramifications of this remarkable system are likely to be truly revolutionary. And, as with all revolutions, it is clear that our understanding of the implications of a new technology is likely to lag behind developments themselves. Because we believe time and study are essential to wise decision-making, and because we do not want to prejudice the ultimate question of control and ownership during the period of study, we urge that:

1. No decisions concerning ultimate control be made until the entire system becomes fully operational.
2. No contracts, decisions, or acts which may prejudice the ultimate decision as to ownership be agreed to until the entire system becomes fully operational.
3. During this period, the Congress be consulted upon the question of ultimate control and ownership and allowed to exercise its constitutional responsibility to supervise activities of Federal agencies regulating foreign and domestic commerce.
4. During this period, all other interested parties be consulted fully upon the question of ownership and control.
5. During this period, all possible questions of international agreement, cooperation, control and ownership related to other nations and the [United Nations] be thoroughly explored.

The United States can demonstrate to the world what a democratic system can accomplish in developing a space communications satellite system. But if decisions are taken in haste and allowed to cramp and prejudice [5] the rational development of the new gift of science, it is likely that we may not only prejudice a question of vital national concern, but we may hinder the rapid development of the system itself.

Your statement of July 24, 1961 makes it clear that if private ownership is to be favored, the ownership and control system must meet eight stringent conditions. We would like to emphasize that the conditions laid down are a very difficult set of tests for

opment of this new system is not [2] impeded by a premature decision as to ownership, we are of the opinion that prudence requires a further investigation of the broadest aspects of the ownership question. Specifically, we believe that the debate over ownership should be separated from the developmental question until the entire system becomes fully operational. During this period development should proceed with all possible speed while careful study is given to the decision as to the control of these unripened fruits of science.

While we believe that the final question of ownership should not be decided at a time when we have insufficient knowledge, we wish to make it clear that should private concerns be authorized to own and operate the system, the government agencies entrusted with responsibility must, consistent with the antitrust laws, prevent any concern from attaining a monopolistic, dominant, or preferential advantage. Otherwise the national interest would be frustrated for generations to come in a historic achievement which, according to a responsible prediction, may well constitute a multi-billion dollar a year business in ten to fifteen years.

On July 24 you issued a policy statement that essential conditions to private ownership of a space satellite communications system are a "structure of ownership and control which will assure maximum possible competition" and "full compliance with antitrust legislation." We are in complete agreement with these conditions and it is for this reason that we are deeply concerned about orders issued by the Federal Communications Commission on May 24 and July 25, 1961 which clearly contemplate limiting ownership to a specified group of so-called "international carriers" which does not even include all these carriers. These orders are contrary to the policy established by you; they are contrary to the principles of the antitrust laws.

The FCC orders appear for all practical purposes to determine that the satellite communications system is to be owned and operated by this group of ten "international carriers." This would mean that only four concerns would participate in the system's ownership since the other six companies in this group have professed no interest whatsoever in space communications. More important, it would mean that one of these four companies, AT&T, would have a dominant and very probably a monopoly position in ownership of the space communications system. In effect, AT&T would be the chosen instrument of the United States Government to own and control civilian space communications.

This would be intolerable from the standpoint of the public interest. As the Department of Justice has stated, "the continuing opportunity (for AT&T) to favor its own facilities would always be present and would inevitably result in discrimination or suspicion of discrimination no matter how strict might be the policy of (AT&T) to provide [3] equal service to its competitors." Furthermore, "the opportunity to favor the purchase of equipment produced by (AT&T's subsidiary, Western Electric Co.) would be irresistible."

The head of the Justice Department's Antitrust Division has testified that "the degree of concentration in this field may very well be one of the reasons why America is not further advanced in the field today than it is . . . . Our system has not produced as it should, and the public interest has suffered because there has been undue concentration in this field."

We believe that to safeguard the public interest it is essential that any plan permitting private ownership if, indeed, such is preferred to public, of the space satellite system must:

(1) afford all interested United States communications common carriers, domestic as well as international, opportunity to participate in ownership of the system; and

(2) afford all interested communications and aerospace manufacturers opportunity to participate in ownership of the system.

We have seen from past experience how the American Telephone & Telegraph Company has been able to expand its monopoly position and strengthen its hold on the American economy by combining, under the aegis of one holding company, its equipment manufacturing concern, the Western Electric Company, and the operating divisions

in 1961 and 1962, as it became clear that such a system would be established within a few years. The Kennedy administration's policy statement on communications satellites (Document I-13 in this volume) was released on July 24, 1961 (approved on July 14), and provoked this response from thirty-five members of Congress who feared AT&T's dominance of an operational system. They urged President Kennedy to wait until any system was fully operational before he made a final decision on the form of ownership. Kennedy did not follow this suggestion; several of the signers of this letter were among those leading the push for public ownership of a communications satellite system during the 1962 congressional debate on the issue.

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[1]

CONGRESS OF THE UNITED STATES
House of Representatives
Washington, D.C.

Emanuel Celler
11th District New York

Chairman
Committee on the Judiciary

August 24, 1961

The President
The White House
Washington, D.C.

My dear Mr. President:

Early development of a space satellite communications system is of fundamental national importance. Such a system gives promise of revolutionizing international communications and communications within the United States. It has potentiality for an unprecedented increase in worldwide telephone and telegraph communications and for providing transoceanic television and radio transmission.

We undersigned members of Congress therefore believe that it is crucial that the United States be the first to develop the system. We further believe that the Federal Government should by contract carry out extensive research, experimentation, and development of a satellite communications system. Not a minute should be wasted. After such a system has become fully operational, but not until then, we believe, can decisions be intelligently made as to whether such a system should be publicly or privately owned and under what circumstances.

As you have pointed out, "the present status of the communications satellite programs, both civil and military, is that of research and development. To date, no arrangements between the government and private industry contain any commitments as to an operational system." We believe this is as it should be. Present commitments of any kind as to the control of this system may hinder its rapid development and prejudge vital questions of public interest and international relations.

The course of research and development for this new system have [sic] demonstrated one overwhelming fact: We do not at present know which system can be put into use first, nor which system will be most efficient once in orbit. Given this technological uncertainty, the complicated question of ownership and control of this system must necessarily be covered with an even greater haze of uncertainty. In order to [e]nsure that the rapid devel-

licenses, frequencies, etc.[,] by the appropriate government agencies.

[6] 3. Government Responsibilities: In addition to its regulatory responsibilities, the government should:

a. conduct or maintain supervision over international agreements and negotiations;
b. conduct and encourage research and development to facilitate accomplishment of these policy objectives and to give maximum assurance of rapid and continuous and technological progress;
c. control all launching of U.S. spacecraft;
d. make use of the commercial system and avoid competition with it;
e. establish separate communication satellite systems, when required to meet unique government needs which cannot, in the national interest, be met by the commercial system;
f. assure the effective use of the radio frequency spectrum;
g. assure that provision exists for the discontinuance of satellite transmissions when required in the interest of communication efficiency and effectiveness;
h. provide technical assistance to newly developing countries in order to attain an effective global system as soon as practicable.

[7] 4. New Uses and Reduced Rates: It is an objective that satellites make available for general use new and expanded international communications services. Transmission of records, voice, and television over great distances should facilitate the exchange of information and ideas throughout the world. These new and expanded uses should, at the earliest possible time, be made available through an economical system, the lower costs of which will be reflected in overseas communication rates. Anticipated greater use and lower costs per channel in a communication satellite system may make lower rates practicable.

5. Global Coverage: A system of communications designed for "global" coverage is to be contrasted with a system limited to connecting heavy traffic markets and subject to expansion only in response to added demands of sufficient volume as to be profitable per se. Rather, a "global" system is one with the potential and the objective to provide efficient communication service throughout the whole world as soon as technically feasible, including service where individual portions of the coverage are not profitable or even have no expectation of future profit. It is a national objective to have such a global system operable as soon as possible within the limits of technology.

[8] 6. Foreign Participation: It is axiomatic that there be foreign participation in any international commercial communication system. In addition to participation through use, there would be foreign ownership or control of ground facilities outside the United States; international agreements as to frequencies and operating practices; arrangements for connections with other systems; and opportunities through foreign ownership or otherwise in the satellites in the system. The U.S. hopes that practical measures for such foreign participation can be developed.

7. Relationship with United Nations: The U.S. should examine with other countries the development of the most constructive role for the United Nations, including the [International Telecommunication Union], in international space communications.

Document I-14

Document title: Emanuel Celler, Chairman, Committee on the Judiciary, House of Representatives, *et al.*, to the President, August 24, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

The form of ownership of an operational communications satellite system became a controversial issue

satellite systems are being examined.

The present status of the communication satellite programs, both military and civil, is that of research and development. Neither the arrangements between government and industry for research and development [3] nor the government participation as to preparation of a plan or plans for ownership and operation of a commercial system have contained any commitments as to the operational system.

A communications system using satellites is made up of a number of interconnected parts, of which the satellites are but one part. The full system includes message origination facilities, ground sending stations, ground receiving stations, and message delivery facilities—in addition to the satellites used for continuous receipt and relay of messages. We already have an elaborate communications system between the United States and some parts of the world. Communication satellites must be integrated into the existing system. Adding communication satellites to this system would permit substantially increasing the coverage, increasing the capacity for communication, and enabling television and high speed data, as well as voice and record, to be transmitted and received over great distances.

Problems

As a matter of progressive action, the central question is how to move from a research and development status to an operational status in which the newly emerging technology may be utilized in the public interest.

[4] There are two principal problem areas: one having to do with continuing to advance the state of the art on an accelerated basis and the technical selection of the specifications of an initial operational system; the other having to do with organization and the mode of operation best suited to accommodate the wide range of public interests involved.

Policy

Following are major objectives and policy guidelines for the proper handling of those problems:

1. Time: Operational satellites should become a part of the means of long distance communication at the earliest practicable time and this should be achieved through the leadership of the United States. This means acceleration of effort in research and development, in plans for operation and management, and in cooperative negotiations with other countries.

2. Ownership: There is a wide variety of types, methods, and procedures for the ownership of the U.S. portion of the system. The type of ownership should be that which gives the greatest assurance that the public interest will be best served. Any ownership plan which promises less would be contrary to policy. [5] The type and nature of ownership should not be decided, however, until recommendations submitted by private enterprise have been evaluated by the appropriate agencies of the government to determine whether they meet the policy requirements. If these policy requirements are met, the government will encourage private enterprise to establish and operate a system. This should be decided as soon as practicable in order to maximize the level of national effort.

In addition to the other policy statements in this document, the following criteria and principles should be employed in evaluating recommendations for private ownership of the U.S. portion of the system:

a. non-discriminatory use of and equitable access to the system by present and future communications carriers;
b. effective competition, such as competitive bidding, in furnishing equipment purchased, leased, or otherwise acquired from non-U.S. government sources;
c. full compliance with antitrust legislation and with the regulation of rates,

Document title: National Aeronautics and Space Council, "Communication Satellites," July 14, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

This policy statement outlines the Kennedy administration's approach to the development of communications satellites. It places a much greater emphasis than the Eisenhower administration on the government's role in ensuring that the public and national interests would be served as this new technological capability was brought into being. It also emphasizes the need to develop a truly global system for satellite communications.

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[1] NATIONAL AERONAUTICS AND SPACE COUNCIL

Policy Document Approved—July 14, 1961

Communication Satellites

National Purpose

Science and technology have progressed to such degree that communication through use of space satellites has become possible.

The President has recognized this potentiality and has requested that it be translated into an actuality. In his Message on the State of the Union, the President invited all nations to join with us in a new communication satellite program. On May 25, the President asked the Congress for $50 million of additional funds to accelerate "the use of space satellites for world-wide communications." Again, on June 15, the President requested the Space Council "to make the necessary studies and government-wide policy recommendations for bringing into optimum use at the earliest practicable time, operational communications satellites."

Hence, the national purpose and intent have been made clear.

Program Status

Research and development in the communications satellite field have been conducted over the past few years. This activity has been [2] under government auspices and guidance and has employed primarily the competence and facilities of private industry, through the use of public funds. From these efforts have come prospects for several different types of communication systems, employing passive and active satellites, in either high or low orbit. Much more scientific and technical work needs to be done before an initial system can be selected for commercial operation.

Agencies of the government have been developing a U. S, position with respect to the international allocation of frequencies, in anticipation of an International Telecommunication Union space conference in 1963.

There is a widespread private industry interest in communication satellites, with the anticipation that they can be utilized to meet increased demands for service and for commercial benefit. Also, foreign countries have indicated their interest in communication satellites.

The FCC has instituted proceedings in which problems concerning communication

9. Insofar as the proposal for such participation may have been motivated by concern that without participation the manufacturers of communications equipment will be excluded from this market by the manufacturing companies affiliated with the participating common carriers, the Commission is well aware of this danger. Accordingly, it is the Commission's intention to require that any joint venture that may evolve shall make adequate and effective provision, such as competitive bidding, to [e]nsure that there will be no favoritism in the procurement of communications equipment required for the construction, operation and maintenance of the satellite system. We want to stress that we shall also take all necessary measures and establish regularized procedures to [e]nsure that such a policy is faithfully and conscientiously administered. In this connection, and also to promote the maximum degree of standardization, the Commission will also require that its approval be obtained with respect to the specifications for all equipment used by the common carriers in the satellite system, including the ground terminals. At the same time, before approving any specifications, we shall examine closely into the relevant patent situation to [e]nsure that an undesirable or dominant patent position will not hamper or frustrate the Commission's objectives in this regard.

10. It is neither possible nor feasible for the Commission here to indicate all the specific features which it believes should be incorporated in any joint venture of international common carriers. These matters will, of course, require careful, extended study and formulation by the interested carriers acting under the aegis of the Commission and in accordance with the procedures and policies hereafter to be provided for. However, regardless of organization or type of entity that may subsequently evolve, it must contain clear and definite provisions which will [e]nsure that existing and future international common carriers, whether or not any such carrier participates through ownership in the joint venture, shall have equitable access to, and non-discriminatory use of, the satellite system, under fair and reasonable terms, so as to obtain communication facilities in the system to serve overseas points with the types of services for which they are licensed or authorized by this Commission. The Commission, in issuing licenses or authorizations that may be required to effectuate such joint venture, will take all appropriate measures to implement this policy and to effect such other safeguards as may be required in the public interest.

11. We are making no determination at this time as to the desirability or need for participation in any such joint venture by domestic common carriers.

[479/5] 12. In view of the foregoing, the Commission hereby announces that it will invite all United States international common carriers and certain United States government agencies to attend a conference with the Commission at an early date to explore plans and procedures whereunder consideration of the matters dealt with herein may go forward. A further order will be issued upon conclusion of such consideration.

FEDERAL COMMUNICATIONS COMMISSION

Ben F. Waple
Acting Secretary

Adopted: May 24, 1961

Released: May 24, 1961

Document I-13

Commission regulatory jurisdiction and subject to the conditions and safeguards hereinafter set forth, some form of joint venture by the international common carriers is clearly indicated as best serving the public interest for the following reasons:

(a) It appears to be generally accepted that because of considerations of practical economics and technical limitations, it will not be feasible for some time to come to accommodate more than one commercial satellite system.

(b) Communication via satellite will be a supplement to, rather than a substitute for, existing communication systems operated by the international common carriers, thereby becoming an integral part of the total communication system of each such carrier.

[477/3] (c) The responses filed by the international carriers express a willingness and indicate a capability to marshal their respective resources for the purpose of developing a satellite communication facility.

(d) By reason of their experience in and responsibility for furnishing international communications service, the international carriers themselves are logically the ones best qualified to determine the nature and extent of the facilities best suited to their needs and those of their foreign correspondents, with whom they have long[-]standing and effective commercial relationships and who necessarily will have a substantial interest in the operations of any satellite system.

(e) Under the Communications Act, the international carriers are obligated to furnish the public with adequate, efficient service at reasonable charges, and this obligation can best be discharged by those carriers maintaining, as far as possible, the greatest degree of direct control and responsibility over the facilities employed in this service.[2]

7. These considerations, in our opinion, demonstrate the desirability of exploring at this time the means whereby the international common carriers may, collectively, but subject to appropriate regulation and safeguards, take such steps as are necessary to plan and effect the ultimate integration of satellite communication techniques into the fabric of international common carrier service. At the same time these considerations would appear to militate against the suggestions which have been made by certain of the respondents that any joint venture with respect to the ownership of satellite communication systems should include participation by the public or by companies in the aerospace and communications equipment manufacturing industries.

8. We are not unmindful of the substantial interests that these industries have made in the field of space science and the important contributions they have to make to this field. Nor are we unmindful of the potential market that satellite systems represent for the sale of communications and related equipment. However, it appears that the adaptation and integration of satellite communication techniques to international common carrier operations is within the economic means of the existing carriers, although [478/4] requiring cooperative arrangements among them. We fail to see why ownership participation by the aerospace and communications equipment industries will be beneficial or necessary to the establishment of a satellite communication system to be used by the common carrier industry. On the other hand, such participation may well result in encumbering the system with complicated and costly corporate relationships, disrupting operational patterns that have been established in the international common carrier industry, and impeding effective regulation of the rates and services of the industry.

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2. It is recognized that this new technology of communication may present numerous, unique and difficult problems which may involve several approaches and solutions of a type and nature different from those which have been used heretofore in the field of international communications. However, we are satisfied that any such new problems can best be resolved by working within the existing framework of our international common carrier industry.

problems relating to the future authorization of commercially operable space communication systems. It was stated in the Notice that it may not be feasible to have more than one or a limited number of commercial satellite communication systems due to the substantial capital investment required and limitation of radio spectrum space; and that this raises a problem as to the manner in which such a system or limited number of systems could be accommodated within the Commission's policy of fostering beneficial competition in the international communication field and within the anti-trust laws. Accordingly, the Notice solicited views from all interested parties as to the best plan of [e]nsuring that international communications common carriers, and others, participate on an equitable and non-discriminatory basis in a single or limited number of satellite systems. Views were also solicited as to the legality of the suggested plan; the Commission's authority to prescribe such plan; and the extent to which participants in the plan would be subject to the Commission's jurisdiction. The Notice directed that responses thereto be filed on or before May 1961 and that replies to such responses be filed on or before May 15, 1961.

2. Responses have been filed by twelve parties, viz., American Rocket Society; American Securities Corporation (for the future Western Union International, Inc.); American Telephone and Telegraph Company; General Electric Company; General Telephone & Electronics Corporation; Hawaiian Telephone Company; International Telephone & Telegraph Corporation (and American Cable & Radio Corporation); Lockheed Aircraft Corporation; Press Wireless, Inc.; Radio Corporation of America (and RCA Communications, Inc.); The Western Union Telegraph Company; and the Department of Justice (commenting only on anti-trust matters).

3. Replies to such responses were filed by American Telephone and Telegraph Company, General Electric Company, and Lockheed Aircraft [476/2] Corporation.

4. In general, the respondents were in agreement that for economic and other reasons a single satellite communications system or a limited number of systems, financed and owned by private enterprise, would best serve the public interest. To the extent that the respondents addressed themselves to a specific type of plan, they generally favor a joint venture for the ownership and operation of a system. The principal difference among respondents in this respect related to the composition of such a joint venture. Thus, American Telephone and Telegraph Company and International Telephone and Telegraph Corporation favor ownership in such a system being limited to international communications common carriers, such entities participating in ownership to a degree consistent with their use of the system; General Telephone & Electronics Corporation would limit the ownership to both domestic and international communications common carriers; while Lockheed Aircraft Corporation,[1] General Electric Company, and The Western Union Telegraph Company favor ownership by common carriers, the manufacturing companies, and possibly the public.

5. Upon consideration of the responses and the replies filed herein the Commission has arrived at certain conclusions, the application of which will serve to foster and accelerate the ultimate establishment of a commercially operable space satellite communication system in the public interest.

6. We have concluded that the recommendations made herein with respect to the formation or arrangement of a joint venture (or joint undertaking) composed only of existing common carriers engaged in international telephone and telegraph communication is deserving of consideration and exploration as an effective means of promoting the orderly development and effectuation of such a system. We believe that, under

1. Lockheed in its reply comments withdrew its proposal that ownership in a satellite system include private interests other than the international carriers.

as quickly as possible, for actual operation of satellite telephones, television, and other communication systems that will bring the world closer together.

I will appreciate your keeping me informed of the steps being taken toward that goal and of tangible progress that is made.

Sincerely,

[signed] John F. Kennedy

Honorable Newton Minow
Chairman
Federal Communications Commission
Washington, D.C.

Document I-12

Document title: Ben F. Waple, Acting Secretary, Federal Communications Commission, "An Inquiry Into the Administrative and Regulatory Problems Relating to the Authorization of Commercially Operable Space Communications Systems: First Report," FCC Report 61-676, 4774, Docket No. 14024, May 24, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

On May 24, 1961, the Federal Communications Commission (FCC), tasked with outlining the initial policy to determine how the communications satellite system would operate, issued its "First Report." The FCC limited participation in the system to international communications carriers—AT&T, ITT, RCA, and Western Union. This policy excluded aerospace and communications equipment manufacturers and consequently provoked numerous complaints. Forced to respond to the aerospace and communications equipment manufacturers' objections, the FCC stated that such companies' participation in the establishment of the system would be neither "necessary nor beneficial." This issue would later play a major role in the controversy over the Communications Satellite Act.

[475/1] Before the FCC 61-676
FEDERAL COMMUNICATIONS COMMISSION 4774
Washington 25, D.C.

In the Matter of	)	
	)	Docket No. 14024
An Inquiry Into the Administrative and	)	
Regulatory Problems Relating to the	)	
Authorization of Commercially Operable	)	
Space Communications Systems	)	

FIRST REPORT

By the Commission:

1. On March 29, 1961, the Commission adopted a Notice of Inquiry (released on April 3, 1961) designed to facilitate an early solution to the administrative and regulatory

pany before the Federal Communications Commission in connection with, as the questioner put it, your "being interested in the $170 million program to put up their (your) own satellites." The direct question was whether I "had any indication that AT&T has taken a new look at the desirability of this."
[5] Although the conversation Dr. Dryden and I had with Dr. Fisk and Mr. Dingman was of quite a general and exploratory nature and was in no way a negotiation or even delineation of official positions, I did get the impression that your company was making a very thorough examination, doing some real soul-searching, and I so stated in my remarks at the bottom of page 12. If this is not correct, I will appreciate your advice.

I agree completely that we should sit down and straighten out any misunderstandings that may have arisen. If you believe our public statements do not fairly represent the position of your company, I will be more than happy to take any steps necessary to make the real facts clear.

Sincerely yours,

James E. Webb
Administrator

Enclosure

A:Webb:ns
N
cc: Dr. Dryden
Mr. Nunn
Mr. Phillips
BAC

Document I-11

Document title: John F. Kennedy to Honorable Newton Minow, Chairman, Federal Communications Commission, May 15, 1961.

Source: NASA Historical Reference Collection, History Office, NASA Headquarters, Washington, D.C.

During his first State of the Union address on January 30, 1961, President Kennedy had called for an international effort to develop communications satellites. Four months later, he reiterated this position while considering a sweeping acceleration of the U.S. space program.

May 15, 1961

Dear Mr. Chairman:

I am most interested in having facilitated early development of communication satellites and will appreciate prompt determination by the Federal Communications Commission, the National Aeronautics and Space Administration, and other appropriate agencies of the conditions and safeguards under which that can go forward. Subject to establishing the necessary precautions, I am hopeful that the public and private resources of our free society can be brought to bear for significant and early research progress in this field, and,

implications and importance to many segments of the communication industry over and above its great significance to your own company.

Last night I took your letter home and read the attachments. Your letter of December 14th to Dr. Glennan does state, on page 3, that you would

". . . like to offer the following specific proposals:

[3] "a. That NASA and we join in the setting of performance specifications for the first experimental active satellite.
"b. That we develop and build the first satellite taking advantage of research already done and developments well under way. We are prepared to pay for this work in its entirety, or for such part of the expense as would reflect our respective interests in the project.
"c. That NASA launch its first satellite and provide tracking data from its Minitrack stations. In this connection, we are willing to bear the whole cost of launching and tracking or to share these costs with NASA in any way you feel will properly reflect our respective interests in the project.
"d. That the existing ground station at Holmdel be made available and modified at our expense for the purpose of making the necessary communications tests. (This station is, of course, compatible with the communications network of this Company.)
"e. That, taking advantage of our long established working relations with overseas communications operating agencies, arrangements be made with at least one of them for more overseas ground stations.
"f. That other common carriers be invited to use the satellite circuits experimentally when such circuits are operational.
"g. That full information on satellite performance be made available to NASA.

[4] I am told that your letter of December 14th was delivered by a number of your associates, that an extended conference ensued, and that it was made clear that NASA would not permit your company, or any other, to pre-empt the program of the United States in this area. [handwritten highlighting in margin] Later, in a letter dated January 17th, 1961, your proposal (e) as amplified in your telegram of January 12th, to undertake negotiations for overseas land stations on behalf of NASA was not accepted, but instead negotiations were initiated and completed by NASA, with the technical advice of your company.

On January 4, 1961, as indicated in your attachment No. 4, March 26, 1961, the letter from your Mr. C. R. Smith to our Procurement and Supply Division, we requested proposals in accordance with our own performance specifications for an experimental low-altitude, active communication satellite. With the letter of Mr. Smith, you submitted a proposal to meet our performance specifications.

I believe you will agree that our request for proposals was not an acceptance of your proposal of December 14th, but was instead the first step toward a policy of permitting all companies interested in this project to furnish competitive proposals rather than limiting the development of the satellite to arrangements that would be made only with your company.

You will recognize that all of the above either took place before or was underway at the time I took the oath of office on February 14th. It is background for the position I have taken publicly, and mentioned above, "to have a good hard look at this before making commitments." I assume part or all of this falls into the category you have called "events which have taken place during the past few months," and needs to be considered in addition to the "specific events" to which you refer in your letter.

With further reference to the record of my press conference, you will note on page 12 that the question which Dr. Dryden answered related to a presentation by your com-

development work on a new, common satellite. The Government ought to examine whether it would make more sense to speed things up.

I propose that DoD consider transferring to NOAA two DMSP buses, which NOAA could then modify for the TIROS configuration and add to it the TIROS sensors. This would give DoD and NOAA 7 satellites each. It would save money in the short term, some of which could be used to fund development of a common satellite system. This is important because budgets are so tight for both DoD and NOAA that neither may be able to afford modernization on their own. It would also mean that DoD and NOAA would likely use up their inventories at about the same time, for a smooth transition to a new common system.

I am writing to urge you and Deputy Secretary of Defense Perry to create a formal working group under appropriate senior officials to attempt to resolve any outstanding issues standing in the way of merging the two government polar-orbiting weather satellite systems.

What is required is leadership from both agencies to resolve issues of data encryption; management of a merged system; potential transfer of DoD assets to NOAA; integration with European meteorological satellite efforts; and cooperation with NASA on the Earth Observing System polar platform.

[3] To take one example, without the personal involvement of you and Secretary Perry, subordinate DoD officials will continue to insist that data must be encrypted and NOAA will insist that encryption is not acceptable. My suspicion is that the case for encryption rests on weak arguments, given the availability of geosynchronous satellites, and European, Chinese, Russian, and NOAA systems all broadcasting in the clear. On the other hand, NOAA may be shortsighted in disregarding other national interests that might justify some form of encryption capability. Resolving this type of problem requires creativity from top policymakers.

The nation cannot afford to maintain and modernize two satellite weather constellations. Working together, however, DoD, NOAA and NASA could pool resources, achieve efficiency and improve capabilities at reduced cost to the taxpayer.

I look forward to hearing your views.

Sincerely,

Jim Exon
United States Senator

cc: Deputy Secretary of Defense William Perry
Vice President Al Gore
NASA Administrator Goldin

Document II-9

Document title: National Performance Review, Department of Commerce, "Establish a Single Civilian Operational Environmental Polar Satellite Program," September 30, 1993.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

This document spells out the financial advantages of achieving the consolidation of the National Oceanic and Atmospheric Administration's Polar-orbiting Operational Environmental Satellite System and the Defense Department's Defense Meteorological Satellite Program. It also points out that a consolidated or converged system with NASA involvement could make efficient use of NASA's development of new Earth observation instruments. This document was part of the Clinton administration's National Performance Review.

A memorandum of law concerning Article XIV of the INTELSAT Agreement is enclosed.

Sincerely,

[hand-signed: "George P. Shultz"]
Secretary of State

[hand-signed: "Malcolm Baldridge"]
Secretary of Commerce

Enclosure . . .

The Office of the Coordinator for International Communication and Information Policy, together with others concerned with the issue, are working with your staff on these and additional issues emanating from the Presidential determination.

Sincerely yours,

[hand-signed: "George"]
George P. Shultz

The Honorable
Malcolm Baldridge,
Secretary of Commerce.

cc: Chairman Mark Fowler

[57] Appendix B

[58] THE DEPARTMENT OF COMMERCE
Washington, D.C. 20230

November 28, 1984

Honorable Mark S. Fowler
Chairman
Federal Communications Commission
Washington, D.C. 20554

Dear Mr. Chairman:

The President has determined that separate international communications satellite systems are required in the national interest. He has also directed that we inform the Federal Communications Commission of criteria necessary to ensure the United States meets its international obligations and to further its telecommunications and foreign policy interests. Prior to final authorization by the Commission of any systems, to assure that the United States meets its obligations as a Party to the Agreement Establishing the International Telecommunications Satellite Organization (INTELSAT) (TIAS 7532):

(1) each system is to be restricted to providing services through the sale or long-term lease of transponders or space segment capacity for communications not interconnected with public-switched message networks (except for emergency restoration service); and,
(2) one or more foreign authorities are to authorize use of each system and enter into consultation procedures with the United States Party under Article XIV(d) of the INTELSAT Agreement to ensure technical compatibility and to avoid significant economic harm.

The President's determination, its conditions, and these criteria are premised on our review of the issues prompted by the applications now before the Commission. If proposals substantially different are forthcoming, further Executive Branch review may be required.

The Commission should afford interested parties an opportunity to submit timely comments on the pending applications in view of these Executive Branch recommendations.

[55] **THE SECRETARY OF COMMERCE**
Washington, D.C. 20230

November 30, 1984

Honorable George P. Shultz
Secretary of State
Washington, D.C. 20520

Dear George,

There are two matters regarding the President's determination on new international satellite systems that need to be clarified. First, the White House has directed our departments to examine the scope of INTELSAT's pricing flexibility. Second, our position on the related issue of direct access to INTELSAT should be made clear.

The executive agreement establishing INTELSAT generally requires uniform pricing for each service. Prices on heavily trafficked routes may now exceed costs while those on thin routes may be below costs. It is not clear whether INTELSAT could vary its prices under the agreement. If INTELSAT's prices on busy routes are artificially inflated, inefficient entry by new systems may be induced. INTELSAT should have pricing flexibility when confronted with actual or potential competition as long as the prices it charges cover its costs.

A related issue is direct, cost-based access to the INTELSAT space segment. Allowing users and carriers in addition to Comsat the option to deal with INTELSAT directly for competitive services would foster competition based on superior efficiency and foresight and tend to deter entry by inefficient systems.

We should express clear positions on these two important points in the filing we will soon be submitting jointly to the Federal Communications Commission. I have asked Dave Markey to work with Bill Schneider to ensure this is done.

Sincerely,

[hand-signed: "Mac"]
Secretary of Commerce

cc: Chairman Mark Fowler

[56] THE SECRETARY OF STATE
WASHINGTON

December 20, 1984

Dear Mac:

Thank you for your letter of November 30 relating to the President's determination on international satellite systems separate from INTELSAT. Your understanding conforms with ours that the White House is interested in having us examine the issues of pricing flexibility in INTELSAT and direct access to INTELSAT by users other than COMSAT.

We have received, and are reviewing, the draft paper prepared by NTIA [National Telecommunications and Information Administration] which might be sent jointly to the FCC.

Government should not stifle private entrepreneurial initiatives absent sound and compelling public policy reasons. Such initiatives should not be discouraged when the services proposed could prove of value to customers, improve their productivity and efficiency, and thus enable American firms to compete more effectively both at home and abroad. The public policy case for continuing the status quo and flatly prohibiting additional international satellite systems is weak. Simply the pendency of U.S. applications has caused INTELSAT to accelerate plans for special business-oriented services and has precipitated a beneficial review of competitive conditions in the international satellite field generally. Further study and inevitable delay are unlikely to yield public dividends commensurate with the economic costs imposed.

[52] It is the view of the Executive branch that the national interest will be furthered by approving additional international communications satellite systems subject to limitations designed to minimize adverse effects on INTELSAT. Specifically, additional systems should be restricted to providing services through the sale or long-term lease of transponders or space segment capacity for communications not interconnected with public-switched message networks (except for emergency restoration service). Consultation must be undertaken with INTELSAT pursuant to Article XIV(d) of the Definitive Agreement.

[53] Appendix A

[54] THE WHITE HOUSE
WASHINGTON

November 28, 1984

Presidential Determination
No. 85-2

MEMORANDUM FOR THE SECRETARY OF STATE
THE SECRETARY OF COMMERCE

By virtue of the authority vested in me by the Constitution and statutes of the United States, including Sections 102(d) and 201(a) of the Communications Satellite Act of 1962, as amended (47 U.S.C. 701(d), 721 (a)), I hereby determine that separate international communications satellite systems are required in the national interest. The United States, in order to meet its obligations under the Agreement Establishing the International Telecommunications Satellite Organization (INTELSAT) (TIAS 7532), shall consult with INTELSAT regarding such separate systems as are authorized by the Federal Communications Commission. You are directed jointly to inform the Federal Communications Commission of criteria necessary to ensure the United States meets its international obligations and to further its telecommunications and foreign policy interests.

This determination shall be published in the Federal Register.

[hand-signed: “Ronald Reagan”]

Specifically, this report concludes that—

(a) Additional international satellite facilities should be permitted by the FCC, provided they satisfy conventional regulatory requirements, but the new entrants must be restricted to providing customized services, as defined in this report. When one or more authorities abroad authorizes use of such new systems, the United States with those authorities will enter into consultation procedures with INTELSAT under Article XIV(d) of the INTELSAT Agreement. Construction permits may be issued at the conclusion of regulatory proceedings to those applicants meeting the public interest requirements of the Communications Act. Final licenses and authorizations should not be issued, however, until after INTELSAT consultation is completed.

(b) The FCC should examine allowing U.S. carriers and users in addition to the Communications Satellite Corporation (Comsat) to have cost-based access to the INTELSAT space segment for customized services. This matter can be pursued on a parallel track, as the pending applications are being processed, however, and does not constitute a condition to FCC action on these applications.

(c) The United States should, and will, maintain its full commitment to INTELSAT, while permitting technology-driven competition in this important sector to evolve. . . .

[50] Conclusion

The applications to establish additional international satellite systems now pending before the FCC presented four options. The Executive [branch] could have recommended (1) approval, (2) denial of the applications outright, (3) approval of the applications subject to specific qualifications, or (4) further study, with postponement of any decision for an indefinite period. The unanimous view among the member agencies represented on the SIG is that it would be in the U.S. national interest to allow new providers of international satellite facilities, provided INTELSAT were not exposed to significant economic harm. The President's determination reflects this view.

There is sufficient risk of significant adverse economic impact on INTELSAT to make blanket approval of unrestricted competition unwise. It would also be premature to take such a step until the results of cost-based access, new fiber optic cables, and new INTELSAT services are fully evaluated. Unrestricted entry could ultimately undermine the economic integrity of this important international enterprise, which would be inconsistent with the U.S. national interest.

[51] The case has not been made for flatly disapproving the existing applications. The new entrants have made a threshold showing that services they propose are not now available on comparable terms. Limited entry along the lines recommended would further U.S. international trade interests, promote technological progress, and be consistent with national defense and security interests as well. Given these limitations, and the restrictions likely to be placed on any new satellite system by telecommunications authorities abroad, the risk of any significant adverse impact on INTELSAT is exceedingly small.

Further study and resulting delay [are] unlikely to further the national interest. Over a year of extensive study and review by the Executive branch has already taken place. This review has not resulted in the submission of credible information supplied by anyone, including INTELSAT and Comsat, which demonstrates plausible adverse effects. There is no basis to assume such information will be forthcoming.

Satellite systems entail significant lead time. Time is required to secure the requisite spacecraft, to reach launch agreements, and to secure operating arrangements. U.S. regulatory procedures are generally more time consuming than those abroad, where decisions can sometimes be reached and implemented without the regulatory proceedings and protracted court appeals characteristic of U.S. regulation. Consultation with INTELSAT is also required. Even were the pending applications approved by the FCC immediately, service would not be available for some time.

Focus of Report

The filing of U.S.-based satellite system applications with the FCC prompted action by the Executive branch, which has special responsibilities in this field under the Communications Satellite Act of 1962, as amended (47 U.S.C. 701 et seq.) including the responsibility to determine whether additional U.S. international satellite systems are "required in the national interest." The Senior Interagency Group on International Communication and Information Policy (SIG) reviewed U.S. international satellite policy to determine whether, and under what conditions, authorizing satellite systems and services in addition to INTELSAT would be: (a) consistent with prevailing U.S. law, practice, and international treaty obligations; (b) compatible with sound foreign policy and telecommunications policy goals; and, (c) in the U.S. national interest.[1]

[2] The Executive agencies represented on the SIG undertook a study and reached a unanimous position in favor of new entry, subject to certain limitations. A recommendation subsequently was made to the President by the Secretaries of State and Commerce. The President determined on November 29, 1984, that international satellite systems separate from INTELSAT were required in the U.S. national interest, subject to certain conditions. Specific criteria relating to the President's determination were then forwarded to the FCC by the Secretaries of Commerce and State jointly. See Appendixes A and B.

This report provides background information regarding the President's determination, and it also provides information on important regulatory and other parallel measures which are desirable to ensure that the Executive branch's fundamental policy goal—an efficient and responsive international communications environment—is achieved. The discussion here focuses on the major communications and information policy issues raised by the applications before the FCC. It addresses commercial, trade, and legal matters, and also examines major U.S. foreign policy interests and concerns.

This report does not seek to resolve all of the questions that have been raised regarding new international satellite systems nor to direct action by the FCC on specific pending applications. It does, however, consolidate much of the extensive analysis that has been undertaken by the Executive branch and sets forth the requirements applicable to any system the FCC may eventually authorize.

The Executive branch has concluded, in brief, that it is technically feasible, economically desirable, and in the national interest to allow new entry by U.S. firms into the international satellite field. Customers should be afforded both the new service options and the benefits of competition among customized service providers that new entry promises. This can be accomplished, moreover, while maintaining the technical integrity of the INTELSAT global system and avoiding significant economic harm to that system. U.S. foreign policy, and international communications and information policy, require a continued strong national commitment to INTELSAT as "a single global commercial telecommunications satellite [3] system as part of an improved global telecommunications network."[2] But our national commitment to INTELSAT and other important goals can be accommodated, provided that new international satellite systems and services are authorized and regulated along the lines discussed in this report.

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1. The SIG is composed of representatives of the Departments of State, Justice, Defense, and Commerce; the Offices of Management and Budget, Science and Technology Policy, Policy Development, and the U.S. Trade Representative; the National Security Council; the Central Intelligence Agency; the U.S. Information Agency (USIA); the Board for International Broadcasting; the Agency for International Development; and the National Aeronautics and Space Administration. Commerce and State co-chair the SIG and USIA serves as vice chair.

2. Preamble, Agreement Relating to the International Telecommunications Satellite Organization "INTELSAT," TIAS 7532, 23 UST 3813, 3814 (1973).

No additional items were reviewed. Dr. Byerly requested a two page programmatic description of the ACTS program.

John J. Madison
Legislative Affairs Specialist

Document I-30

Document title: William Schneider, Under Secretary of State for Security Assistance, Science, and Technology, and David J. Markey, Assistant Secretary of Commerce for Communications and Information, "A White Paper on New International Satellite Systems," Senior Interagency Group on International Communication and Information Policy, February 1985.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

This report sets forth the reasoning behind the November 28, 1984, determination by President Ronald Reagan that "separate international communications satellite systems are required in the national interest." (A copy of the determination is included in the excerpts from this report.) This decision marked the end of an era during which it was U.S. policy to protect the position of INTELSAT as the only provider of global point-to-point communications via satellite.

A White Paper on New International Satellite Systems

Senior Interagency Group
on International Communication
and Information Policy

William Schneider, Jr.
Under Secretary for Security
Assistance, Science, and Technology
U.S. Department of State

David J. Markey
Assistant Secretary for
Communications and Information
U.S. Department of Commerce

February 1985

[1] Introduction

Since 1983, several U.S. firms have filed applications with the Federal Communications Commission (FCC) to establish international communications satellite systems in addition to the global system owned by the [International] Telecommunications Satellite Organization (INTELSAT). Orion Satellite Corporation, International Satellite, Inc. (ISI), and Cygnus Corporation propose new transatlantic communications systems, and RCA American Communications, Inc. (RCA) has applied to use capacity on a U.S. domestic satellite to provide international service. Pan American Satellite Corporation (PanAmSat) proposes to establish a system which would serve Latin America. In addition to existing and planned regional satellite systems independent of INTELSAT, other transoceanic satellite systems are under consideration abroad. Approved and proposed transatlantic submarine cable communications facilities, many of which are actually or potentially competitive with INTELSAT, are pending as well.

[no pagination]

Memorandum for the Record

SUBJECT: Advanced Communication Technology Satellite (ACTS) program meeting, October 13, 1983

PRESENT: Committee staff: R. Byerly, T. Clark;
NASA: R. Lovell and J. Madison

The purpose of the meeting was to review the status of the NASA ACTS program.

Dr. Byerly started the meeting by asking a number of questions about the rational for NASA's recommitment to develop a second generation satellite communications technology base for industry. The following points were established by the ensuing discussions:

- The current global shift form [sic] an industrial to an information-based economy is creating a rapidly increasing demand for capacity that cannot be met by the satellite communication technology base developed by NASA and industry during the period of 1962 to 1973.
- The satellite communications industry is not monolithic; individual sectors like the hardware manufacturers, the common carriers, the antenna manufacturers, the entrepreneurs who buy transponders one-at-a-time and resell them and other[s] have had little interest in maintaining an advanced technology base.
- The U.S. competitive edge in the world market has been substantially eroded by the transfer of technology to foreign manufacturers; in the U.S., only two out of five former leaders in the world market remain competitive.
- To provide the capacity to meet the forecasted demand, NASA and industry over the past five years focused research on the precursor technologies to an experimental system like ACTS; the technologies include frequency reuse through spot beams, on-board switching and regeneration, data compression, modulation and demodulation and beam hopping; there is now a good understanding of the technical risks related to most of the technologies.
- The ACTS program provides for the testing of many of these technologies in an experimental network that could be applied to the next generation of geostationary communications satellites. It's [sic] objective is to restore the preeminence of the U.S. industry in satellite communications.

Dr. Byerly and Mr. Lovell discussed the NASA effort that supports the ACTS program. It consists of two activities. One involves fundamental research aimed at developing the devices and processes that support an advanced components development activity and some highly sophisticated components which are beyond the technical level of ACTS. The second is directed toward developing components that will reduce some of the technical risk related to the ACTS experimental flight systems.

Dr. Byerly inquired into the status of the ACTS program. Mr. Lovell indicated that NASA was still involved in the source selection process. One proposal was submitted in response to the RFP [request for proposals] which was issued in March 1983. The proposed industry team is composed of RCA, TRW, COMSAT, Hughes and Motorola. RCA would act as the prime contractor responsible for the satellite bus and the integration of the ACTS payload. The total estimated cost of the ACTS program is $354.0 million. Industry will contribute to the cost of the program.

Some discussion about the incentives for industry to participate in the ACTS program followed. The principal motivators are: a $10-$15 billion per year commercial communications market in the 1990's, an opportunity to be the beneficiary of a good technology transfer mechanism and good protection of proprietary data amid an activity including a number of competitors.

the development of technology such as multi-beam spacecraft antennas, low-cost earth stations and on-board signal switching—technologies which do not readily derive from current or anticipated future activities of the private communications common carriers. In addition, because of the disaggregated nature of those who need these services, the private sector often cannot find a ready market which justifies the risk of expansion into the provision of these new services. There is, then, an appropriate federal role in [31] assisting the development of needed technology and in demonstrating new public services for a sufficient period that their users may be perceived as a viable market by the private sector. The most appropriate supplier of the needed technology is NASA.

> *The Committee recommends that as soon as possible, NASA, with the participation of appropriate user groups, begin conceptual definition of both the needed technology (Option 4) and the public service experiments themselves (Option 5).*

These initiatives are the first steps in the implementation of the Committee's Options 4 and 5 which have been described earlier in this report. The report also describes a process of checks and balances which the Committee believes are essential to channel the expanded NASA role in the needed direction.

Document I-29

Document title: John J. Madison, Legislative Affairs Specialist, NASA, Memorandum for the Record, "Advanced Communications Technology Satellite (ACTS) program meeting, October 13, 1983."

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Beginning in 1980, NASA reentered the communications satellite research and development area, first with a technology development effort and then with a proposal for a satellite mission that would demonstrate various new technologies and their ability to work together as a system. This mission, known as the Advanced Communications Technology Satellite (ACTS), was controversial within the government. The Reagan administration believed that it was the private sector's responsibility to invest in technology and demonstrate its capabilities in areas where the primary payoffs would be commercial. For several years during the mid-1980s, President Reagan refused to approve funding for NASA to develop ACTS. Hughes, the world's leading builder of communications satellites, also opposed the program on the grounds that it represented inappropriate government competition with the private sector. Congress, with a Democratic majority, believed in a partnership between the public and private sectors would assure the nation's continued leadership in the communications satellite sector. Each year, for several years, Congress restored funding for the mission to NASA's budget. It was not until early 1987 that the Reagan administration reversed its opposition to the program, allowing it to move forward. ACTS was finally launched in 1993. This memorandum captures the early NASA justification for the program, as presented in a meeting of two staff members of the space subcommittee of the House of Representatives (Rad Byerly and Tim Clark), head of the ACTS program at NASA Headquarters (Robert Lovell), and NASA's legislative affairs specialist (John Madison). The program's rationale and design underwent continual change until a program concept acceptable to both the executive branch and Congress was developed.

the country in satellite communications and then to make detailed recommendations on the basis of such a comprehensive study. Instead, the Committee focused upon classes of possible NASA programs (called "options" in this report) and, accordingly, the Committee's conclusions and recommendations are focused on the options considered.

The Committee concludes that the current NASA satellite communications program (Option 1) is inadequate, both in terms of meeting NASA's statutory advisory obligations and in terms of meeting the country's needs in satellite communications research and development. Some members, but not all, felt that if this option were the only one that the nation was willing to support, NASA should drop out entirely of the satellite communications research and development business, and that legislation should be sought which would terminate NASA's statutorily mandated advisory responsibilities in satellite communications.

The Committee believes that the extra funding required to support an expanded NASA satellite communications technology program (Option 2) is not likely [30] to produce enough returns of value to the country to make it worthwhile pursuing, and therefore recommends against it.

Option 3, a satellite communications technology flight-test support program, has considerable appeal in that it is directed at removing a major roadblock in the way of increased private sector investment in satellite communications research and development. Such a program would face many difficulties in deciding fairly who should be provided such opportunities and in resolving questions of access to results, patent protection, government rights, and proprietary rights, to name a few. The Committee therefore is skeptical of the likely efficacy of such a program and recommends against pursuing it—even if undertaken in conjunction with Option 1.

> *The Committee recommends that NASA implement an experimental satellite communications technology flight program (Option 4) using the safeguards provided by the first two phases of the decision process discussed in the preceding section.*

That procedure is intended to ensure that the communications technology program is responsive to the perceived needs of the entire satellite communications community, including, in particular, potential users of the services. In addition, it is believed that following this procedure will help foster better transition of the experimental results into subsequent operational systems.

It seems clear to the Committee that there are a number of potential public service satellite communications systems which should be investigated in detail for possible implementation. However, as discussed in the preceding chapter, the Committee also believes firmly that NASA should pursue such a program only if one or more potential user groups are involved from the start of the program through its finish, and only if the estimated costs and benefits are thoroughly investigated and the balance indicates the pursuit of the program is worthwhile.

> *The Committee recommends that NASA implement an experimental public service satellite communications system program (Option 5), provided that the program is carried out using the entire four-phase decision process discussed in the preceding section.*

The Committee concludes that the arguments against an operational public service satellite communications system program (Option 6) are compelling, that such an option is inappropriate for NASA, and recommends against it.

In summary, the Committee on Satellite Communications concludes that there might well be a number of public service communications needs which satellite communications systems of the future could help satisfy. Some of these services and systems may require

20 watts of power per kilogram. New designs having more efficient cells on lightweight flexible substrates should be able to produce 50 watts per kilogram.

It may also be possible to develop even higher power per unit weight by means of larger solar array structures or deployed parabolic solar concentrators which could be used with either solar cells or perhaps Brayton closed-cycle turboalternators. These means for achieving larger satellite capacities and thus lower earth station costs require new technology in prime power devices, in structural efficiency, and in the high power transmitter devices themselves.

Modulation Systems

Most contemporary systems employ analog frequency modulation voice and TV transmission. For FM voice systems, a 50 dB [decibel] power signal-to-noise ratio in a one-cycle band is required. Digital speech transmission systems operating at 2400 bits per second with very efficient modulation systems have been demonstrated to operate at power signal-to-noise ratios of about 40 dB. While currently these digital systems are far too costly to be used in inexpensive mobile terminals, recent advances in the reduction of the cost of digital equipment indicate the possibility of low-cost voice systems operating at significantly lower signal-to-noise ratios.

OTHER TECHNOLOGY AND PHENOMENOLOGY

Other improvements are needed in satellite support systems. Typical of these needs are those for lighter, longer life (nickel-hydrogen) batteries and station-keeping engines (ion engines). Better understanding is also needed of certain space phenomena such as static discharges at geostationary orbit and the effects of rain on the polarization of radio signals. It should be noted that AT&T's COMSTAR satellite carries radio propagation experiments at 18 GHz and 30 GHz. These experiments, although singular, are typical of the many experiments needed to better understand potentially limiting natural phenomena. . . .

[29] CONCLUSIONS AND RECOMMENDATIONS

The Committee, in its deliberations, reviewed a number of future communications needs which potentially could be satisfied by satellite systems. These included needs in fields such as education, health care delivery, hazard warning, navigation aids, search and rescue, electronic mail delivery, time and frequency dissemination, and geophysical exploration. Many of these are public service needs which might be satisfied by satellite communications systems using high power and a high-gain antenna in the space segment, permitting low-gain, low-cost earth stations. To make such systems possible, technological advances in multibeam spacecraft antennas, low-cost earth stations, large satellite power systems, high-speed spacecraft communications switches, and spacecraft supporting technology may be required. If costs can be reduced by the application of new technology, many potential public service users may benefit from new satellite communications services.

The Committee concludes that the technology to meet such needs is often not provided by the private sector because of the technical and cost risks involved. The Committee therefore concludes that there is an appropriate federal role and that NASA should resume the research and development activities needed to provide the new technology. . . .

As discussed earlier in this report, it became clear as the Committee progressed through its deliberations that it would be neither possible, nor appropriate, for a part-time, short-duration committee to undertake an exhaustive study of the future needs of

whole. To point the beam accurately, the satellite's location in space must be known, the directional vector to the earth determined, and then pitch, roll and yaw maneuvers performed. The spacecraft location can be determined by means of a series of ground-based observations of satellite range and range rate or by means of an on-board sensor system. One on-board system, in a Lincoln Experimental Satellite, used a precision chronometer and visual and / or infrared sightings of the sun and the earth's edge. The satellite location was determined by noting the time at which the observed angle between the sun and earth reached a given value.

A spacecraft with a large antenna can be turned in space by means of an onboard momentum wheel or wheels. By speeding up or slowing down the wheel, pitch maneuvers can be made. Pivoting of the wheel axis can produce roll and yaw motions. The spacecraft must also be kept in proper orbital position. This is often accomplished by hydrazine-fueled thrusters. Ammonia thruster systems can also be used and electronically powered thrusters have been considered. Current aiming techniques need to be improved and additional research and development initiated to provide simple and accurate systems.

On-Board Message Switching

The use of multiple beam high-gain satellite antennas will permit the use of small terminals. On the other hand, the problem remains of how to interconnect users on different beams. One solution would be to collect the signals from the various beams and transmit them on a very wide-band downlink to a large ground terminal. The interconnection could then be made by conventional switching equipment and the signals returned to the spacecraft on a wide-band link with each signal addressed to the proper downlink beam. This solution, while permitting the complex switching equipment to be located on the ground, would require additional very wide-band channels in the already crowded radio frequency spectrum. Much more power would be required in the satellite and the existing 0.25 second time delay would be doubled.

Another solution would be to perform the switching in the satellite. On[-]board switching can be done in several ways. While switching at radio frequency would avoid the complexity of demodulation, time sharing in the use of the downlink transmitter would be very difficult.

An alternative is demodulation of the up-coming signals to identify on which beam the down-going signals must be placed to reach the intended recipients. Recent advances in high-speed digital signal processors offer encouragement that on-board switching is possible. Much research and development is needed to arrive at practical solutions and experimental verification in flight will be necessary before the communications industry can risk operational use.

[9] Higher Satellite Power

A way to increase satellite capacity or achieve a given capacity with low cost ground stations is to increase the satellite transmitter power. The transmitter power output is the product of the available prime power and the efficiency of the transmitters.

There is relatively little possibility of increasing the 60% efficiency of current satellite solid-state transmitters operating at frequencies up to 2.0 GHz. At frequencies above 2.0 GHz, travelling wave tubes with efficiencies of up to 40% are commonly used and improvements in efficiency should be possible.

Significant advances in the performance of prime power systems should be possible. Most current satellites employ silicon solar cell power systems having efficiencies as low as 10%. The lightest weight arrangement involves solar-oriented planar arrays having about

earth terminals, high-gain satellite antennas must be employed. To be economical, these must be shared by large numbers of users at many locations. Many antenna beams from a single satellite will [7] be required, along with methods for accurately aiming the antenna and a means for switching signals from one beam to another by means of a switching system aboard the satellite.

High Gain Spacecraft Antennas

The possibility of high gain (large) spacecraft antennas seems antithetical to the notion of spacecraft weighing, at most, a few thousand kilograms. (The standard 25-meter ground antennas weigh hundreds of thousands of kilograms.) There is one large difference, however, between the surface of the earth and space; namely, in the absence of gravity and wind forces, large space antennas can be built using very light structures.

The NASA ATS-6 spacecraft incorporates a 10-meter parabolic antenna that weighs less than 100 kg [kilograms] and is operable to 10 GHz [gigahertz]. This antenna consists of a series of sheet aluminum ribs on which is stretched a metallized net. During launch, the antenna is packed into a small container by wrapping the ribs and mesh around a central hub. Upon reaching orbit, the ribs are released whereupon they unwind into their deployed position.[12] Other designs need investigation with the objectives of further reducing weight, increasing performance, and increasing size.

Multiple Beams

One difficulty with high gain spacecraft antennas is that they produce very narrow beams and therefore have limited coverage on the earth's surface. For instance, the ATS-6 10-meter antenna has a beamwidth of about 1° at one of the operating frequencies, 2.6 GHz. If such an antenna is to be usefully employed over the earth's surface visible to the satellite, it will be necessary to generate a total of about seventy-five beams and to share the spacecraft antenna aperture among these many beams.

As an example, the Massachusetts Institute of Technology's Lincoln Laboratory developed a 10 GHz lens antenna about 0.75 meter in diameter, illuminated by 19 feed horns and producing 19 beams—which in the case of this antenna will just cover that part of the earth visible from geostationary orbit. The satellite transmitter can be connected by command to any combination of the feed horns. The entire antenna system weighs less than 20 kg. Similar arrangements might be made for large parabolic reflector antennas. In that case, a cluster of antenna feeds would be located at the focus of the parabola. Further development of these concepts is needed both to achieve the proper performance over the required bandwidth and to minimize effects of the space environment such as extremes of temperature.

[8] Precision Antenna Aiming

With today's technology, aiming an antenna in space to a precision of 0.1° is relatively easy. However, the high gain antennas of anticipated future spacecraft will have beamwidths of 0.1° to 0.5° and will require a pointing precision of 0.01° or better. It is advantageous to attach the antenna rigidly to the spacecraft and aim the structure as a

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12. Computer Sciences Corporation. *NASA Compendium of Satellite Communications Programs.* Report of Work on Contracts NAS 5-24011 and NAS 5-24012. Computer Sciences Corporation, Silver Spring, Maryland, 1975, pp. 13-59 to 13-81.

NASA had developed the technology and demonstrated its practical use, however, that commercial firms were able to risk operational systems. Today the price of multi-channel point-to-point voice service has dropped to several thousand dollars per channel-year. Both transoceanic and domestic systems are in operation or planned in a large number of countries.

The situation for other classes of long-range satellite communications—for example, service to mobile platforms (ships and aircraft) or to widely distributed or remote ground locations—is much less favorable. Most users of such communication terminal installations feel they can afford only modest sized and low-cost antennas. The services so provided might include public activities such as education, mail, environmental monitoring, geophysical exploration, hazard warning, health care delivery, navigation aids, time and frequency dissemination, public safety, search and rescue, or wildlife monitoring.

The U.S. Department of Health, Education and Welfare and NASA have recently conducted experiments in Appalachia, the Rocky Mountain States, Alaska, and Washington State.[6] These experiments were designed to assess the value of service to remote locations and to assess the communications satellite as a means for providing it. For example, using television, voice, and a variety of data signals relayed by ATS-6 (Applications Technology Satellite 6), the experiments delivered health care and education services to thousands of Alaskans living in [6] areas too remote to reach readily in person or through ground-based communications.[7,8]

These experiments successfully demonstrated the capability to provide diagnostic consultative services between medical professionals and paraprofessionals, transmit and provide consultations on x-rays, and transmit and up-date medical records, all in real-time via satellites. As a result, the Alaska Native Health Board now assigns highest priority to development of the community health aide program and to improving the communications that provide the aides with professional back-up.[9]

The Public Service Satellite Consortium[10] has compiled the needs of numerous current and potential users similar to those portrayed in the Alaska example, but the fact is that most potential users cannot afford current communication service prices, much as the transoceanic point-to-point users could not afford early satellite communications systems before technology advances brought lower prices. If prices could be reduced, an increased market for such services might well develop.

REQUIRED TECHNOLOGY

The technical challenge in reducing costs for satellite service to small terminals is difficult, but it is no greater than that faced in originating satellite communications in 1958. The basic approach already can be envisioned.[11] To enable small antennas to be used at

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6. Marion H. Johnson, "ATS-6 Impact: A View from the Control Room," *National Library of Medicine News.* Vol. XXX, No. 10-11, October-November, 1975, pp. 3–7.

7. Charles Brady, "Telemedicine Moves North to Alaska," *National Library of Medicine News.* Vol. XXX, No. 10-11, October-November, 1975, pp. 7–10.

8. Martha R. Wilson and Charles Brady, "Health Care in Alaska Via Satellite," AIAA Conference on Communication Satellites for Health/Education Applications, AIAA Paper 75-898, New York, 1975.

9. Subcommittee on Appropriations for the Department of the Interior and Related Agencies, U.S. House of Representatives. Testimony on behalf of the Alaska Native Health Board by Lillie H. McGarvey, May 13, 1975.

10. The Public Service Satellite Consortium is a private organization dedicated to aggregating the public services satellite market. Its subscribers number more than 65 state, local and regional organizations currently conducting over 20 public service satellite communications experiments with the NASA ATS-series satellites and the NASA/Canadian Communications Technology Satellite.

11. Walter E. Morrow, "Current and Future Communications Satellite Technology," Presentation to the International Astronautical Federation 26th Congress, Lisbon, September 1975.

Applications Board. It was also agreed that the Committee should be constituted of technologists, communications system operators, satellite communications users, a communications policy specialist, and a regulatory economist. The members were selected with due regard for a balance in viewpoints. . . .

In its work, the Committee considered whether it is likely that satellites in geostationary orbits could make voice, video, and data communications attractive for a variety of public uses not presently provided. Such satellite systems should be able to provide new services to remote and distant places and to sparsely distributed users. For example, using the ATS-6 satellite, Brazil has experimented with delivering television broadcasts to some of its isolated populace. The U.S. has experimented with providing health care information and educational services to inhabitants of remote villages in Alaska, Appalachia, and the Rocky Mountain West. When the ATS-6 was withdrawn from such experiments to keep an international commitment to conduct similar demonstrations in India, a number of user groups testified to their need for the replacement satellite which NASA had planned to launch.[4] However, funds to complete and launch the replacement satellite were not appropriated and no individual user or combination of users was able to afford the estimated $45 million to $50 million to launch and operate it. While the cost-effectiveness of any single application of this type by a satellite may be questionable,[5] the use of multi-purpose satellites may open an increasing number of opportunities for public service, government, and commercial uses.

[4] Among the non-technical questions confronting the Committee, therefore, were these: Are there a large number of disaggregated, mainly public service users in remote places likely to need and want the capabilities of satellite communications? Is an experimental program, building on the experience of the curtailed ATS-6 experiments, warranted to permit users to evaluate the worth of such services and to demonstrate the market and the costs? If so, what should such a program comprise and what should be the respective roles of the government, the communications industry and the potential public service sector users?

Collectively in Committee meetings and individually outside of those meetings, the members of COSC: (1) reviewed the history and present status of satellite communications, (2) considered a number of important communications service needs expressed by potential users, (3) identified advances in technology required for meeting those needs, (4) judged which of those advances probably would, and which probably would not, be met by the private sector, (5) structured and evaluated several possible NASA roles in the advancement of technology, and (6) decided upon recommendations.

[5] PERCEIVED NEEDS AND REQUIRED TECHNOLOGY

PERCEIVED NEEDS

The government investment in research and development on multi-channel point-to-point satellite communications, which began with the space age and culminated in the formation of the Communications Satellite Corporation, clearly has borne rich dividends for the country. The revenues from this new industry currently exceed $200 million per year and are expanding rapidly. It was only after the Department of Defense (DOD) and

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4. U.S. Senate Committee on Aeronautical and Space Sciences. Hearings on S.3542, A Bill to Authorize Appropriations to the National Aeronautics and Space Administration for Research and Development Relating to the Seventh Applications Technology Satellite, July 23, 1974.

5. See Educational Policy Center, *Instructional Television: A Comparative Study of Satellite and Other Delivery Systems.* Syracuse Research Corporation, Syracuse, New York, 1976.

INTELSAT I which could carry 240 telephone channels or one TV channel. INTELSAT II, III, IV, and IVA satellites were added in subsequent years. As of January 1977, the system provides telephone and TV links between the 94 countries that share in ownership of the system. There are also 13 non-owner countries that use the INTELSAT system.

Use of satellites for domestic communications within the U.S. was delayed by political and regulatory processes until 1974 when policy decisions were made about who would provide such services. Meanwhile, Canada's ANIK satellite system had become operational in early 1973, supplying some U.S. domestic services. Since then, a number of companies have entered the field and today satellites are being used to provide domestic telephone or TV services. Additional domestic satellites are planned for the U.S. and for other countries.

Since 1963, the United States has led the world in satellite communications. Initial experiments were conducted by the National Aeronautics and Space Administration and the Department of Defense. Transition from experimental to practical use of satellites was rapid for transoceanic telephone and TV services because there existed an infrastructure ready to exploit this new medium and because the number of new undersea cables was unable to keep pace with the demand. U.S. aerospace and electronic industries were able to capitalize on their own work as well as on the research and development funded in these industries by the federal government to develop a competitive advantage in the world market.

The private sector has continued to make advances in the technology for providing conventional telephone and TV services. The industry has taken some risks; for example, one company paid for launch vehicle improvements and incorporated much advanced technology, not previously proven in flight, in its satellite to improve performance. However, it became clear that the risk the private sector was willing (or could permit itself) to take was limited and that most private initiatives were being channelled to existing markets and to where technical risks were not perceived as unacceptably high. It is clear that even in the largest companies, prudent management requires that large investments in R&D not be made unless there is reasonable assurance that relatively short term payoffs will result. Furthermore, the risk of violating federal anti-trust and trade regulation statutes has led companies to refrain from entering into joint efforts that might permit them to share risk. As a result, following the withdrawal of the federal government from satellite communication R&D, there have been no commercial experimental satellites to test new techniques and concepts or to permit users to experiment with new services.

There are a number of potential communications services, such as for health care delivery, educational services, search and rescue, electronic mail, teleconferencing, and environmental data collection, which apparently cannot readily [3] or economically be provided using the technology available to the common carriers for producing conventional telephone and television services. If the option to initiate some of these services is to remain open in the future, then advances must be made in needed technology by undertaking research and development programs now.

There are examples of work which must be undertaken if new services are to be contemplated. These include technology for utilizing new portions of the radio frequency spectrum, employing larger and more sophisticated spacecraft antennas, utilizing a satellite as a switchboard in space, and advancing technology to drive down the cost of communications.

As time passed, many concerned with the development and the future of satellite communications came to realize that NASA's 1973 decision to reduce R&D in the field might indeed close options if advancements in technology such as those just cited did not become available. Mindful of this, NASA, in the fall of 1975, asked the NRC to conduct a study of the federal role in satellite communications research and development. The NRC agreed on October 7, 1975, to undertake the study and decided that the work should be done by a new Committee on Satellite Communications (COSC) under the NRC's Space

cant background information and working papers assembled by the Committee during its deliberations will be published separately.[2]

[1] INTRODUCTION

In the one hundred years since the invention of the telephone, telecommunications has become a pervasive part of the developed world. The telephone is in nearly every home and in every office in the United States, and there is about one telephone for every ten persons on earth. Radio broadcasting and other radio links have become commonplace tools for providing both entertainment and services. Television provides entertainment, news, and educational services to most homes in the technologically developed countries of the world. There remain, however, some troubling limitations to further improvements in communications services. For example, the cost of providing telephone or TV service by conventional means is high in remote and sparsely populated regions. Thus, the Rural Electrification Administration has made and guaranteed about $650 million in federal loans annually to stimulate an extensive rural telephone service now serving 3.1 million subscribers in 47 states.

High frequency radio is widely used to span great distances but suffers from outages caused by solar disturbances of the ionosphere. As a result, ships and aircraft are frequently out of communication with their bases for long periods or during critical phases of their journeys. High frequency radio is also severely spectrum-limited and its use is largely confined to the provision of voice and low-speed data services. First steps in improving ship communications began in 1976 with the launch of COMSAT General's MARISAT satellites which now provide urgently needed, reliable services to U.S. Navy and commercial ships in the Atlantic and Pacific Ocean basins.

Nineteen years ago when the first satellites were launched, it was clear that they could serve as high-altitude relay stations and thus overcome some of the limitations of terrestrial communications systems. First efforts involved bouncing radio signals from orbiting balloons and even from earth's natural satellite, the moon. Another approach involved the use of a receiver-transmitter, called a transponder, in a satellite to relay signals from one distant point on earth to another. Early efforts using low-altitude satellites showed the feasibility of the transponder technique, but such satellites had short orbital periods, did not remain within sight of the earth stations at all times, and required that earth stations continuously track those satellites in view.

The promise of communications via satellite was realized with the use of satellites in geostationary orbits at an altitude of 36,000 km [kilometers]. At that height, the orbit period, synchronized with the earth's rotation, places the satellite in an essentially stationary position above a selected point on the equator and within line-of-sight of about one-third of the earth's surface. This possibility [2] for providing continuity of service and solving the tracking problem was pointed out by Arthur Clarke[3] in 1945 and first achieved by NASA's SYNCOM in 1963.

In 1963, the U.S. Congress established the Communications Satellite Corporation (COMSAT) to bring about a commercial international satellite communications system as quickly as possible and to represent the U.S. in the International Telecommunications Satellite Organization. International satellite communications service began in 1965 with

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2. *Federal Research and Development for Satellite Communications: Working Papers*. Committee on Satellite Communications of the Space Applications Board, National Research Council. National Academy of Sciences, Washington, D.C., 1977.

3. Clark, A.C. "Extraterrestrial Relays," *Wireless World*. October, 1945, pp. 305–308.

By 1975, critics were beginning to call into question NASA's decision to withdraw its support from the research and development (R&D) of communications satellites. Such critics argued that the nation needed a government program to investigate related technologies in their early stages of development, as well as to explore technologies and applications that were not clearly linked to private-sector objectives. In response, NASA contracted with the independent National Research Council to conduct a study on whether there was a justifiable federal role in communications satellite R&D. The study concluded that there was definitely a need for such a program (excerpts of the study report are included here). This conclusion formed one of the bases for NASA going ahead with the controversial Advanced Communications Technology Satellite (ACTS) program; ACTS was finally launched in September 1993.

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Report of the
COMMITTEE ON SATELLITE COMMUNICATIONS
of the
SPACE APPLICATIONS BOARD
ASSEMBLY OF ENGINEERING
NATIONAL RESEARCH COUNCIL

Federal Research and Development for Satellite Communications

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PREFACE

In January 1973, the National Aeronautics and Space Administration (NASA), faced with the necessity of reducing expenditures, examined its programs to determine what could be eliminated. While NASA made a number of reductions, one of interest to this study was the decision to essentially eliminate its satellite communications activities because this was felt to be a relatively mature field and NASA believed that R&D in support of future activities could be provided by the communications industry. Since January 1973, several organizations have assessed the consequences of that decision and have urged that the decision be re-examined.[1]

In late 1975, NASA asked and the National Research Council agreed to study further the question "Should federal research and development on satellite communications be resumed and, if so, what is the proper federal role in this field?" To undertake the study, a Committee on Satellite Communications (COSC) was formed under the auspices of the Space Applications Board (SAB). This report presents the Committee's findings; signifi-

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1. "The Federal Role in Communications Satellite R&D," American Institute of Aeronautics and Astronautics, New York City, 1975; "The NASA R&D Program on Satellite Communications," A Position Paper of the Satellite Telecommunications Section, Communications and Industrial Electronics Division, Electronic Industries Association and the Government Products Division, Electronics Industries Association, Washington, D.C., 1974; untitled paper, Aerospace and Electronic Systems Group, The Institute of Electrical and Electronic Engineers, Inc., Washington, D.C., 1976.

Plumbrook cut because this is where all the nuclear work was going on. However, we have indicated that until we can get things sorted out, we would not accept a cut at Marshall or elsewhere at this time. We stated, instead, that a number roughly approximating the 1880 would be coming out of NASA's budget, but exactly where these cuts would be made we will determine later. In the meantime, I want to make a major effort to see whether we can "sell" the excess NASA capabilities to agencies such as EPA [Environmental Protection Agency] (for Lewis) and the DOT [Department of Transportation] (for Marshall). This is different from what we attempted last year when indicated that we would make NASA capability available as a service to these other agencies. After trying for a year to make that work, it just is clear that it won't. Instead, our intention now is to "spin off" some of the capabilities directly to other agencies so that they can develop an in-house capability.

As I mentioned before, I spent Monday, December 18, writing our reclama letter to Weinberger, and, in addition, writing a letter to Kissinger soliciting his support on Viking. Copies of the drafts of these letters are attached. In the [6] meantime, Fletcher had been working with Whitehead, Anders, and Jon Rose to get their G-2 on what was really going on in the White House, and, at the same time, he also received their free advice. Jon, who is used to dealing within the White House, felt that the letters that I had written might make their mark with OMB but he really felt that they were needed with Erlichman and Flanigan and were not suitable for that purpose. Accordingly, he rewrote both letters just before Fletcher had a meeting with Weinberger and Morrill on December 19 (I was back in Houston at that time). A copy of their rewrite is also attached. There were no changes in substance with one exception: the engine refan program was back in the words but not back in the budget. This is a program where a great deal of pressure has been applied to the Vice President's office and Bill Anders would, therefore, like to see it back in the budget. We indicated to OMB that we would certainly undertake the project if additional money were added over and above the mark for this purpose. At the time of this writing, it is quite probable that this money will be added. I forgot to mention that Bill Anders met with us on the 18th, and that we engaged in a very significant philosophical argument with him. It is Bill's opinion (shared apparently by all White House staffers) that NASA's main objectives should be to explore and to provide launch services. Subjects such as applications and science we should only do as a service for others, and, therefore, should seek their funding, e.g., user agencies or NSF [National Science Foundation], for this purpose. Both Fletcher and I engaged in a fairly vehement argument with Anders on this point. Although I don't think we persuaded Anders, at least he knows where we stand.

Our budget submission as revised, was only approximately $50 million over the OMB mark for both FY 1973 and FY 1974. Weinberger was apparently quite pleased with our proposals, and it is quite probable that they will be accepted. However, at the time of Christmas weekend we have not yet heard positively that our proposals have been accepted or that the NASA budget is locked up. As a final afterthought, Fletcher went back to Weinberger and asked him whether it wouldn't be possible to reinstate OSO. The reasoning is that this might be a minor concession to make to the scientific community. [7] This reinstatement, of course, we could only make with additional funding. This, too, is an open item at the time of this writing.

Document I-28

Document title: Committee on Satellite Communications, Space Applications Board, Assembly of Engineering, National Research Council, "Federal Research and Development for Satellite Communications," 1977.

Source: National Research Council, National Academy of Sciences, Washington, D.C.

Within NASA we were fairly unanimous in deciding that a Viking cut would be unacceptable. First of all, Viking is the only highly visible sign of space exploration in the middle 70's. Secondly, more than half of the $800 to $900 million on Viking has already been spent. Third, it would be almost impossible to sustain the support of the scientific community for the rest of the NASA program if Viking were cancelled. For all of these reasons and many more, we decided to do our best to try to get Viking back into the budget. My first inclination was to try to cancel the ASTP [Apollo-Soyuz Test Project] mission, since from NASA's point of view it contributed least to our overall program. However, after some discussion and after some G-2ing by Fletcher, it became very clear that the President considers ASTP the highest priority NASA mission, and that any suggestion on our part to cancel this flight would be totally unacceptable. The President also considers the Shuttle the second priority NASA mission, and, we were told, would not consider cancelling [4] that project. From NASA's point of view, of course, it was clear that at a $3 billion level we would not have started either the Shuttle or ASTP. Thus, we were in a major bind.

I then suggested that it might be time to phase out of the communications business. The reasoning here goes something like this: NASA has been a catalyst for space communications development in the early phase of the space program and until now. However, there now has developed a significant communications satellite capability in private industry. For example, COMSAT/INTELSAT is spending $14 million a year on advanced R&D. It is clear, therefore, that communications work will go on whether or not NASA participates. Of course, there are some areas, such as direct broadcasting, which will take much longer without federal government participation. In other areas of applications, such as earth resources, environmental work, etc., there exists no commercial/industrial capability that will carry on if the federal government gets out of it. I, therefore, reasoned that it would be best to do one applications area well instead of doing two major areas not nearly so well. Fletcher at first was quite reluctant to accept this reasoning, but after a day or so of thinking about it, enthusiastically supported it. As a result, we decided to propose cancellation of ATS-G, to carry out ATS-F because most of the money on it was already spent, but at the same time to phase down all in-house communications R&D so that by the time ATS-F flies we will completely phase out of this business. Incidentally, this may be a major first for a government agency to get out of an R&D business of its own volition.

In the Office of Space Science we decided to keep Viking, but suspend HEAO [High Energy Astronomy Observatory]. Suspending a program is something else that has never happened in NASA before. Basically, we would keep a skeleton team together, both in NASA and in industry, for a year or more while we reviewed HEAO to determine whether we can meet its objectives at, for example, half the costs. Naugle was in favor of outright cancellation, if this were the case, but my view was that through suspension we might be able to pick the project up again without again seeking a "new start." In space science also, OSO is no longer in [5] the program as we submitted it (I will come back to that later), and there were many across-the-board cuts.

In OAST [Office of Aeronautics and Space Technology], in our basic and first submission, QUESTOL and the engine refanning were out, almost all nuclear work was canceled, and there were additional cuts in SRT/ART. In the overall SRT/ART program, I established guidelines that 90% of this work should have a promise of being relevant within a period of seven years; and that only 10% of our SRT/ART work should be in the future beyond the seven-year period.

In Manned Space Flight, Skylab and ASTP were left as they were, and the Shuttle was cut back somewhat in costs and thereby delayed by a total of one year, considering the schedule changes already made by previous 1973 expenditure cuts on top of the present cuts.

OMB also suggested major cuts in personnel totaling 1880 with the bulk of these coming at Marshall and at Lewis/Plumbrook. We have, in effect, accepted the Lewis/

and meeting on NASA's fiscal year 1973 and fiscal year 1974 budgets with officials of the Office of Management and Budget (OMB) in Washington. To meet the stringent budget cuts proposed by the Nixon administration's OMB, it was Low's idea to take NASA out of communications satellite research and development (R&D). NASA had had an Applications Technology Satellite (ATS) program since 1963 to follow up its support of the initial Relay and Syncom projects, and that program had helped develop many new technologies and capabilities in the communications satellite area. The NASA decision to withdraw from communications satellite R&D meant that the final ATS mission, the ATS-G, was canceled.

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[1] December 23, 1972

PERSONAL NOTES NO. 83

[2] Fiscal Year 1973 and 1974 Budget

Meanwhile back on earth, things weren't going quite as well. On Monday, December 11, approximately at the time of the lunar landing, we received a call from Bill Morrill asking Fletcher, Lilly, and me to meet with him to discuss the FY 1973 and 1974 budgets. We tried to get him to give us our mark by telephone, but he was unable to do so. As a result, Fletcher, McCurdy, Shapley, Lilly, and I traveled back to Washington on Wednesday, December 13, roughly between EVAs 2 and 3. (We were in Houston for the full period of both of these EVAs.)

We met in Bill Morrill's office with Morrill, Young, and Taft. (We had left Houston at 5:15 in the morning on a Jet Star for Andrews [Air Force Base] and arrived in Morrill's office at precisely 9:30, the time of the appointment.) Morrill informed us that the President was determined to bring the FY 1973 budget down to a $250 billion ceiling in outlays, and to have a not too much higher number for FY 1974. As a result, all departments and agencies had to take major cuts, both in FY 1973 and in FY 1974. The 1973 cuts were particularly difficult to sustain, since only one-half year was left for money savings. In effect then, any cut made in 1973 would have double the normal effect. In NASA's case, OMB had accepted the "submarginal submission" and made drastic cuts below that level. Within the submarginal budget, we had already cut out the aircraft engine retrofit work, most of the new starts, almost all of the nuclear work, and had cut back in many other areas. The OMB mark, in addition, canceled Viking, canceled QUESTOL, delayed the Shuttle, delayed ERTS-B [Earth Resources Technology Satellite or Landsat] (did not allow ERTS-C in the Interior budget), and made further across-the-board cuts. (I should [3] have mentioned that OSO-I was also cancelled in our submarginal submission.) The net result was a budget at approximately the $3 billion level in outlays for both FY 1973 and FY 1974. We were also told that the number of cuts were policy decisions approved by the President and not ours to change. These were particularly the major ones such as Viking, OSO [Orbiting Solar Observatory], nuclear work, QUESTOL, etc. In the area of minor cuts, we would be allowed to make adjustments. The President then also asked, we were told personally, that a fairly substantial number of dollars be included in the NASA budget on the supersonic transport, with the words that he felt that this was a mandatory development for the country and that NASA should take on the fight with the Congress.

Our meeting lasted for about an hour, and following that meeting, Lilly continued to meet with Young and Taft for approximately one more hour. We then got back on our airplane and returned to Houston. We held additional meetings on the plane on the way back to Houston, in Houston the next morning, and then returned to Washington immediately after the lunar rendezvous and docking for meetings on the following Friday, Saturday, Sunday, and Monday. By Sunday noon we had firmed up our position and Monday was spent in writing the position for a reclama submission to OMB.

of all U.S. communications on the ground for purposes of rate averaging. Moreover, Comsat has additional problems as an international operative. At one time I urged that Intelsat be encouraged to become a truly international communications carrier, supplying domestic communications services for the world as well as internationally. It seemed to me an appropriate, and symbolic, peaceful venture for nations in need of one. But that idea never caught on either. So now, it seems, we are doomed to a world in which every nation must have not only its own airline, merchant marine, and steel mill, but its own domestic satellite system as well. Given such a world, however, it seems to me inappropriate for Comsat—already carrying the burdens of Big Brotherism into its international meetings—to have to confront its world partners with the potential conflicts of interest (and division of managerial energies) involved in operating the world's most lucrative domestic satellite system.

(3) If we are not to have an experimental system or a chosen instrument, because of a deistic reverence for competition, then we ought to really have competition. I'm reminded of the children's riddle: [867] "Where does an 800-pound gorilla sleep?" And the answer: "Any place he chooses." True competition is one of the most highly regulated states of economic operation possible. That's what the antitrust laws are all about—when they're enforced. You either keep the 800-pound gorilla (in this case the $18 billion Bell) out of the canary cage entirely, or you tell him where to sleep.

If we're really serious about experimenting with the radical notion of free private enterprise, I'm all for it. But then there have to be some very meaningful restraints on AT&T and Comsat—at the very least in the initial stages. Otherwise, we're just kidding ourselves—though very likely nobody else.

If we want a competitive arena I would keep out AT&T and Comsat entirely. (AT&T has never been consistently enthusiastic about using space anyway.) Let anyone else in who wants in. Let them experiment with equipment and the search for services and markets. Try to maintain some conditions of fair competition. If after a few years the Commission wants to reassess this decision, and let AT&T into the business in ways consistent with maintaining this newly burgeoning industry, fine. But not until then.

(4) Finally, I cannot but bemoan our failure to provide expressly for—at least—free interconnection for the Public Broadcasting Corporation and other educational users. I always felt that the Ford Foundation had made a fairly persuasive case that more was called for. The American people, having invested more than $40 billion in the soaring growth stock called civilian space, are entitled, someday, to a little bit of a dividend. One has yet to be declared. Ford proposed that a proportion of the savings to the commercial networks from the use of space be passed on to the public in terms of a funding source for public broadcasting. It seemed to me a fair idea.

But all this is history. We're now in countdown. It's no time to dissent. I'm on board.

Document I-27

Document title: George M. Low, Deputy Administrator, NASA, "Personal Notes," December 23, 1972.

Source: George M. Low Papers, Rensselaer Polytechnic Institute, Troy, New York (used with permission).

George Low was NASA's deputy administrator from the fall of 1970 until 1976. During that period, he dictated "personal notes" on a regular basis to record his actions and thoughts. These notes provide a fascinating record of the events of the time. As the Apollo 17 astronauts explored the Moon during the last Apollo mission in December 1972, Low, NASA Administrator James Fletcher, and other top NASA officials had to divide their time between monitoring the lunar surface activity from Houston

We are entering into a new area of communications. The next few years will be years of experimentation and gathering of experience. It's not that we don't know how to launch and operate a satellite. Comsat, NASA, the military, and numerous American companies have a great deal of expertise in this field.

But we have no experience with the non-technical aspects of this operation. Will the public tolerate the short delay, or echo effect, in voice communications by satellite? What new institutional (and possibly personal) uses of communications will evolve to use the peculiar qualities of satellite distribution systems (cheaper long-haul costs, possibility of multiple distribution points, and so forth)? What problems will arise in joint operations of satellites, or of earth stations? What new ratemaking or regulatory concepts and procedures will be needed?

(1) Accordingly, I still believe there is some merit to the idea of a pilot project at this stage. Rather than have it operated by a chosen company (Comsat, AT&T, some other present company, or a new entity), however, I would have it operated by NASA or some other entity of government. This is not such a radical idea. It is the way every other nation in the world has dealt with the problem. And most have resolved the issue long before us. It is the way, in fact, that we run our space program. It is the way we evolve new technology in many areas of the economy. And, even as to space communications satellites, the military and NASA have already operated such systems.

All I would propose is that for the first generation of experience (3 to 7 years) a public entity undertake the operation of America's first domestic communications satellite system for the benefit of all potential users and operators. Every effort would be made to test, at cost, any reasonable proposal from any American company, institution, or individual. The results of all tests would be made fully open to any interested party. Training opportunities would be made avail- [866] able to as many interested persons as possible. This would save a tremendous amount of money for American business, as well as the public, and open up the possibility of a great deal more use (and competition—if that's what we're *really* interested in) when the system or systems are finally established on a commercial basis.

I have made this proposal throughout my six year term at the Commission. It has never received the support of the White House or a majority of the Commissioners. There is little doubt in my mind that we would be much further down the road today if it had been adopted in 1966.

(2) If there is not to be an experimental system, there is much to be said for a chosen instrument. A single system operator can insure economies of scale, fair and open access to all comers, the lowest possible rates, and the most geographically disbursed system (including, for example, the best service to Alaska, Hawaii and so forth).

My preference would be to create a new entity—a Domsat—for domestic satellite services only, that would have every incentive to compete fully with AT&T. No carrier would be permitted to hold stock in the company or sit on the board (although, of course, individual shareholders could hold stock in AT&T and Domsat).

Another alternative would be to give AT&T a monopoly over domestic satellite service. AT&T is now having some growing pains even keeping up with expanding service on earth. But AT&T exclusive operation in space would have the advantage that all users—including the homeowner—would get *some* benefit from the new technology, which will now flow almost exclusively to large corporate users of satellites. If this were done, AT&T should probably want to be required to provide such service through a separate corporate entity for purposes of bookkeeping (as its current corporate practices would indicate it would probably want to do anyway).

Comsat could also be the chosen instrument. It does have the expertise. But it would not have the advantage just described that AT&T would have—virtually monopoly control

report and order had been drafted, and tentative expressions of the position of each Commissioner had been made.

Before issuing it, however, then-Chairman Hyde took the document to the White House to inform the White House staff of the action the Commission was to take. In the interim there had been a change in Administration, and the information-providing trip resulted in a request that the Commission hold any action while the White House once again examined the policy questions.

The White House recommendations, for an "open-entry" policy, came in a January 1970 memorandum from Peter Flanigan to Chairman Dean Burch. In March 1970 an FCC Report and Order, 22 F.C.C. 2d 86, concluded that no decision could be made on the appropriate policy for domestic satellite entry and specific proposals from potential entrants were requested. The next Commission order, and the staff's recommended decision came in March 1972.

Today's action seems to signal the end. Open entry is adopted with certain modifications. The benefits to be realized by public broadcasting are, at this point, speculative.

There are several interesting conclusions to be drawn about the Commission's role in policymaking at least for domestic satellites.

(1) The Commission has relied heavily on the parties appearing before it for the analyses and proposals it has considered. Although there is no readily available way to make an exact calculation, I suspect that most of the important parties appearing before the Commission have invested significantly more resources, each, on these policy questions than has the Commission in total. This seems particularly true for the Executive Branch. The Commission has been a "captive," responding to and arbitrating between the variety of forces which have attempted to move it.

(2) The relative congruence between Commission action and White House recommendation, occurring over periods of significant shifts in policy, is striking. The ability of the Commission to move in variance with White House positions on important policy questions (regardless of who is President) is very questionable.

(3) The effects, benefits and costs, of both regulation and delay would be worthy of a detailed analysis. Suppose any entrant, including ABC, had been able to launch a satellite system in 1965 by merely "purchasing" the needed resources, including spectrum. Suppose the Commission had gone ahead with a pilot program authorization in early 1969. What would have been the results of these—or other alternatives—on services, technology development, and so forth? Are we better off, or worse today? Should the domestic satellite question have been handled differently, and if so, what can we learn about [865] handling other policy questions before this and other governmental agencies that engage in an economic planning function?

(4) Over and over again the Commission meets the question of melding competitive and monopoly portions of the telecommunications common carrier industry. The issues were joined in the Telpak and other bulk offering and private line proceedings, and are still unresolved. They are met again in the relationships between monopoly landline telephone companies and miscellaneous carriers who offer a variety of land mobile services in competition and monopoly in communications equipment and interconnection. They are met in the pricing questions surrounding the entry of specialized competitive carriers. And they are met here in the treatment, particularly of AT&T and Comsat, of certain entrants for domestic satellite services. The issues remain unresolved.

Given these limitations, I believe the staff work and ultimate Commission position put forward today is much better than anyone had a right to expect. Accordingly, as a realist, I concur.

Because of the significance of the policy, however, perhaps a few more words regarding my own preferred approach to decision would be appropriate.

own strong conviction, in view of the decision as here formulated, is that AT&T will *not* so choose. Why should it, in effect, subsidize its own competition—and competition operating under a protective umbrella at that—by [863] filling idle satellite capacity with the only substantial traffic now available?

There is, in all candor, no ideal solution to this problem. Our job is to come up with the best alternative *available*—and I make no apologies for thus relying on marketplace realities in an effort to bring to the consuming public some immediate benefits of a new technology. In my view, the answer is to be found in an approach that affirms in essence the AT&T/Comsat contractual arrangement but then attaches to it one critical condition: namely, that Comsat, with its unique technical and managerial expertise, also provide satellite service to those entities who, lacking the initial nucleus of assured traffic, might be unwilling or unable to risk the huge investment necessary to launch satellite facilities of their own. As an alternative, Comsat should be free to elect the route of an end-to-end retailer.

The majority attempts to "structure" behavior largely by recourse to penalties and blue-sky "models" of pure competition. But the proposal before use, in my judgment, suffers from two fatal flaws: it may retard the evolution of satellite technology, not get it going, and it may thus withhold realistic benefits to the public. The Commission can and must do better than that.

(Commissioners Reid and Wiley join with Chairman Burch in this Dissenting Statement.)

CONCURRING OPINION OF COMMISSIONER NICHOLAS JOHNSON

The Commission now arrives at the denouncement of this seven year old proceeding. An examination of the plot of this story, and its several acts, gives a revealing insight to the policymaking process at the FCC.

Domestic satellites became a policy question at the FCC, not because of Commission action, but with the filing of a proposal for domestic satellite television network interconnection by ABC in September 1965. To examine the important policy questions before taking definitive action, the Commission returned the ABC application and instituted an inquiry. 31 F.R. 3507 (March 2, 1966).

In response to the inquiry, the Ford Foundation filed a proposal in August 1966 linking the financing of public broadcasting to the institution of domestic satellite service. Under the Ford plan, the savings in interconnection costs would be used to finance public broadcasting as a "people dividend" from the $40 billion of public expenditures to develop the space technology that made the satellite system possible. This was a proposed alternative use of the savings—rather than flowing them through to networks' profits, or lower costs to users and their customers. J. Dirlan and A. Kahn, "The Merits of Reserving the Cost-Savings from Domestic Communications Satellites for Support of Educational Television," 77 Yale L.J. 494 (1968).

The FCC responded with a further notice of inquiry. 31 F.R. 13763 (October 20, 1966). In February 1967 President Lyndon Johnson proposed the legislation that later became the Public Broadcasting Act of 1967. And in April 1967 Comsat proposed a pilot domestic satellite system to demonstrate the potential and benefits of satellites, including their use for public broadcasting.

[864] On August 14, 1967, President Johnson announced the formation of a Task Force to review a variety of telecommunications policy questions, including domestic satellites. This began what was to become a three year review by the Executive Branch of important policy questions before the FCC in this area. By late 1968 the Johnson Task Force had completed its work with a recommendation that a Comsat-directed pilot program be authorized. In early 1969 the FCC was prepared to authorize such a pilot program. A

excessive trade-off of present and near-term benefits for mostly speculative long[-]range developments that, in any case, may be a wash from the consumers' perspective.

(b) Other inhibitions and restrictions are rationalized (see in particular pars. 9 and 11) on the ground that AT&T's "unique advantage" of being able to fill satellite capacity with existing and predictable future traffic will inevitably produce "unfair" competition and somehow disserve the public. I find this an ironic twist indeed—that "success" is to be penalized rather than rewarded and that economies of scale must be foresworn as inconsistent with a theoretical model of pure competition (for traffic that is mostly a gleam in some speculators' eyes). The Commission would have been better advised, in my view, to take existing traffic as a "given" and then attempt to build from there—with safeguards, as specified in the earlier Specialized Common Carrier decision, against undue dominance of these specialized markets by existing carriers. This might have redounded to the immediate benefit of the consuming public, available alike to AT&T's customers and to its competitors', in the form of lowest unit costs.

(c) The Commission majority, by contrast, stands the usual norms of [862] competition on their head. In its attempt to "structure" the marketplace rather than permit full and fair competition between new and existing carriers, the Commission in effect ignores its sound commitment in the Specialized Common Carrier decision not to create any "protective umbrella" for new entrants or "any artificial bolstering of operations that cannot succeed on their own merits." Thus, AT&T is precluded from providing point-to-point private-line services via satellite—even though, as the majority acknowledges, "other applicants, lacking a[n] initial traffic nucleus, would be operating with lightly loaded, costly facilities." All of which presumably means that the consumer will have to pay artificially inflated rates for specialized services during an initial three-year developmental period (unless by terrestrial facilities alone, wholly in line with the "full and fair" competitive entry formula of the earlier decision, AT&T is able to undersell its competitors anyway). And further, because the majority document is open-ended (see par. 21), this initial period could be extended *ad infinitum* at the Commission's sole discretion. Again, there is the question "who benefits"—except possibly the stockholders of a few specialized carriers operating in a protected marketplace, and all in the much abused name of "competition"!

My overriding concern is not so much that this decision will lead to irrational results as that it may lead to no results at all that will be of substantial public benefit. It is doubly ironic, in view of the majority's determination to inhibit AT&T and that company's own downbeat projections as to the cost/benefits of satellite technology, that AT&T may in the end simply apply for a satellite system of its own. And because its monopoly services—MTT, WATS, AUTOVON—constitute the vast preponderance of present traffic, an AT&T system is the only one that could conceivably achieve an immediate fill and thus conclusively demonstrate its economic viability.

The big loser seems to be the one applicant with genuine experience in space-segment management—namely, Comsat. By rejecting the AT&T/Comsat contractual arrangement out of hand, *rather than attaching conditions that might encourage the evolution of real competition*, the Commission majority has reduced Comsat's effective choice to one: that is, electing to become an end-to-end retail carrier. But even here, the option is more apparent than real. Because of a seemingly innocuous sentence at the end of par. 26 ("In the event that Comsat elects to proceed other than as a carrier's carrier, it will be prohibited from owning or operating domestic satellite facilities at any overseas point served by INTELSAT facilities (staff recommendation, paragraph 114)."), Comsat would be barred from serving any noncontiguous state or territory, would lose its present traffic to these points (almost all of which is traffic to the mainland), and would be left with virtually unutilized "white elephant" earth stations in Alaska, Hawaii, and Puerto Rico. Some option.

The other option—becoming a carrier's carrier and leasing transponders on tariff to all comers, including AT&T—is in the end AT&T's choice and not Comsat's at all. And my

and Order; or whether it desires additional time for the purpose of reframing its proposal consistently with such policies and conditions.[11]

c. The Commission retains full jurisdiction over all aspects of this proceeding.

FEDERAL COMMUNICATIONS COMMISSION
Ben F. Waple, *Secretary*

DISSENTING STATEMENT BY CHAIRMAN BURCH

In this proceeding, the Commission is dealing with matters of extraordinary complexity and even subtlety. We are called on to establish ground rules for an industrial technology that does not yet exist, to serve some present markets and some that are at best speculative—and most difficult of all, the interrelationships between the two. The policy decisions thus arrived at are not in the usual sense definitive: rather, they represent "signals" to the applicants that will cause them to reformulate their proposals, and these in turn will almost surely not be the same as those with which the Commission is here ostensibly dealing. Our objective is to engraft a new and untested technology onto an existing domestic communications complex, whose characteristic problems are essentially independent of satellite technology *per se*.

In approaching such a maze of unpredictables and potential pitfalls, the Commission would have been well advised to adopt a posture of "least is best" (thus making only those decisions necessary to elicit the applicants' genuine intentions), to build from the base of irreducible marketplace realities (namely, AT&T traffic), to discipline itself [861] against the temptation to piggyback on this already complex policy finding its favorite regulatory schemes and hangups (for example, the desire to "get a handle on AT&T"), and to offer all applicants a maximum of options (which might well lead to the evolution of a competitive marketplace in which the consumer will benefit). As a general proposition, I believe the Commission has violated every one of these counsels of caution.

And to whose real benefit? That is most difficult to say. For, although the thread runs through the majority document that its key findings have been made in the interest of "competition," somewhere along the line the overriding purpose of the competitive marketplace seems to have gotten lost: namely, benefit to the consumer in the form of better and/or cheaper goods and services than would otherwise be available. Instead, the Commission has gone off in pursuit of a peculiar and novel form of competition—measured, so far as one can tell, by how many satellite systems go aloft in how many "space segments" (a benchmark that I strongly suspect would strike the typical consumer as irrelevant even if he could grasp its meaning). "Space segment" competition may, of course, translate into consumer benefit one day. Then again it may not. It all depends—and it is here that the majority document leaves pragmatic reality behind and takes off into the blue sky of academic abstraction. For example:

(a) There is repeated reference (see in particular par. 10 and fn. 2a) to "meaningful" and "definitive comparison" between the relative costs "and other advantages" of satellite technology as against terrestrial facilities in providing communications services to the public—most of which services are not unique to satellite technology anyway. This is used as a principal rationale for imposing inhibitions on AT&T, for example. I agree that such "basing point" comparisons are desirable. But this proceeding is not mere academic exercise. Tens of millions of investment dollars are involved, and so are services to the consuming public—present and near-term as well as future. In my judgment, there is an

11. Upon considerations of such responses, the Commission will issue a public notice concerning the procedures we will follow in processing applications.

17. Like the staff and most parties, we think it unwise to attempt to select or prescribe one system (either a consortium of all the applicants or selection of one applicant) or to choose one or more systems through comparative hearings. In addition to the reasons given by the staff (staff recommendation, paragraphs 50–61), which we adopt, such a course would not promote our policy objectives discussed above. However, we are not accepting the alternative recommended by the staff (paragraphs 71–78) or requiring of encouraging consolidations of applicants along guidelines prescribed by the Commission. While we recognize that there may well be advantages to and need for voluntary consolidations or sharing arrangements (such as "launch risk pools") undertaken at the applicants' initiative as a matter of prudent business judgment, we do not deem it advisable to structure the architecture of any joint space segment operations. Rather, we will permit and encourage such arrangements so long as they are consistent with the policy conditions set forth herein. Accordingly, we will accord the system applicants a 30-day period within which to apprise the Commission as to whether they intend to pursue their pending applications, as modified to achieve compliance with this *Second Report and Order*, or whether they desire further time to reframe their proposals.

18. Our decision in favor of multiple entry does not mean that we have opted for a policy of "unlimited or unrestricted open entry." Our aim, as outlined above, is to afford qualified applicants a reasonable opportunity to demonstrate the public advantages in use of the satellite technology as a means of communications. But such entry cannot be "open" in the sense that it is without any restrictions or limitations. Pursuant to statute we must require showings of financial, technical and other qualification and make the requisite finding that a grant of the particular proposal will serve the public interest, con- [851] venience and necessity. Although, as discussed in paragraph 15 above, it is our intention to make such determinations with due regard for the unique circumstances involved here, each applicant must make a sufficient showing of potential public benefit to justify the assignment of orbital locations and frequencies. Moreover, we believe it necessary to impose certain conditions to protect the public from possible detriment and to further the implementation of our policy objectives. In addition to the conditions discussed below, we will require a reasonable showing by any common carrier applicant now engaged in providing essential communications services that revenue requirements related to the proposed domestic satellite venture will not be a burden or detriment to customers for such essential services. . . .

IV. ORDER

[860] 44a. Authority for the policies and conditions adopted herein is contained in Sections 1, 2, 3, 4(i) and (j), 201, 202, 212, 213, 214, 218, 219, 220, 301, 303, 307–309, 310(b), 319, 396, 403 and 605 of the Communications Act of 1934 and Section 102 and 201(c)(8) of the Communications Satellite Act of 1962.

45. Accordingly, IT IS ORDERED, That:

a. The policies and conditions set forth herein, and such portions of the staff recommendation (34 FCC 2d 9) as are expressly approved or clearly consistent with the policies and conditions herein, ARE ADOPTED, effective July 25, 1972.

b. Each of the applicants for domestic communications satellite systems named in paragraph 1 above, SHALL APPRISE THE COMMISSION on or before July 25, 1972, as to whether it intends to pursue its pending system applications, in whole or in part, with such modifications as are required to achieve compliance with the policies and conditions specified in this Second Report

the nation's policies and objectives with respect to the earliest possible establishment of a global communications satellite system, does not preclude authorized carriers from voluntarily disposing of their shares of Comsat stock.[3] All of the major carriers who originally owned Comsat stock, except AT&T, have since divested their interests. While the participation of experienced carriers had a useful function when Comsat was newly organized and gaining communications experience, this relationship warrants reassessment in light of current conditions.

15. Aside from the foregoing basic considerations of fairness and equity we reaffirm the staff recommendation in favor of multiple entry. In this connection it is important also to take cognizance of the fact that the initial implementation of domestic satellites does not confront us with a normal or routine situation. Some departures from conventional standards may be required if the public is to realize the potential benefits of this high capacity technology and we are to pursue our objective of competitive entry. This is true not only in the case of AT&T, but also for other applicants because of different factors. For example, as the staff points out, the capacity proposed by most system applicants substantially exceeds the traffic under their control or firm customer commitments. They are relying primarily on speculative business which they hope will materialize after the facilities become operational. We must, of course, make the requisite statutory findings as to an applicant's financial qualification and ability to implement its proposal, and we can require a reasonable showing that there will be no adverse impact on rates or services to customers of carrier applicants now engaged in providing essential communications services to the public. But if we adhere too strictly to conventional standards in this unconventional situation, such as requiring a persuasive showing by new entrants that competition is reasonably feasible and that the anticipated market can economically support its proposed [850] facilities, most such new applicants may in effect be denied any opportunity to demonstrate the merits of their proposals at their own risk and without potential dangers to existing services—thereby depriving the public of the potential benefits to be derived from diverse approaches by multiple entrants. It is our judgment that the potential benefits to the public warrant the application of rules and policies which will afford a reasonable opportunity for domestic satellite facilities to be established initially on a competitive basis. It is also necessary to retain flexibility to alter our initial determination in the light of evolving circumstances.

III. DETERMINATION ON THE ISSUES

A. Number of systems to be authorized initially

16. In light of the foregoing policy objectives, we have concluded that the public interest would be best served at this initial stage by affording a reasonable opportunity for entry by qualified applicants both pending and new, subject to the showings and conditions described below which we believe to be necessary to implement our objectives and to protect the public. We have reached this decision after consideration of the various alternatives discussed in the staff recommendation (paragraphs 45–78) and the views expressed by the parties.

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3. Indeed, in 1969 Congress amended the 1962 Act to provide for fewer common carrier elected directors in proportion to their decrease in stock ownership in Comsat (47 U.S.C. 733). This schedule contemplates that the percentage of common carrier stock ownership may fall below eight percent, in which event there would be no directors elected by common carriers.

carried over into this new arena. Moreover, the cross-subsidy aspect is only part of the deterrent to a reasonable opportunity for competitive satellite entry in the specialized field and, even if resolved, would not overcome AT&T's unique advantage of being able to control satellite circuit costs by the extent to which it chooses to load the high capacity satellite facilities with telephone traffic while the specialized field is being developed.[2a]

12. All of the foregoing factors and concerns with respect to AT&T, in our judgment, might well result in discouraging or deterring others from attempting to penetrate the markets for specialized services. As a further consequence, AT&T's dominance in the communications field would be extended rather than lessened in the domestic area. This would derogate from our policy of seeking to promote an environment in which new suppliers of communications services would have a bona fide opportunity for competitive entry. This policy was the basis for our decision in the *Specialized Common Carrier Services* proceeding (29 FCC 2d 870). While this policy explicitly accommodates an opportunity for AT&T and other existing carriers to compete "fully and fairly" with new entrants, it does not preclude the Commission from taking reasonable measures to assure that competitive entry would be a meaningful reality in the high capacity satellite field. Paragraph 104 of the *Specialized Carrier* decision states: "We further stress that our policy determination as to new specialized carrier entry terrestrially, does not afford any measure of protection against domestic communications satellite entry or otherwise prejudge our determination in Docket No. 16495 as to what course would best serve the public interest in the domestic satellite field" (29 FCC 2d at 920).

13. The same considerations lead us to conclude that the achievement of our objectives would be prejudiced by authorizing the Comsat/AT&T proposal based on their contractual arrangement. First, since AT&T is a principal source of the domestic service revenue that Comsat would seek to obtain, it is not realistic to expect Comsat to compete vigorously in the provision of specialized services on an end-to-end or "retail" basis and thereby challenge AT&T's terrestrial domination in this field. Secondly, if Comsat should proceed in the dual capacities proposed in its two pending system applications, the revenues that would be guaranteed to Comsat from the AT&T contractual arrangement would give it an extraordinary advantage and head start over all other potential domestic satellite entrants seeking to develop specialized services in competition with Comsat as well as with AT&T's [849] terrestrial services. If Comsat were given the option of serving AT&T soley [sic] and accepted it, such a course would unnecessarily deprive others of the benefit of Comsat's expertise in the communications satellite field. If Comsat were to elect to serve only entities other than AT&T, its expertise and facilities would be available to the public and carriers other than AT&T. But if Comsat is to be authorized to provide satellite services to AT&T, it should operate exclusively as a carrier's carrier—not engaged in retailing communications services to the public—and provide such service under a tariff offering which would afford an opportunity for other carriers to have non-discriminatory access to the same system.

14. Finally, our consideration of the conditions under which AT&T and Comsat should be permitted to enter the domestic satellite field is necessarily affected by AT&T's ownership of 29 percent of Comsat's stock and its ability to elect three of the 15 Comsat directors. Such ownership was contemplated and encouraged by the Congress in enacting the Communications Satellite Act of 1962 (see Section 394(b)(2)). Thus, this is not a matter over which Comsat has any control. However, that Act, which was formulated to meet

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2a. We recognize that AT&T, in its offerings of specialized services, may not, for rate purposes, distinguish between specialized services provided via satellite on the one hand, and terrestrial facilities on the other hand, and thus somewhat alleviate the competitive problem. However, we believe that it will from a regulatory standpoint complicate a definitive comparison between the relative cost and other advantages of satellite and terrestrial facilities in serving the competitive market for specialized services.

(b) to afford a reasonable opportunity for multiple entities to demonstrate how any operational and economic characteristics peculiar to the satellite technology can be used to provide existing and new specialized services more economically and efficiently than can be done by terrestrial facilities;

[847] (c) to facilitate the efficient development of this new resource by removing or neutralizing existing institutional restraints or inhibitions; and

(d) to retain leeway and flexibility in our policy making with respect to the use of satellite technology for domestic communications so as to make such adjustments therein as future experience and circumstances may dictate.

8. We are further of the view that multiple entry is most likely to produce a fruitful demonstration of the extent to which the satellite technology may be used to provide existing and new specialized services more economically and efficiently than can be done by terrestrial facilities. Though specialized services constitute a relatively small percentage of AT&T's total traffic, it is presently the predominant terrestrial supplier of specialized services. There is some existing and potential competition from Western Union and any new specialized carriers authorized pursuant to the Commission's decision in *Specialized Common Carrier Services* (29 FCC 2d 870). But the capacity of their terrestrial facilities is small compared to those of AT&T or the high capacity facilities proposed by the satellite system applicants.[2] The presence of competitive sources of supply of specialized services, both among satellite system licensees and between satellite and terrestrial systems, should encourage service and technical innovation and provide an impetus for efforts to minimize costs and charges to the public.

9. Of course, the incentive for competitive entry by financially responsible satellite system entrepreneurs to develop specialized markets must be meaningful and not just token. This requires that we take appropriate measures toward the end that a reasonable opportunity for effective entry is not defeated or weakened by AT&T, either directly or through its existing or future relationships with Comsat. In this regard, we cannot ignore the effects upon achievement of our objectives that might result from AT&T's existing economic strength and dominance stemming from its permeating presence and influence in all domestic communications markets. Nor can we ignore the ability of AT&T—an ability not possessed by other applicants—to load a high capacity satellite system with MTT and WATS traffic and thereby control the cost of specialized services furnished via that system. Other applicants, lacking a similar initial traffic nucleus, would be operating—at least initially—with lightly loaded, costly facilities until such time as they might succeed in reducing their unit costs by a substantial specialized traffic fill.

10. In addition, where AT&T combines its monopoly and competitive services on the same facilities, it is difficult to identify AT&T relevant costs associated with specialized services to insure that revenues from the monopoly services are not being used to subsidize any part of its competitive services. Thus, if AT&T were permitted unrestricted use of satellites for both monopoly and specialized services, this might obscure any meaningful comparison of operating costs between satellite and terrestrial facilities for the provision of specialized services as [848] well as curtail any realistic opportunity for entry by others to serve the specialized markets via satellite.

11. We recognize that the problem of cross-subsidy now exists with respect to the establishment of rates and identification of relevant costs for specialized services furnished by AT&T terrestrially. However, this longstanding problem would be exacerbated by permitting the troublesome monopoly and competitive service combinations to be

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2. The Commission has also authorized terrestrial facilities to various miscellaneous carriers providing program transmission service to CATV systems and broadcasters.

II. INTRODUCTORY POLICY STATEMENT

4. As the Commission recognized in the 1970 Report (22 FCC 2d at 88, 95–96), and as confirmed by the applications and responses filed pursuant to that Report, the satellite technology has the potential of making significant contributions to the nation's domestic communications structure by providing a better means of serving certain of the existing markets and developing new markets not now being served. There are concrete proposals before us for the use of communications satellites to augment the long-haul terrestrial facilities of existing carriers for point-to-point switched transmissions services, and to connect off-shore distant domestic points (i.e., Alaska, Hawaii, Puerto Rico) to the contiguous states. There are also proposals for the use of satellites as a means of providing point-to-multipoint services, such as program transmission, although plans for such use are now most tentative and uncertain. Other proposals reflect the view that the most important value of domestic satellites at the present time lies in their potential for developing new markets and for expanding existing markets for specialized communications services.

5. Notwithstanding the specific proposals that have been submitted, the true extent and nature of the public benefit that satellites [846] may produce in the domestic field remains [sic] to be demonstrated. The United States has a well-developed and rapidly expanding complex of terrestrial facilities, and advances in terrestrial technology and operations can be expected to continue the present trend toward reduced transmission costs and more efficient services. Although pointing to some increased operational flexibility in the routing of its traffic, the predominant terrestrial carrier, AT&T, disclaims that the satellite technology presently offers any cost savings or other marked advantages over terrestrial facilities in the provision of the switched services that constitute the bulk of its traffic, message toll telephone (MTT) and wide area telephone service (WATS). At the same time, there is an uncertainty, that can only be resolved by actual operating experience, as to whether the time delay inherent in voice communications via synchronous satellites will provide an acceptable quality of service to the general public when domestic telephone traffic is routed indiscriminately and on a large scale basis via satellite and terrestrial facilities.

6. Although the satellite technology appears to have great promise of immediate public benefit in the specialized communications market, here too there are uncertainties as to how effectively and readily satellite services can develop or penetrate that market. Thus, in the area of point-to-multipoint transmission, the commercial broadcast networks are as yet undecided as the whether to use this technology in whole or in part. We do have a concrete proposal for a CATV network from Hughes, expressions of interest by public broadcasting and other educational entities, and the possibility of interest by independent supplies of program material to CATV and broadcast outlets. Moreover, several system applicants, in addition to seeking to attract program transmission business, have premised their proposals on the sale of other specialized services—in part as a complement to existing or proposed terrestrial offerings, but in the main with the expectation of expanding existing special service markets and developing new markets. To be sure, the applications generally do not identify specific services that are new or innovative. However, in our judgment, the uncertain ties as to the nature and scope of the special markets and innovative services that might be stimulated will only be resolved by the experience with operational facilities.

7. Under the circumstances, we will be guided by the following objectives in formulating the policies to govern our licensing and regulation of the construction and use of satellite systems for domestic communications purposes, namely:

(a) to maximize the opportunities for the early acquisition of technical, operational, and marketing data and experience in the use of this technology as a new communications resource for all types of services;

to explore various legal, technical and policy questions associated with the possible authorization of domestic communications satellite facilities to nongovernmental entities. On March 24, 1970, the Commission issued a first *Report and Order* (1970 Report) inviting the submission of applications to assist our determinations (22 FCC 2d 86, 35 F.R. 5356), and consolidated a concurrently issued Notice of Proposal Rule Making (22 FCC 2d 810). In response to the 1970 Report, system applications were filed by the following:

The Western Union Telegraph Company (Western Union)
Hughes Aircraft Company and various telephone operating companies of GTE Service Corporation (Hughes/GTE)
Western Tele-Communications, Inc. (WTCI)
RCA Global Communications Inc. and RCA Alaska Communications, Inc. (RCA Globcom/RCA Alascom or "the RCA applicants")
Communications Satellite Corporation and American Telephone and Telegraph Company (Comsat/AT&T)
Comsat
MCI Lockheed Satellite Corporation (MCI Lockheed)
Fairchild Industries, Inc. (Fairchild)

In addition, applications for earth stations only were filed by:

Hawaiian Telephone Company
Twin County Trans-Video, Inc.
TelePrompTer Corporation
LVO Cable, Inc., and United Video, Inc.
Phoenix Satellite Corporation

[845] 2. Comments and reply comments on the applications and rule making issues were received from the applicants and other interested parties. By a Memorandum Opinion and Order issued on March 17, 1972 (34 FCC 2d 1), the Commission afforded the parties an opportunity to file written comments and to be heard orally on a proposed Second Report and Order (34 FCC 2d 9) recommended by the Chief of the Common Carrier Bureau (staff recommendation). Written comments were received and oral argument before the Commission en banc was held on May 1–2, 1972.[1]

3. Upon consideration of the entire record, we are of the view that the staff recommendation adequately describes the background of this proceeding, the general nature of the pending applications, and the previously filed comments and reply comments of the parties on the applications and rule making issues. Accordingly, we will adopt the descriptive portions of the staff recommendation without reiterating such material here. However, as stated in the Memorandum Opinion and Order of March 17, 1972, our action in designating the staff recommendation for written and oral comment was taken "before reaching any determinations in this matter" and "therefore does not reflect any predisposition by the Commission with respect to the resolution of the issues involved" (34 FCC 2d at 2). The Commission's determinations, which are set forth below, incorporate the staff's reasoning and conclusions on the issues only as expressly indicated herein or to the extent that they are clearly consistent with our statements of policy and conclusions.

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1. The two entities who had not previously participated in this proceeding were granted leave to be heard orally: the Department of Defense and the Network Project (FCC 72-314).The motions of various parties to correct the transcript of oral argument are hereby granted. Some applicants have submitted statements, without leave from the Commission, purportedly in further response to questions from individual Commissioners at the oral argument. While such statements have been placed in the record, we do not rely on them.

[hand-signed: "Leonard H. Marks"]
Leonard H. Marks, Ambassador
Chairman, United States Delegation

Document I-26

Document title: "Second Report and Order in the Matter of Establishment of Domestic Communications-Satellite Facilities by Non-Governmental Entities," Docket No. 16495, June 16, 1972.

Source: *Federal Communications Commission Reports: Decisions and Reports of the Federal Communications Commission of the United States, June 9, 1972 to August 4, 1972*, Volume 35, Second Series (Washington, DC: U.S. Government Printing Office, 1974), pp. 844–851, 860–867.

When the original institutional arrangements for communicating via satellite were discussed during the 1962–1964 period, the White House and Congress focused on setting up a system for international communications as quickly as possible. Little attention was given to issues related to using communications satellites for domestic services within the United States. Beginning in 1966, however, various companies began to apply to the Federal Communications Commission for authorization to develop and operate such domestic satellite systems. This order and accompanying report represent the Federal Communications Commission's decision on the matter, opening the U.S. domestic market to interested multiple providers of various communications services via satellite.

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[844]

Federal Communications Commission Report

F.C.C. 72-531

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C. 20554

In the Matter of		
ESTABLISHMENT OF DOMESTIC COMMUNICATIONS-SATELLITE FACILITIES BY NON-GOVERNMENTAL ENTITIES	} } }	Docket No. 16495

SECOND REPORT AND ORDER

(Adopted June 16, 1972; Released June 16, 1972)

BY THE COMMISSION: CHAIRMAN BURCH DISSENTING AND ISSUING A STATE MENT IN WHICH COMMISSIONERS REID AND WILEY JOIN; COMMISSIONER JOHNSON CONCURRING AND ISSUING A STATEMENT.

I. PROCEEDINGS BEFORE THE COMMISSION

1. This proceeding was instituted by the Commission on March 2, 1966 (Notice of Inquiry, 31 F.R. 3507; Supplemental Notice of Inquiry, October 20, 1966, 31 F.R. 13763)

VII. Future Meetings

The Conference provided for two types of future meetings. First, member and observer countries are to notify the Conference Secretariat if they intend to participate in or observe meetings of the intersessional Preparatory Committee, which is to convene in Washington as soon as possible after May 20, on a date to be notified by the Conference Secretariat. The Committee is then to meet again thereafter at such times as it may decide as necessary to complete its work.

A second plenipotentiary session of the Conference is scheduled to convene in Washington on November 18, 1969.

The Preparatory Committee is intended to be broadly representative of all areas and attitudes. It is encouraged to resolve in an objective manner differences of views presented during the Conference, although it is not empowered to negotiate definitive arrangements. No country will be bound by the views and positions of the Committee's report, whether or not it is represented on the Committee.

The Committee is instructed to elect its own Chairman and to establish its own procedures and methods of work. Its report is to be circulated through the Secretary General of the Conference at least sixty days prior to the reconvening of the Conference. The report will be in [20] the form of draft agreements, with such alternate drafts of specific articles as may be necessary to reflect differences of significant views. However, degrees of support are not to be reflected in the report.

If the Committee should be unable to complete its work in time, it may postpone the reconvening of the Conference and request the host Government (U.S.) to reconvene the Conference at the earliest convenient date.

VIII. Conclusions

From the outset it was known that the task of establishing definitive arrangements for a global commercial communication satellite system would be demanding, complex and time consuming. During the four weeks of this session, the Conference collected, considered and condensed a great many views. This was an essential and desirable first step.

Machinery has now been established for further significant steps, i.e. preparation of drafts and, hopefully, resolving of differences of views. This work is to be done in the intersessional Preparatory Committee. The Committee's work product will be draft agreements, including alternative provisions where appropriate, which all interested countries can consider prior to and at a reconvened session of the Conference, now scheduled for November 1969.

One overriding value of the first session was the educational benefit it offered to all participating countries. Many countries, particularly those not represented on the ICUS, expressed their views at this session for the first time. Many of the earlier published positions of other countries were explained, elaborated and documented. In the increased international understanding it produced, and in the high level of international cooperation it evidenced, this first session was undoubtedly successful. The individual and joint efforts of all the participating representatives and observers, particularly those of the Conference officers and Committee and Working Group Chairmen, have advanced the prospects of successful conclusion of these considerations immeasurably.

The first session appropriately concluded on a note of constructive optimism and cooperation. The provisions for further work and deliberations should make possible [21] a continued valuable exchange of views and timely conclusion of definitive arrangements for the presently operating global commercial communications satellite system established by INTELSAT.

The Chairman of the Delegation wishes to thank the other members of the Delegation for their very able assistance and sound advice.

Document II-8

[1] June 2, 1993

The Honorable Ron Brown
Secretary of Commerce
US Department of Commerce
Herbert C. Hoover Building
14th Street and Constitution Avenue, N.W.
Washington, D.C. 20230

Dear Secretary Brown:

I plan to make a statement on the Senate floor soon about the weather satellite systems operated by the Department of Defense (DoD) and the National Oceanographic and Atmospheric Administration (NOAA). I do not believe that two separate U.S. Government weather satellite systems can be justified any longer given the budget problems we face.

The DoD operates a constellation of two weather satellites called the Defense Meteorological Satellite Program (DMSP). These satellites are flown in sun-synchronous polar orbits (meaning that they cross the same point above the Earth twice a day at the same times every day). They are built by the General Electric Corporation. They are equipped with sensors for imaging clouds, determining moisture and temperature in the atmosphere, and for measuring ocean currents. The data from DMSP is broadcast to tactical users over an encrypted link and at the same time the data is remotely relayed to Omaha's Weather Central for comprehensive analysis. Historically, the DoD system's primary customer was a classified intelligence gathering program.

The National Oceanographic and Atmospheric Administration (NOAA) of the Department of Commerce also operates a constellation of two weather satellites called TIROS. These satellites are also flown in sun-synchronous polar orbits, are built by General Electric, and have sensors for imaging clouds and taking readings of moisture and temperature in the atmosphere. TIROS data also is broadcast directly to users around the world as well as to a central processing location in the United States. TIROS data, however, is completely unclassified.

In terms of capacity, the United States does not need four weather satellites in orbit. In last year's defense authorization act, the conferees directed the Secretary of Defense to develop a comprehensive space investment strategy. As [2] part of this effort, the conferees directed DoD to examine anew the potential for greater cooperation between civil and military weather satellite programs in light of changes in the world and budget pressures.

Merging the two satellite programs will take time—time to design a common system, to determine management arrangements between DoD and NOAA, to build new satellites, and to launch them. Both DoD and NOAA will obviously have to continue to launch and operate their own systems until the new system can be deployed.

Ideally, DoD and NOAA would run out of their current satellites at precisely the same time and precisely when the new system became operational. It appears that this is possible, but not without some planning.

Last year Congress directed NOAA to procure two more TIROS satellites. If this happens, NOAA will have 7 satellites, which could last until 2005, and DoD's inventory of 9 DMSP satellites will last until 2007 or longer. That would mean waiting 12 to 15 years to deploy a common, merged satellite system and waiting several years before starting

These two letters, one from Congressman George E. Brown, chair of the House Committee on Science, Space, and Technology, and the other from Nebraskan Senator Jim Exon, chair of the Senate Subcommittee on Nuclear Deterrence, Arms Control and Defense Intelligence, urged National Oceanic and Atmospheric Administration (NOAA) Administrator D. James Baker and Commerce Secretary Ron Brown to evaluate the concept of converging NOAA's Polar-orbiting Operational Environmental Satellite System with the Department of Defense's Defense Meteorological Satellite Program. These letters helped establish the political basis within Congress for the convergence to take place.

Document II-7

February 22, 1993

Dr. D. James Baker
Acting Under Secretary for Oceans and Atmosphere
U.S. Department of Commerce
Washington, D.C. 20230

Dear Dr. Baker:

I want to congratulate you on your selection to become the next National Oceanic Atmospheric Administration (NOAA) Administrator. I look forward to working with you on the very important programs NOAA has planned for the future. The Committee on Science, Space, and Technology intends to consider a number of dual-use technology and defense convergence issues during the 103rd Congress. In that regard, we believe that the issues related to the convergence of the NOAA Polar Satellite Program with the Defense Meteorological Satellite Program (DMSP) should be re-examined to look for potential opportunities for reducing overall costs. As you know, recent significant changes in agency requirements and policies may be more conducive to a merged system than was the case in the past.

In addition, I feel that the relationship between NOAA's continuing operational global observing system and NASA's planned 15-year Earth Observing System should also be examined to determine the potential benefits and liabilities of closer cooperation on these programs.

I believe that it would be prudent to examine these opportunities for convergence and possible cost savings at the same time rather than separately. Therefore, I ask that NOAA, and as soon as appropriate, NASA and DOD, jointly study and assess the possible benefits and mechanisms for merging all or parts of the three programs and provide a jointly developed plan to the Committee on Science, Space and Technology.

Thank you for your cooperation.

Sincerely,

GEORGE E. BROWN, JR.
Chairman

We are pleased with the promptness and thoroughness with which the Goddard Space Flight Center conducted the feasibility study for a Synchronous Operational Meteorological Satellite which could be built and launched in a short time period should strong National interest dictate such a move. It now appears likely that the earliest we will obtain funds for such a system will be in our regular FY 1968 budget. Therefore, with the extra time available for planning studies, it would seem wise to examine the trade-offs of spacecraft and ground station cost and performance as a function of system design, especially with regard to frequencies and data format.

We consider the continued strong emphasis and support of NASA in this area to be very important.

3. Global observations of atmospheric structure needed for numerical weather forecasting.

As cited in last year's letter this goal continues to carry the highest priority to ESSA from a meteorological point of view, because of the importance of describing the atmosphere adequately in terms required for numerical weather prediction. The schedule of development of the World Weather System is critically dependent upon progress in this area. Therefore, we support ongoing Nimbus flights and those of other advanced satellites in the NASA program [3] which are devoted to attaining this objective. Because of the critical importance of this portion of the NASA program, we are hopeful that adequate priority will continue to be supplied in support of this program element with respect to others in the National budget. We hope NASA will continue, and if possible expand its support of the development and flight test of the new sensors and supporting subsystems in its R&D program in order to provide the technology needed to meet this objective.

The Environmental Science Services Administration is now examining how its present and future operational satellites can satisfy environmental data requirements in other areas than meteorology. Undoubtedly there will be a need for R&D support from NASA in these new areas. I suggest we review this matter after our needs are established and discussions have been held under the leadership of Messrs. Jaffe and D. S. Johnson. We have been most pleased with the joint effort this past year in resolving problems and in allocating available resources to meet operational and R&D meteorological satellite needs. We are looking forward to the continuation of this excellent cooperation.

Sincerely yours,

Robert M. White
Administrator

Document II-7

Document title: George E. Brown, Jr., Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, to D. James Baker, Acting Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, February 22, 1993.

Document II-8

Document title: Jim Exon, Chairman, Subcommittee on Nuclear Deterrence, Arms Control and Defense Intelligence, U.S. Senate, to Ron Brown, Secretary of Commerce, June 2, 1993.

Source: Both in NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

[1] [rubber stamped: "AUG 15 1966']

Dr. Homer E. Newell
Associate Administrator for Space
Science and Applications
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Homer:

I would like to thank you for the briefing given by NASA on its proposed FY 1968 meteorological research and development program at the 1 July 1966 meeting of the Meteorological Satellite Program Review Board (MSPRB). As in the past two years our comments are directed toward an evaluation of the effectiveness of your program plans in the development and improvement of operational meteorological satellite systems.

In arriving at our comments on the NASA R&D program, we have reviewed our letters of the past two years, based on similar briefings. We find that significant progress was made last year with respect to interagency program development and effective use of available resources in attempting to attain program objectives. Our primary objectives have not changed and remain as follows: (1) The establishment and maintenance of a satellite system to obtain global observations on a regular basis, (2) meteorological observations from synchronous altitude, and (3) global observations of atmospheric structure needed for numerical weather forecasting. Following are specific comments with respect to each of these.

1. Global observations on a regular basis.

The initial deployment of the Tiros Operational Satellite (TOS) system, with the launch of the ESSA 1 and ESSA 2 satellites, has been quite successful and is providing very useful data to the meteorological community throughout the world. Launch of ESSA 3 is now imminent due to a recent camera failure on ESSA 1. We are very pleased with the effort, direction and progress being made in the "TIROS M" program. We look forward to this development solving the major problem raised under this objective in our letter last year. The program review showed a line item for "improved HRIR day/night imaging and higher resolution," to be accomplished by a two-channel radiometer (visible and 11 microns) of high resolution. Also, funds were shown for development of a [2] multichannel radiometer under the Nimbus B flight program and in the TOS improvement program. [handwritten underlining on original] We would like to determine whether or not additional radiometer development activity is needed to meet the TOS system requirements. Also, there is a strong requirement to increase the resolution of satellite cloud pictures to one mile (photo resolution). We would like to examine with you the possible technical approaches to meeting this requirement within the framework of the TOS system and the probable costs of doing so. If a reasonable approach can be found, from the point of view of both cost and technology, we would want to proceed with those steps needed to provide this improved operational capability. We consider these programs essential to the full attainment of the first objective and hope that it will be possible for NASA to devote additional resources and increased priority in the NASA R&D program to them.

2. Meteorological observations from synchronous altitude.

The continued progress on meteorological experiments with the ATS series is most gratifying. The data relay experiments being planned jointly by NASA and ESSA, in conjunction with the spinscan camera, will make a major contribution to the development of the World Weather Watch.

SECTION V. AMENDMENTS

This agreement may be amended at any time by the mutual consent of the Agencies concerned. The agreement will be reviewed formally for necessary changes at least once every two years from the date of the agreement or as required at the request of either agency. For particular programs, a Memorandum of Understanding may be used at the working level to clarify any of the functional responsibilities and procedures.

SECTION VI. RELEASE OF PUBLIC INFORMATION

Release of public information on the operational and R&D programs may be initiated by either the Weather Bureau or by NASA. Before any [12] release is issued to the public, however, clearance and final approval must be given by the agency having the assigned function listed in Section 2 D or Section 3 B. Coordinated or joint releases should be issued where appropriate.

SECTION VII. INTERNATIONAL RELATIONS

1. Regarding the international aspects of meteorology and space satellites, international negotiations may be carried out by either agency according to its basic responsibilities and functions as defined in this agreement, with due regard to the provisions 2 and 3 below and subject to normal State Department policy guidance.
2. Where such negotiations imply obligations or place commitments upon the other agency, that agency will be consulted in advance of international agreement or commitment.
3. The design of operational meteorological systems will give due consideration to commitments already expressed or implied by the United States.

Hugh L. Dryden
Deputy Administrator
for JAMES E. WEBB
ADMINISTRATOR, NASA
January 30, 1964

Luther H. Hodges
LUTHER H. HODGES
SECRETARY OF COMMERCE
January 30, 1964

Document II-6

Document title: Robert M. White, Administrator, Environmental Science Services Administration, National Environmental Satellite Center, U.S. Department of Commerce, to Dr. Homer E. Newell, Associate Administrator for Space Science and Applications, NASA, August 15, 1966.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Transcending the turf battles that marked its relationship with NASA in the early 1960s, the U.S. Weather Bureau made progress during the later half of the decade in refining its requirements for an operational meteorological satellite program. Using information gathered from three separate satellite programs—TIROS, Nimbus, and the Advanced Technology Satellite (ATS)—in August 1966, the Weather Bureau issued to NASA this statement outlining its objectives for an operational meteorological satellite program.

[9] 3. The DOC - WB may conduct sensor development but will maintain close liaison with NASA to ensure compatibility with future spacecraft configurations.

C. Funding

NASA will fund for the supporting technology for operational meteorological satellite development programs.

D. Management Procedures

1. Supporting technology for Operational Meteorological Satellite programs is the responsibility of the Office of Space Science and Applications, in NASA Headquarters.

2. NASA will maintain a coordinating mechanism whereby the contributions of the Weather Bureau and other competent agencies can be considered in the development program. It will consist of five members, two nominated by NASA (Chairman), two by the Weather Bureau, and one representing the non-Government meteorological community.

3. The NASA, after considering the advice of the coordinating mechanism, will choose, and allocate space in meteorological satellites for flight tests of experimental meteorological sensors. NASA will fund for these tests, including the costs of flight hardware beyond the preprototype stage, but the execution will be the responsibility of the experimenting agency.

[10] E. Data

1. Data from proven meteorological sensors flown in NASA research and development meteorological satellites, such as TIROS camera data and Nimbus AVCS data, will be made available at the request of the Weather Bureau for operational use on a cost reimbursable basis, for such added costs as may result from the operational requirement.

2. Data from experimental meteorological sensors flown in NASA R&D meteorological satellites, such as the Nimbus HRIR and other new sensor developments of potential operational use, will be made available to the Weather Bureau as soon as practicable on a non-interference basis to NASA missions for the conduct of operational experiments. In the case of these data, the experimenting agency retains exclusive publication rights for a period of eighteen months, but the Weather Bureau may conduct operational experiments during this period with the proviso that dissemination of these data is restricted to such purposes and that scientific publication will not result without the concurrence of the experimenter. NASA will be reimbursed for all additional costs incurred in making such data available to the Weather Bureau.

SECTION IV. METEOROLOGICAL SATELLITE PROGRAM REVIEW BOARD

A Meteorological Satellite Program Review Board is hereby established. [11] The Board is composed of two members each from NASA and DOC - WB with the Associate Administrator for Space Science and Applications of NASA and the Chief of the Weather Bureau serving as co-chairmen. The Board will meet quarterly or at the request of either co-chairman to review the program and consider any substantive issues which may arise. It may make recommendations to the DOC - WB on the resolution of issues concerning the operational programs, and to the NASA concerning the responsiveness of the NASA R&D program to the needs of NOMSS. Either chairman may refer any issue to the Associate Administrator of NASA and to the Assistant Secretary of Commerce for Science and Technology for resolution.

E. Management Responsibilities and Procedures

1. The management of the functions of the Department of Commerce portion of this agreement is a responsibility of the Weather Bureau under the authority delegated by the Secretary of Commerce to the Chief of the Weather Bureau under Department Order No. 91 of May 23, 1963. The Weather Bureau shall provide or obtain the necessary DOC resources for NOMSS and shall serve as the official DOC contact for this program.

2. The management of the NASA portion of this agreement is the responsibility of Headquarters, Office of Space Science and Applications. It shall provide the necessary NASA resources to NOMSS and shall serve as the official NASA contact for this program.

3. The following specific management functions and procedures are agreed upon:

[7] a. The DOC - WB will forward mission requirements to NASA for review and acceptance.

b. NASA will forward the basic plan of approach to the DOC - WB for review and approval.

c. NASA will forward the Project Proposal to the DOC - WB for review and approval.

d. NASA will forward requests for proposals to the DOC - WB for review and comment.

e. A representative of the DOC - WB will be assigned to the NASA GSFC Project Office and will participate in review for source evaluation, definitization of statements of work and project status reviews.

f. NASA will make the final source selection, and will negotiate with and be the single interface with the contractor.

g. NASA will submit to DOC - WB for review and approval the definitized contract work statement, schedules and cost.

h. NASA will forward the final Project Development Plan to the DOC - WB for review and approval.

i. Major changes involving schedules, costs and system performance will be forwarded by NASA to the DOC - WB for review and approval.

[8] j. All changes affecting the interface between NASA provided equipment and DOC - WB equipment will be forwarded to the DOC - WB for review and approval.

F. Interagency Relationships

The DOC - WB will furnish a statement of mission requirements to NASA, and will ensure that such requirements and the resulting project plans meet the needs of DOD and other user agencies.

SECTION III. THE DEVELOPMENT OF SUPPORTING TECHNOLOGY FOR OPERATIONAL METEOROLOGICAL SATELLITES

A. Scope

This section deals only with the development of space technology which is specifically identified as applying to NOMSS.

B. Basic Responsibility and Functions

1. NASA has the basic responsibility for supporting civilian satellite technology.

2. The DOC - WB will submit to NASA estimates of future meteorological satellite requirements and the DOC - WB estimates of present technological limitations to meeting them. NASA will draw up its R&D plans with due consideration of the stated Weather Bureau requirements and will keep DOC fully informed on R&D program plans and developments.

C. Funding

The DOC - WB will submit requests for annual appropriations to carry out NOMSS. The DOC - WB will develop the plans and budget estimates and the justification thereof, with the assistance and support of NASA and user agencies, as appropriate. At the beginning of each fiscal year, or as soon thereafter as funds are appropriated, or as program changes require, the DOC - WB will issue a reimbursement order to NASA for the full amount of funds required for the execution of the NASA portion of the program in accordance with the approved project proposal prepared under this agreement. NASA will account to DOC - WB for the funds so transferred. NASA also will provide necessary reports to the DOC - WB regarding the proposed and actual commitments, obligations and expenditure of these funds, so that DOC - WB [4] may meet its fiscal responsibilities with respect to the funds appropriated to it or otherwise received.

D. Functional Responsibilities

The functions of the DOC - WB and NASA in the conduct of NOMSS are as follows:

1. The Department of Commerce - Weather Bureau shall:
   a. Determine overall meteorological program requirements (including cost and schedule).
   b. Specify quantities to be measured by satellite meteorological instruments.
   c. Approve Project Development Plan and changes involving schedules, resources, interfaces, and performance.
   d. Monitor the performance of the system for meeting meteorological requirements.
   e. Determine the need for replacing a spacecraft that has experienced marginal failure in providing meteorological data.
   f. Operate the Weather Bureau Command and Data Acquisition [CDA] Stations, including control of the operational satellite after NASA has determined that the satellite is ready for operational use.
[5] g. Manage meteorological data analysis activities at the CDA stations.
   h. Communicate operational data from CDA stations to [the National Weather Service Center and the Goddard Space Flight Center (GSFC)] and others, as appropriate.
   i. Process data for integration into weather analyses.
   j. Disseminate data, analyses and forecasts.
   k. Archive the information (processing, storage, retrieval).
   l. Use the data for research and climatological purposes.
   m. Conduct system studies as required to meet its responsibilities.
2. The National Aeronautics and Space Administration shall:
   a. Prepare the Project Development Plan.
   b. Design, engineer, procure and qualify flight spacecraft.
   c. Select and procure launch vehicles.
   d. Maintain and operate launch sites.
   e. Design, construct, and insure initial operational status of Command and Data Acquisition stations.
   f. Prepare the pre-launch of spacecraft and launch vehicle.
   g. Conduct launch operations.
[6] h. Track and determine basic orbit during the useful life of the satellite.
   i. Monitor the engineering status of the satellite and command the satellite during initial time in orbit, and, as requested, during periods of malfunction using the Weather Bureau Command and Data Acquisition stations.
   j. Consult, as appropriated, on technical matters.

[1]

Basic Agreement Between U.S. Department of Commerce and the National Aeronautics and Space Administration Concerning Operational Meteorological Satellite Systems

SECTION 1. AUTHORITY AND PURPOSE

Recognizing the success of the National Aeronautics and Space Administration (NASA) research and development (R&D) meteorological satellite program and the utilization by the Department of Commerce - Weather Bureau (DOC - WB) of satellite data in weather analysis and forecasting; and

Taking note that Congress, also recognizing this success, provided in the Supplemental Appropriation Act of 1962, and thereafter, funds authorizing DOC - WB to establish and operate a system for the continuous observation of world-wide meteorological conditions from space satellites and for the reporting and processing of the data obtained for use in weather forecasting . . .": and

Recognizing the broad responsibilities of NASA under the Space Act for continuing a research and development program for the development of spacecraft technology and meteorological satellite systems for (1) application to operational systems and (2) research activity in the atmospheric sciences; and

Taking note that Congress appropriated separate funds to NASA for the purpose of supporting such an R&D program of spacecraft technology and meteorological satellite systems;

[2] It is, therefore, the purpose of this agreement to define the relationship between, and the functions to be performed by the DOC - WB and NASA (1) in the conduct of operational meteorological satellite programs, and (2) in the development of supporting technology for operational meteorological satellite programs.

SECTION II. ESTABLISHMENT AND OPERATION OF THE NATIONAL OPERATIONAL METEOROLOGICAL SATELLITE SYSTEM

A. Objective

The primary objectives of the National Operational Meteorological Satellite System (NOMSS) is to provide meteorological information for prompt and effective use by the various national meteorological services in weather analysis and prediction. The operation of NOMSS will be based on, but not be limited to, the technology produced in the NASA R&D Meteorological Satellite Program and will satisfy the meteorological requirements of user agencies, subject to limitations of budget, resources of law. The DOC - WB may modify NOMSS as appropriate and in accordance with the terms of this agreement to accommodate changes in meteorological requirements and developments in technology.

[3] B. Basic Responsibility and Functions

1. The DOC - WB by law has the basic responsibility for the establishment and operation of the NOMSS, which includes obtaining necessary funds.

2. Each agency agrees to perform the functions and follow the management duties and procedures set forth in paragraphs D and E of this section.

launching, data retrieval and processing, and dissemination to users.
   b. An organization to perform all activities related to the operational meteorological satellite observing system would be established as a self-contained entity reporting to the Chief of the Weather Bureau.
   c. Coordination will be accomplished by a "Civil-Military Liaison Committee" and resident liaison personnel.
   d. The operational system will be started by the end of Fiscal Year 1962. (Adequate funding is required to accomplish this.)
2. With respect to Research and Development:
   a. NASA has the responsibility for the equipment design and development, launching and data retrieval associated with experimental satellites. The design of the operational space craft will be based on the results of this work.
   b. The Weather Bureau has the responsibility for the data analysis and meteorological research.
3. In operations and research and development, it is assumed that the Department of Defense would be responsible for:
   a. Military application of satellite data and National Meteorological Center products.
[3] b. Specialized communication systems and other facilities to meet unique needs not covered by the National Satellite Meteorological Program.
4. International participation will be developed by existing international bodies such as the World Meteorological Organization. . . .

Document II-5

Document title: Hugh L. Dryden, Deputy Administrator, for James E. Webb, Administrator, NASA, and Luther H. Hodges, Secretary of Commerce, "Basic Agreement Between U.S. Department of Commerce and the National Aeronautics and Space Administration Concerning Operational Meteorological Satellite Systems," January 30, 1964.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington D.C.

When the Interagency Panel on Operational Meteorological Satellites released a plan in April 1961 calling for NASA to develop an operational weather satellite system to be managed by the U.S. Weather Bureau, the bureau was concerned by the lack of influence it had over the developmental stages of this next generation of weather satellites, named Nimbus. Some of these fears were realized as the NASA-managed Nimbus program suffered numerous delays as well as dramatic costs increases. On September 27, 1963, frustrated with NASA's performance, the Weather Bureau announced that it would develop its own satellite system based on the TIROS design, with the Department of Defense providing launch services. Outmaneuvered, NASA agreed to helping the Weather Bureau develop its TIROS-based system, as well as granting it an increased role in developing the Nimbus satellite, which became an experimental rather than an operational system. This agreement codified the NASA-Weather Bureau relationship.

Explorer VII and TIROS I. This report delineates a first approach to the design of the system, the required organization and a method of implementation for obtaining and utilizing meteorological satellite data as soon as possible for daily weather forecasting and storm warnings.

This plan, although preliminary, represents a starting point in formalizing a program, portions of which are already in operation. The plan is circulated among meteorological groups for the purpose of inviting comments and cooperation on how best to take advantage of this epochal new means for observing certain meteorological phenomena and to assist in planning more effectively for future programs.

[hand-signed: "F. W. Reichelderfer"]
F. W. Reichelderfer
Chief of Bureau

November 3, 1960 . . .

[1] I. Goals of a National Plan

The TIROS I Weather Satellite has brought the objective of meteorologists for a world wide observational network a long step toward fulfillment. Conceived initially as a research project, TIROS I demonstrated immediate limited operational value. This monumental scientific achievement is a manifestation of the policy declared by the Congress in the National Aeronautics and Space Act of 1958—"that activities in space should be devoted to peaceful purposes for the benefit of all mankind." The President of the United States in his address to the United Nations General Assembly, September 22, 1960 proposed that "We press forward with a program of international cooperation for constructive uses of outer space under the United Nations. Better weather forecasting, improved world wide communications . . . are but a few of the benefits of such cooperation."

Several additional weather satellite experiments are planned for the next two years. In view of the impact of the increasing operational aspects of the experiments, a national plan leading to a fully operational system is necessary for making maximum use of meteorological satellite data at the earliest possible time.

It is the purpose of this study to formulate a national plan for a common system of meteorological observation satellites. This plan would have the following goals:

1. Complete global coverage.
2. Uninterrupted continuity in time.
3. Design for maximum national and international utilization for the benefit of all mankind.
4. Adequate readout stations to insure timely receipt of all the data.
5. Complete communication facilities to transmit data from the readout stations to the National Meteorological Center and other user points.
6. Analysis of the data received at the National Meteorological Center.

[2] 7. Depiction of these analyses in forms suitable for transmission via adequate communication facilities.

8. Communication of processed data to all domestic (civil and governmental) and international users for application to their particular requirements.
9. Intensive research to improve weather forecasts through the application of satellite data.

For planning purposes it has been assumed that:

1. With respect to the Operational System:
   a. The U. S. Weather Bureau as the National Meteorological Service will have program responsibility for the operational meteorological satellite observing and data processing system. This would include equipment procurement,

required for Project TIROS in excess of the $11,649,000 provided by ARPA.

5. Equipment acquired for Project TIROS will remain available to the Project until its conclusion. The disposition of any such equipment at the conclusion of the Project will be as mutually agreed upon by NASA and DOD.

[hand-signed: "Hugh L. Dryden for"]	[hand-signed: "Ray W. Johnson"]
T. Keith Glennan	Roy W. Johnson
for NASA	for Department of Defense

Document II-4

Document title: U.S. Department of Commerce, Weather Bureau, "National Plan for a Common System of Meteorological Observation Satellites," Technical Planning Study No. 3, Preliminary Draft, October 1960, pp. 1–3.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

When NASA's first TIROS satellite proved highly useful in studying large-scale weather systems, the U.S. Weather Bureau began planning for a fully operational national weather satellite system. The Weather Bureau proposed to remove NASA from its overall lead position to the role of performing research and development in support of the operational system. In October 1960, NASA organized the first meeting of an interagency panel to discuss the issue of an operational system. At the meeting, the Weather Bureau brought forth its plan; the foreword and first section of the study appears here. Predictably, NASA objected to giving up as much control over the program as the U.S. Weather Bureau desired. The result was a compromise plan issued in April 1961.

National Plan for a Common System of Meteorological Observation Satellites

Washington, D.C.
October 1960 . . .

[no page number]

FOREWORD

The present report is a summary of planning that commenced shortly after the successful launching and operation of TIROS I, April–June 1960. The results of this remarkably successful meteorological satellite clearly show that satellites must be included as an integral part of a comprehensive, world-wide weather observing system. Their ability to give complete global coverage, to look at familiar meteorological phenomena from a new vantage point and to reveal organized motions and processes over a great range of dimensions will influence virtually all phases of meteorological development and operations.

Representatives of the government departments directly interested met at the National Aeronautics and Space Administration Headquarters on October 10, 1960 for discussions of how to proceed with an operational meteorological satellite program. Need for a national plan indicated at this meeting prompted issuance of this report at the present time. It represents an effort to utilize results of studies made since 1954, including a 1959 report to the World Meteorological Organization, and experience gained from

Document II-3

Document title: Hugh L. Dryden, for T. Keith Glennan, NASA, and Roy W. Johnson, Department of Defense, "Agreement Between the Department of Defense and the National Aeronautics and Space Administration Regarding the TIROS Meteorological Satellite Project," April 13, 1959.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Among the military space projects President Eisenhower transferred in 1958 to the newly created National Aeronautics and Space Administration was the Television and Infrared Operational Satellite (TIROS) meteorological satellite project, previously controlled by the Department of Defense's Advanced Research Projects Agency. Although the Defense Department continued to participate in the TIROS project and made excellent use of the information returned from operational satellites, this agreement marked the beginning of a permanent split in military/civilian meteorology that led for more than three decades to both the military and the civil sector designing and operating their own meteorological satellite systems.

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[1]

Agreement Between the Department of Defense and the National Aeronautics and Space Administration Regarding the TIROS Meteorological Satellite Project

l. Effective April 13, 1959, the National Aeronautics and Space Administration (NASA) shall assume technical and management direction of the meteorological satellite project designated Project TIROS, as set forth in Order No. 10-59, dated July 25,1958, and Task No. 1 of Order No. 17-59, dated September 4, 1958, of the Advanced Research Projects Agency (ARPA) of the Department of Defense (DOD).

2. In order to insure the complete availability to DOD and NASA of all information developed under Project TIROS and to insure that the respective interests of both are fully recognized in carrying out the Project, the following arrangements are agreed to:

a. A committee will be established under NASA chairmanship, with representation from both DOD and NASA, to advise NASA on technical matters related to Project TIROS, including DOD requirements, and to make any necessary arrangements for the close cooperation and full exchange of information between NASA and DOD.

b. Copies of all NASA directives issued to agencies of DOD in connection with Project TIROS will be furnished to ARPA for information.

c. Copies of all documents pertinent to the conduct of Project TIROS in the possession of ARPA will be furnished to NASA.

3. Contracts under Project TIROS to be funded by DOD will continue to be placed and administered by procuring activities of DOD, subject to the technical and management direction of NASA, and any facilities, equipment and personnel of DOD currently assigned to Project TIROS will remain available to NASA to carry the Project to completion.

[2] 4. ARPA will fund Project TIROS up to a total of $11,649,000. An amount of $6,711,000 has already been committed under ARPA Order No. 10-59, and $2,000,000 under Task No. 1, ARPA Order No. 17-59, leaving a balance of $2,938,000 which will be set aside for obligation by DOD on Project TIROS at the request of NASA. These funds are not, however, available for the construction of facilities. NASA will provide any funds

cal analysis is therefore suggested, in which (*a*) the desired area is divided into small regions of similar climate, geography, etc., and (*b*) a statistical survey of cloud types and associated weather found with various weather situations (fronts, etc.) in each region is made.

3. Owing to the fact that identification of fronts as fronts may be very difficult, it is suggested that it may be possible to identify air masses from high-altitude pictures and to utilize them in the formulation of the synoptic picture. Since general classifications of air masses include as integral identifying features the stability of the air, the moisture, and the type of clouds produced in a given air mass, this should not be too difficult, in many cases. An air-mass identification has the further advantage of establishing more closely the possible limits of the various meteorological parameters.

4. A major advantage of satellite weather observations is the repeated broad spatial coverage. Such broad coverage provides the meteorologist with an essential element for his analysis, which is generally referred to as *continuity*. It permits him to follow a given system as it moves and develops over a period of days. It is a relatively simple matter to identify a system once it is known that such a system is present. Once a weather situation is so identified, it can be earmarked from high-altitude pictures, and not only may it then be tracked across an inaccessible area like an ocean, but any over-all changes or modifications that affect the visible parameters may be almost immediately noticed. It is also likely that, having a complete analysis of the surrounding territory on land, where observations are plentiful, and many satellite observations of the unknown area (through which it is possible to get fixes on systems and to examine visually the over-all weather [23] picture), a complete analysis of the desired region will become a much simpler thing to construct.

Each of the above suggestions affords excellent possibilities of providing the required information. It should he kept in mind, however, that these suggestions appear to offer the best solution when systematically used together. . . .

[31] CONCLUSION

In the section entitled “What Can Be Seen,” . . . it was shown that, given at least 500-ft resolution, it was possible to differentiate between the various types of clouds. Under “Limitations of the Analysis,” . . . the possible limitations to the type of analysis to be studied were indicated. Given the identity of virtually all the cloud forms viewed, it was further shown, in the section entitled “What Can Be Determined from High-Altitude Observations,” . . . that it may be possible to estimate the various meteorological parameters under certain conditions and assumptions. The main assumption was that some estimate of the over-all synoptic situation could be made initially and a “hunting” technique could be applied. Several suggested methods of estimating the synoptic picture were presented and discussed.

This report has attempted to show what is thought to be necessary in the making of such an analysis. It is obvious, however, that, with the limited data available, many important points may inadvertently have been overlooked. An inquiry of this type can therefore serve only as a guide to a full-scale study of the subject, in which every suggestion and method is put to a full test and is either accepted, modified, or discarded.

The development of all the suggested methods mentioned in this report appears to be feasible. As any analysis depends on its integral parts for its accomplishment, from this standpoint, if from no other, the analysis of synoptic weather from satellite observations is also feasible.

to its height, the greater the lapse rate of the surrounding air."

This provides one with very rough criteria for estimating the degree of stability of the air.

To sum up, water vapor in the air is a latent source of heat energy. When moist air is carried rapidly upward, the water vapor condenses in the form of liquid droplets and the latent heat of condensation is released to the surrounding atmosphere. It is this source of latent heat that feeds thunderstorms and other types of vertically developed clouds. Cumulus clouds are an indication of moisture and relative instability, and, conversely, when there is moisture in the air there will be a greater tendency toward convection and turbulence.

Moisture

Clouds, being composed of water droplets, naturally indicate the presence of moisture in the atmosphere (see the above section). Resulting from the difference in formation conditions, cloud types can give a further breakdown of moisture distribution. For example, cumulus and cumuliform clouds of vertical development require the entrainment of continuous supplies of moist air to prevent their complete evaporation shortly after forming. It can therefore be said that with this type of cloud we may associate fairly moist air near the surface. In like manner, positioning of the moisture in the atmosphere may be associated with other cloud forms, and an over-all estimate may be made from visual observations. Once the synoptic picture has been established, closer estimates may be made utilizing the other meteorological parameters, and the value of moisture content may be worked into the "hunting" technique previously mentioned.

Precipitation

Although it will not be possible to observe any form of precipitation directly, it is known that the largest amounts usually fall from two main types of clouds: cumulonimbus (showers—rain, snow, etc.) and nimbostratus (steady precipitation, sleet, etc.). Furthermore, the probability of precipitation in one form or another, which arises whenever these types are present, is higher than for any other types of clouds. Further infor-
[21] mation may be obtained from the fact that it may be possible to distinguish between newly fallen snow and old snow, owing to a difference in albedos (see Table 5 . . .), and the new snow may then be connected with the proper form of cloud observed downwind from it.

[22] SUGGESTED METHODS OF ATTACK ON THE PROBLEM OF DETERMINING THE SYNOPTIC SITUATION

From the above discussion it can be seen that the analysis is based primarily on cloud observations. During the course of this study several systematic methods of accomplishing these presented themselves. Although neither time nor proper data were available for a complete study of these possibilities, the most promising were considered and are presented herewith as a guide to any more intensive study.

1. It is suggested that a typing of clouds as to *cause* rather than *appearance* will greatly facilitate the identification of the synoptic situation. Classification into two main categories would constitute a possible breakdown, as follows: (*a*) Regional clouds (those caused by purely local conditions), and (*b*) migrating cloud systems (clouds that appear to move as a unit). The breakdown might then be coupled with a knowledge of the clouds associated with various weather phenomena to complete the synoptic picture.

2. It is a recognized fact that similar synoptic situations occurring under different climatic and/or topographic conditions may produce radically different weather. A statisti-

bends back on itself with increasing height, the decrease of the horizontal pressure gradient with height is (as Brooks also points out) much stronger than in the previous case. If one assumes that the slope of vertically developed clouds may be observed from 350 mi altitude (at least at the edges of scanning strip), further pressure data may be gathered.

Degree of Stability

As has been mentioned above, the degree of stability in a given layer may be estimated by the amount of vertical development present in clouds. In any mechanism of vertical development, the stability of the air plays a major part. Convective, orographic, or upslope lifting may produce clouds in the absence of instability, but, for any large-scale vertical build-up of clouds, a great tendency for the atmosphere to "overturn" must be present. [original placement of Fig. 4] (Absolute instability is taken to mean that the decrease of temperature with height is greater than the dry adiabatic lapse rate. In the presence of unsaturated water vapor, the dry adiabatic lapse rate is about 9.8°C/km, whereas, in the presence of saturated water vapor, the smaller saturated adiabatic lapse rate with a nonlinear variation of temperature is used.) In the presence of water vapor, the latent heat (energy) of condensation that is released when the air is forced to rise and its moisture forced to condense may be sufficient to continue independently the upward motion. This motion indicates a condition of instability where none may have existed at the beginning of the process. Continuation of this motion, therefore, indicates the instability of the air in the presence of saturated water vapor and is evidenced in towering cumulus or cumulonimbus. If, on the other hand, condensation occurs but the ascending air is not provided with a sufficiently large amount of heat so as to warm it to a higher temperature than that of the surrounding air, the layer is considered absolutely stable and may be characterized by smooth, flat-topped cloud forms, usually arranged in layers or sheets. This is also true when a small layer of instability is "capped" by an inversion (increase of temperature with height). This concept of absolute stability, absolute instability, and conditional instability (unstable or stable depending on whether the water vapor present condenses or not) is presented graphically in Fig. 4.

Fig. 4—Graphical representation of degrees of stability as given by lapse rate of temperature

It may be said that, in the presence of vertically developed clouds, a dry adiabatic lapse rate (or very close to it) exists below the base of the cloud, a relatively steep lapse rate exists within the cloud, and a relatively stable lapse rate exists above the cloud. In [20] the case of flat-topped or sheet-type clouds, it may be that, although instability may exist in a small layer comprising the cloud, an inversion layer of very stable air exists immediately above, causing the cloud to stop its vertical growth.

In his paper on clouds, Brooks[16] suggests the following further refinements on this:

1. Detached, lumpy cloud with a flat base and rounded top has (*a*) adiabatic lapse rate below it, (*b*) greater than saturated-adiabatic lapse rate (unstable) within the cloud, and (*c*) almost the same lapse rate as (*b*) (unstable) from its top to the height that the cloud will grow.
2. Towering, sharply-bounded cumuliform cloud: The diameter of cloud at different levels is an indication of the relative steepness of the lapse rate (except in the presence of large wind shear). "The narrower such a cloud or cloudlet is, relative

16. *Ibid.*

ty will determine the departure from an adiabatic lapse rate, while the degree of cloudiness (moisture) will help an analyst to decide whether to use the moist or the dry adiabatic lapse rate as the limiting one.)

Vertically developed cloud will also aid in determining the temperature gradient of the surrounding area. This is true because of the fact that the vertical shear, as indicated [18] by the slope of towering cumulus and cumulonimbus clouds, orients the direction of the higher and lower temperatures in the areas. This method is employed by taking the direction of vertical shear as being from the low levels toward the high levels. If one then faces in the direction of shear in the northern hemisphere, the lower temperature will be on the observer's left and the higher on the observer's right (see Fig. 3).

This relationship holds for the northern hemisphere. In the southern hemisphere the directions of decreasing and increasing temperature in relations to vertical shear are reversed.

Fig. 3—Vertical wind shear—temperature gradient relationship

Pressure

It is apparent that no quantitative values of pressure are forthcoming from this analysis. Furthermore, it is virtually impossible even to make a quantitative estimate other than to state whether the area is thought to be under the influence of a high- or a low-pressure system. Charts of average pressures for various times of the year in different areas of the world are available. Using these and the weather situation at the time, trends of pressure may be established. This information when applied in conjunction with known weather may be a very useful tool for forecasting purposes. Little work has been attempted on this subject in this pilot study, and the above should serve only as a possible starting point for any detailed research along these lines.

C. F. Brooks[15] points out some further pressure information that may be obtained from clouds. He says, in effect, that, since in the presence of any constant vertical shear the cumulus clouds will tend to lean or slope (the amount of departure from the vertical being a resultant of the vertical velocity and the rate of change of wind velocity with height), any cloud that has a uniform rate of vertical growth and a 90° slope throughout is an indication of the "uniformity of wind velocity in all layers pierced." This indicates a decrease of horizontal pressure gradient with height. (This can be shown very simply by an examination of the geostrophic wind equation

$$V_g = \frac{1}{p}\frac{(\partial p)}{(\partial n)}\frac{1}{\lambda},$$

where V_g = the geostrophic wind velocity
p = density o air
$\partial p / \partial n$ = horizontal pressure gradient
λ = Coriolis parameter.

[19] It can be seen that since λ, which depends on the sine of the latitude, will remain constant and p decreases with height, $\partial p / \partial n$ must also decrease *for* V_g, to remain constant.) This decrease turns out to be very small when actual values are used. In the case of a uniformly growing cumulus that slopes in its lower layers and then straightens or even

15. C. F. Brooks, "Clouds in Aerology and Forecasting," *B. Amer. Meteorol. Soc.*, Vol. 22, November, 1941, pp. 335–345.

winds, cumulus clouds that have formed in mountainous country appear to form to the lee of the mountains rather than to their windward side. In the presence of very light winds, it was noticed that the cumulus tended to form on the peak of the mountain. This phenomenon requires further study before its degree of usefulness as an observational tool can be determined.

3. Owing to the fact that cumulonimbus clouds extend from as low as 1600 ft up to 40,000 ft, their slope becomes a good indication of the vertical shear within the layer. It was first thought that this direction of slope would be an indication of the direction of the upper winds. However, although the wind velocity normally increases with altitude, it is obvious that for any given case one should not disregard the possibility that the wind velocity might decrease with height or that the direction and velocity distribution in the vertical might be of such a nature as to cause the cumulonimbus to slope into the upper wind. When this slope is combined with other factors that indicate wind direction [17] at one particular level, it may be possible to construct a picture of the change of wind direction with height in the layer under consideration.

4. A further indication of wind direction (in the lower levels) was observed when small, detached clouds were seen to form in line, stretching from a mountain top. These could be due to moist air being forced upward by the mountain and then moving downslope on the lee side, causing the formation of small "rotors" or individual cellular eddies each capped by small cumulus clouds and extending for a considerable distance downwind from the mountain. This phenomenon is known as a "standing wave" and is often accompanied by other standing clouds at higher altitudes.

5. It has also been observed in a layer of stratus overlying mountainous terrain that air funneling down a valley and spreading out in a relatively flat section produced lines and swirls in the top of this cloud layer that closely matched the path the air must have taken. This action may be very useful in determining wind direction in sections completely covered by sheet-type clouds and may be found to be of further use over areas that are not particularly mountainous. Although photographs of large flat areas were not available for analysis, it is thought that wind-direction determination in these sections may still be accomplished in the lower levels. This may be done by utilizing many of the above methods and several others that could be an outgrowth of such an analysis. One such method might use the inherent uniform structure of a stratus sheet. In this case it is thought that if a sheet passes over flat ground on which there are isolated protuberances projecting into the sheet, a wake will be produced in the cloud that may also show up when viewed from above and that will stretch downwind from the object.

Temperature

The starting point for any determination of temperature must be the statistical normal for that time of the year. The first estimation may then be modified by the various affecting conditions. The prevailing weather situation provides the first modifying influence. This estimation is, of course, dependent on the analyst's ability to estimate the synoptic conditions with a degree of accuracy that will answer the question, Is the sector under observation being affected by relatively cold or warm air? Cloud systems, wind directions, and even forms of ground cover (snow, etc.) will help in deciding this. This is the first indication of the over-all complexity of this type of analysis and serves as an actual illustration of the "hunting" technique mentioned above.

Upper air temperatures may be estimated in the same manner, clouds indicating the boundaries between air masses (fronts). A further help in estimating this quantity is the fact that, once having decided on a ground temperature, the degree of stability (indicated by vertical development in clouds) and the presence or absence of intervening fronts will enable one to construct an applicable temperature lapse rate. (The degree of stabili-

[Altostratus] Very often these formations contain considerable vertical development.
[Nimbostratus] This seems to be especially true when these forms are associated with the passage of a front.

It is clear that any attempt to formulate an atlas of cloud appearance as seen from high altitude is a major undertaking. The work done on the subject in this report represents, at best, the beginning of the work that must be accomplished to make high-altitude cloud photographs a usable weather tool.

THE ANALYSIS

Having once established the identity of almost all the clouds viewed, the formation of the synoptic weather picture becomes the next problem. The following question arises: Given an over-all cloud picture, what, in fact, can be determined, either directly or indirectly?

According to conventional meteorological practice, the various parameters, such as pressure, temperatures, etc., are plotted on a map, and the subsequent analysis of these quantities produce the synoptic picture. Almost the reverse is true in the case at hand. Here the synoptic situation must first be established, and the various parameters must be estimated from it. Actually, it is not quite so straightforward a procedure. Rather, it becomes a "hunting" technique, in which one makes a first approximation to the over-all weather situation, using the clouds, and, from this, a first estimate of the value of temperature, pressure, humidity, etc. This picture of the weather is then modified to fit [16] obvious deviations of the estimated values from those indirectly observed. This process continues until a satisfactory situation is evolved that appears to fit all existing conditions (an attempt being made to satisfy both physical and theoretical considerations); from this, final estimations of the various parameters are made. (Several possible approaches to the problem of approximating the synoptic picture are discussed in the section entitled "Suggested Methods of Attack on the Problem of Determining the Synoptic Situation.". . .)

The normal observable meteorological parameters may be divided into two main categories, viz., those that may be estimated in some measure directly from observations of the clouds and / or ground, and those that require a knowledge of the over-all weather patterns before an estimate can be made. In the first category may be listed wind, humidity, precipitation, and a variable not normally considered by itself as such—degree of stability. In the second listing may be found pressure (and pressure tendency) and temperature. Before an attempt at its analysis can be made, a considerable amount of experience and general knowledge of the workings of the atmosphere is required concerning each item, regardless of which category it comes under. It is found that this estimation method is neither a quick nor a simple process, regardless of the qualifications of the analyst. Rather, each of the items requires a very careful study and the weighing of all the possible influencing conditions before approximate values can be assigned.

As a result of this pilot study, several suggested methods of estimating the various meteorological parameters were evolved and are discussed as follows:

Wind

1. From the established meteorological models it is assumed that certain definite weather situations will produce certain sequences of clouds preceding or following them. This will therefore tend to orient the situation with respect to the ground. Once this orientation has been established, the wind direction may be approximated through a knowledge of the theoretical circulation associated with a given synoptic weather situation.
2. It has been noticed in several photographs that, in the presence of strong upper

scanned from extreme altitudes might be built up. Using this information, a trained observer should have little trouble in establishing the identity of almost any visible cloud. The importance of such an atlas cannot be over-emphasized, because the degree of confidence in a synoptic picture formed from this type of observation or in the subsequent forecast becomes extremely small if the identity of the clouds cannot be established. An attempt along these lines has been made, utilizing several series of photographs taken from V-2's fired at White Sands, New Mexico. It should be kept in mind, however, that this attempt was made using data which were not originally gathered for this purpose, and the necessary ground observations are therefore not available for positive identification purposes. Because of this, the results presented here are a classification and identification based on the writer's observational experience.

From a study of the above-mentioned photographs it was observed that two general cloud forms stand out from each other under the usable resolution conditions. Since these two forms are also two types of cloud formations, most other clouds can be considered as being a special form or combination of these and may be so categorized. This is partially attempted in the table [below].

It is noticed that certain formations of clouds very often assemble in over-all patterns peculiar to these formations. Clouds, therefore, may also be partially categorized according to pattern. In the case of clouds formed by globular masses joined together to produce a single layer, the pattern is still apparent to an observer on the ground as a result of the differences in light intensities caused by the variations in cloud thickness. It is likely, therefore, from the section on cloud contrast, that these patterns will also be visible to an observer stationed above the layer, owing to the difference in albedo values caused by cloud sections of different thicknesses. These patterns are very useful in cutting down the overlap present in the following table.

[15]

A Vertically Developed	Remarks	**B** Stratiform	Remarks
1. Cumulus }	Varying degrees of	1. Stratus }	In some forms may
2. Cumulonimbus }	vertical development	2. Altostratus }	be very similar.
		3. Cirrostratus	May be distinguished because fibrous texture is visible even when viewed from above.
		4. Nimbostratus	When there is no vertical development on top this form may appear to be very similar to Nos. 1 and 2.

Combinations of A and B (forms similar in appearance are bracketed)

Cloud Formations	**Remarks**
[Altocumulus] [Cirrocumulus]	Altocumulus cloud elements may exhibit vertical development, or there may be just closely packed globular masses. In the first case, the altocumulus may seem to be very similar to altostratus or nimbostratus that have vertical development in their tops, although the layer may retain some semblance of orderly pattern.

[13] LIMITATIONS OF THE ANALYSIS

It is a known fact that the reliability of any form of synoptic meteorological analysis depends on the experience of the analyst. An analysis of the type dealt with in this report is no exception. If anything, it is even more dependent on analytical experience because of the sparseness of data and the difficulties in interpretation. To date, the meteorological cloud atlas has been built up almost entirely from ground observations. The changeover to "looking down" upon the clouds means that the dominant features which served to identify types of clouds when observed from the ground are no longer to be seen. The halo and corona that served so well to classify cirrostratus and altostratus, respectively, are absent. Also, the upper surface of large scale cloud decks is, for the most part, completely different in appearance from the lower surface. Therefore a completely new concept of cloud-identification features must be formed, and only those experienced on these new concepts will be able to make an intelligent analysis.

There is also danger of an incorrect interpretation of the cause for the clouds, which might lead to a completely erroneous analysis. Take, for example, the case in which the entire picture under consideration exhibits one complete deck of clouds. In this case the deck of clouds might be stratus caused by radiational cooling and so might constitute an entirely local phenomenon. An analyst looking at this situation might jump to the conclusion that the clouds in question were of frontal origin, possibly altostratus, and might forecast accordingly. It is evident that a forecast made from such an erroneous assumption of the cause would be completely incorrect. (Methods of attack on this problem of analysis are treated more fully in a later section of this report.)

There are also many definite advantages to be gained in the analysis of weather by this method; chief among these is the fact that extremely large areas may be visually observed in a relatively short period of time. The disadvantages of large gaps (between stations) on the usual weather map and the comparatively limited field of view of each ground observer are eliminated. What is obtained is, in effect, the cloud pattern integrated over a wide area. From many points of view this is highly desirable, owing to the fact that, for the first time in the history of synoptic meteorology, the classical models of various weather situations may be examined *in toto*.[14]

[14] WHAT CAN BE DETERMINED FROM HIGH-ALTITUDE OBSERVATIONS

CLOUD IDENTIFICATION

Assuming, from the previous section, that cloud shapes of the order of 500 ft or more in diameter are distinguishable from an altitude of 350 mi, the problem of identifying these clouds can be treated. As stated previously, attributes and/or phenomena that served to establish the classification of clouds when viewed from the ground are almost completely different when these same clouds are viewed from above. The question is, What can actually be done to tell the various cloud forms apart?

The solution to this problem may lie in a new classification system formed by means of close correlation of observations of clouds viewed from above with observations of these same clouds viewed from below. In this manner, an atlas of identifying cloud features as

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14. This idea of "the over-all look" was first described by Major D. L. Crowson, USAF, in a recent article in *B. Amer. Meteorol. Soc.*, Vol. 30, No. 1, January, 1949. His primary object was the use of vertically fired rockets in conjunction with the regular meteorological observations as a supplement rather than as a possible replacement. In this regard, his analysis of rocket photographs is very similar to that presented by Dr. J. Bjerknes in Appendix I.

. . . gives the albedos for various ground covers. Applying these values to Fig. 2, it can be seen that, except for the case of newly fallen snow combined with clouds thicker than 600 meters and the case in which the background albedo approaches very close to cloud albedo, 500-ft resolutions are obtainable over a wide range of conditions.

There is one other factor that might limit contrast and, therefore, resolution. This is aerial haze between the camera and the ground. As has recently been shown in several [11] [original placement of "Fig 2—Available contrast with varying cloud and background albedos"] V-2 photographs, this problem is almost completely solved by use of an infrared filter in the optical system.

Fig. 2—Available contrast with varying cloud and background albedos

From the foregoing section we may conclude that, from the standpoint of area coverage and resolution, weather observations from a satellite are a definite possibility.

[12] **Table 5***

SURFACE ALBEDO AND SCENE CONTRAST OF CLOUDS AGAINST VARIOUS BACKGROUND SURFACES

Ground Surface	Albedo[+]	References[±]
Fresh snow	.80-.93	1, 3, 4
Old snow, sea ice	.40-.60	3, 4
Brown soil	.32	1
Grass	.10-.33	4
Green leaves	.25	1
Sandy loam	.24	2
Sand	.13-/18	3
Asphalt paving	.15	2
Dry earth	.14	4
Rock	.12-.15	4
Moist earth	.08-.09	2, 4
Cultivated soil, vegetable	.07-.09	3
Smooth sea surface		
Solar elev 5 deg	.40	3
Solar elev 10 deg	.25	
Solar elev 20 deg	.12	
Solar elev 30 deg	.06	
Solar elev 40 deg	.04	
Solar elev 50-90 deg	.03	

* This table was prepared by Dr. R. S. Wehner and is included in the RAND general report on the satellite (see footnote 1 . . .).

[+] Values of albedo apply to illumination by "white" light or sunlight.

[±] References:

1. *International Critical Tables,* 1929 ed., Vol. 5, p. 262.
2. *Handbook of Chemistry and Physics,* 1942 ed., pp. 2147–2148.
3. H. Landsberg, *Handbook of Meteorology,* McGraw-Hill Book Company, Inc., New York, 1945, p. 932.
4. J. Charney, *Handbook of Meteorology,* McGraw-Hill Book Company, Inc., New York, 1945, p.296.

ified. It is obvious that if, for various combinations of cloud-ground and cloud-cloud, albedo differences are such that their contrast values fall below the limiting contrast, these combinations cannot be observed by high-altitude weather reconnaissance.

Hewson, in an article in a meteorological journal[11] and in his book (written in collaboration with Longley) on theoretical and applied meteorology,[12] calculated and tabulated diffuse-reflection coefficients for clouds of various thicknesses. In doing so, as a result of the extensive variation of cloud liquid-water densities and cloud droplet radii, he was forced to choose one set of values for these two parameters. Those on which his figures are based are a density of 1.0 gm of liquid water per cubic meter of cloud and a droplet radius of 5 X 10-4 cm. Owing to the fact that these values probably apply to a large percentage of the usable clouds observable from extreme altitudes, they may be reasonably [10] employed in making estimates for this study. These values are plotted in Fig. 2, the ordinate and abscissa being contrast and background albedo, respectively. Each curve represents a particular albedo applicable to a particular cloud thickness. According to the definition of contrast,

$$C = \frac{P_b - P_d}{P_b}$$

where P_b = brightness (albedo) of the brightest thing viewed (either object or background)
P_d = brightness of darkest object viewed (albedo)
C = contrast between the two.

From the above definition, each curve may be represented by the following relation:

$$C \begin{cases} = 1 - \frac{A_b}{A_t}, & \text{for } A_b < A_t \\ = 0, & \text{for } A_b = A_t \\ = 1 - \frac{A_t}{A_b}, & \text{for } A_b > A_t \end{cases}$$

where C = contrast between object and background
A_b = albedo of background
A_t = albedo of clouds of various thicknesses.

It is therefore seen that, except for the small range of albedo combinations around the point of discontinuity on the curves, a large majority of possible cloud-background albedo combinations fall within the range of at least 10 per cent contrast. As can be seen from Table 1, assuming at least a 2.0-in. aperture and sunlight illumination, an f/10 camera will permit at least 10 per cent contrast for approximately 500-ft resolutions.[13] Table 5

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11. E. W. Hewson, *Quart. J. Roy. Met Soc.*, Vol. 69 (1943), p. 47.
12. E. W. Hewson and R. W. Longley, *Meteorology, Theoretical and Applied,* John Wiley & Sons, Inc., New York, 1944, pp. 73–75.
13. Using the equation (for altitude of 350 mi)

$$C = \frac{1600}{ga\sqrt{t}}$$

where C = contrast
a = aperture
t = exposure time (or time of one frame)
g = minimum resolvable surface dimension,
it is possible to calculate the contrast (minimum) needed to obtain at least 500 ft resolution under the conditions given in the example of ground coverage which assumed full daylight illumination. This value turns out to be 3.56 per cent. Owing to the unrealistic power requirements necessary to transmit 3.56 per cent contrast, this value has been raised to 10 per cent.

around the 56th parallel. In any event, the coverage, as mentioned here, if achieved with any measure of success, should produce good weather reconnaissance results.

RESOLUTION AND LIMITING CONTRASTS

Since it is now obvious that clouds will be the chief meteorological element directly observable from high altitude photographs, it must be ascertained how closely these clouds may be identified and what may be determined from them, either directly or indirectly.

As can be seen from Tables 1, 2, and 3, when a set of conditions such as aperture, illumination, exposure time, and focal length-aperture diameter ratio of a given camera have been established, the remaining factor for determination of the minimum resolution attainable is the contrast value. In cloud photography of the type to be attempted from the satellite, one is unable to choose the surrounding photographic conditions. Features such as background, lighting at time of observation, etc., are examples of the uncontrolled variables, and, as a consequence, any system of data gathering by photographic means must be flexible enough to give adequate results over a wide range of limiting factors. The question is: If the camera and optical system are chosen,[10] and if the various conditions of lighting, background, etc., are assumed to remain within the limits providing [9] usable resolution, will the resulting limiting contrast values still enable one to observe the weather under a wide-enough range of actual conditions?

Before endeavoring to answer this question it is desirable to define the term "usable resolution." It was thought that details of cloud structure as small as several hundred feet in diameter might possess significance when an attempt was made to form a synoptic picture by means of cloud analysis. This was borne out when high-altitude rocket photographs were examined. Further reasons for asserting this to be the appropriate minimum size to be resolved were found when a simple test was conducted on these photographs. (The heights at which these pictures were taken varied between 50 and 70 mi.) Using an adjustable viewer, the photograph was taken slowly out of focus until it was impossible to identify definitely the forms of clouds other than by saying that they were widespread or were in small clusters. For example, beyond this point it was impossible to distinguish between closely packed cumulus and a deck of altocumulus, and also between a dense layer of stratus or altostratus and the fibrous texture of cirrostratus. A study of other parts of the photograph, where recognizable or measurable objects were located at ranges about equal to those of the clouds, showed that the limiting resolution at which the clouds lost their distinguishability was from 500 to 1000 ft. This is what is meant by "usable resolution." As may be imagined, this is at best only a rough approximation, but because of its apparent agreement with previously estimated values it should serve very well as a working basis.

It was mentioned above that in order to obtain a known, usable resolution, once the camera and lighting conditions are chosen, the limiting contrast value must also be spec-

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10. Previous studies at RAND have shown that one of the best available television cameras for use in the satellite would be one employing an *image orthicon pick-up tube*. The characteristics of this tube approach those of the human eye over part of its operating range, it has a greater sensitivity than earlier types, and it is capable of stable operation without adjustment over a wide range of illumination intensity. Since it is not the purpose of this report to delve too deeply into the technical aspects of the the problems of a television viewing system, only results of resolution computation of the image orthicon tube are presented here. These are summed up in Tables 1, 2, and 3. For technical information and equations involved, see R. B. James, R. E. Johnson, and R. S. Moore, *RCA Review*, Vol. 10 July 1949, pp. 191–223; and A. Rose, "Television Pickup Tubes and the Problem of Vision," *Advances in Electronics*, Vol. 1, Academic Press, New York, 1948.

The daylight camera with an f/10 lens and an image orthicon television tube[,] and whose performance is summarized in Table 4, should have a 2-in. objective to give the proper ground coverage per frame. This combination allows a 500-ft object to be resolved with only 10 per cent contrast,[7] which is reasonably small. It should be emphasized that these figures are presented here merely to give some *examples* of performance of viewing systems and not as a description of the *optimum* system performance.

Some calculations of the efficiency of coverage of an inaccessible area such as an ocean were also made by direct measurements (assuming different strip widths) on a grid map. On this map were projected complete cycles[8] of traverses for two proposed satellite trajectories. Once again, curvature of the earth was neglected. The results obtained are as follows:

1. For a satellite with 24-hr complete cycle (354.6-mi altitude, angular velocity 15 times that of earth, and trajectory tangent to lat. 56°N.)—

   Assuming a 100-mi-wide scanning band (50 mi on either side of path): In the vicinity of lat. 45°–50°N., we find that in 24 hr the surface has been covered in a grid fashion such that about one-third of its area has been scanned and presumably televised.

   Assuming a 200-mi-wide scanning band (100 mi on either side of path): As may be expected, doubling the scanning band does not quite double the area covered. This is owing to some overlapping of the bands. (It can be shown that, [8] to cover the area completely, a scanning band approximately 450 mi in width is needed.)

   As a result of the grid-like coverage, the 100-mi-wide band, at its worst, should pick up at least portions of the largest, most active weather disturbances and enough of the remaining cloud coverage to orient the system in relation to the ground.

2. For a 48-hr complete cycle (altitude 453.3 mi, angular velocity 14.5 times that of the earth, and trajectory tangent to lat. 56°N.)—

   Assuming a 100-mi-wide scanning band (50 on either side of path): In the vicinity of lat. 45°–50°N., we find that in 48 hr it has been covered, grid fashion, so that two-thirds of its area has been scanned and presumably televised. (It can be shown that to cover the area completely in a 48-hr cycle, a scanning band approximately 250–300 mi in width should be required.)

The results so obtained give an idea of the areas which can be covered (or scanned) from a vehicle in an orbit 350 mi above the surface of the earth. The 350-mi-wide strip discussed in the first part of this section will therefore cover in 24 hr a large percentage of the area between 45°N. and 56°N.[9] with considerable overlapping of scanning, particularly

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7. This resolution and contrast represents the maximum needs of satellite weather observation. This is obtainable with 25 percent contrast when using an f/10 lens with a 2-in. objective in sunlight illumination (see footnote to Table 1 marked (+).

8. Initially, the trajectory of the satellite is set tangent to a given latitude. Owing to the relative difference in the angular velocities between the satellite and the earth and to the relative stability of the orbit of the missile, the vehicle's trajectory appears to "creep" over the surface of the globe. A complete cycle is the time it takes for the trajectory of the satellite once again to become tangent to the original point. (This "creep" causes the traverses to become more widely dispersed as the trajectory approaches the equator.)

9. A large percentage of the area should be covered in the 24-hr trajectory, and almost all should be scanned in the 48-hr trajectory.

[6] **Table 4**

POSSIBLE PERFORMANCE CAPABILITIES FOR VARIOUS IMAGE ORTHICON CAMERAS, TAKING INTO ACCOUNT ILLUMINATION SOURCES

Ratio of Focal Length to Aperture Diameter, and Illumination Source*	Aperture (in.)	Focal Length (in.)	Approx. Minimum Contrast Necessary to Give at Least 500-Ft Resolution (%)	Maximum Number of Frames/Sec	Computed Angle of View of Each Frame (deg)	Computed Width of Square Surface Viewed in Each Frame+ (mi)
f/10 camera, clouds illuminated by sunlight	0.5	5	25	10	11.44	70
	1.0	10	10	10	5.74	35
	2.0	20	10	40	2.86	17.5
	5.0	50	2.5	10	1.14	7
f/1.4 camera, clouds illuminated by 2nd- and 3rd-quarter moons	5	(‡)	(‡)	(‡)	(‡)	(‡)
	10	(‡)	(‡)	(‡)	(‡)	(‡)
	20	28	100	4	2.05	1.25
f/0.7 camera, light of night sky illumination	...	(**)	(**)	(**)	(**)	(**)

NOTE: For the purpose of computation, in the relation written on p. 3:

W = width of the target in inches, which is taken to be equal to 1 in., the size of the commercial RCA image orthicon target

d = optical range, which is taken to be equal to 350 mi (the height of the satellite).

All computations made assuming a minimum signal-to-noise ratio of 20:1.

* All cameras mentioned here refer to those using an image orthicon tube.

\+ Since the curvature of the earth was not taken into account, the figures in this column are lower than the actual figures.

‡ No resolution of the order of 500 ft or less.

** No resolution of the order of 500 ft or less, regardless of aperture.

[7] Calculations must also be performed to arrive at the possible area coverage. Since it is apparent that cloud observations, to be at all useful, have to be made over a wide-enough strip (at least as wide as the height of the satellite), it should be considered that the camera will be mechanically scanned. This may be accomplished by means of a 45° plane mirror rotatable about the axis of the camera. The mirror actually does the "looking" and scanning for the camera, which is mounted horizontally, its axis being parallel to the axis of the missile. Taking a sequence of 20 nonoverlapping frames will produce a strip 350 mi long, transverse to the trajectory of the satellite, and 17.5 mi wide. If the camera is set to take 5 frames/sec and the rotatable mirror is fixed with a fast snap-back device, the system will then be in position to take a second strip by the time the satellite has moved ahead approximately 17.5 mi relative to the earth. (The speed of the missile relative to the earth's surface is about 4.4 mi/sec.) This will produce a continuous 350-mi-wide strip around the earth with each complete traverse of the missile.

[5] **Table 2***

RESOLUTION OF CLOUDS BY SECOND- AND THIRD-QUARTER MOONLIGHT

(Image orthicon f/1.4 camera operated at 20:1; signal-to-noise ratio at rates of 40, 10, and 4 exposure frames/sec; and a satellite height of 350 mi)

Contrast (%)	Aperture (in.)	Minimum Resolvable Surface Dimension 40 Frames/Sec (ft)	10 Frames/Sec (ft)	4 Frames/Sec (ft)
100	5	1.08	0.54	0.34
	10	0.54	0.27	0.17
	20	0.27	0.14	0.09
25	5	4.32	2.16	1.36
	10	2.16	1.08	0.68
	20	1.08	0.54	0.34
10	5	10.8	5.4	3.4
	10	5.4	2.7	1.7
	20	2.7	1.35	0.85

* The material contained in this table is included in RAND Report R-217 (see footnote 1. . .).

Table 3*

RESOLUTION OF CLOUDS BY LIGHT OF THE NIGHT SKY

(Image orthicon f/0.7 camera operated at 20:1; signal-to-noise ratio at rates of 40, 10, and 4 exposure frames/sec; and a satellite height of 350 mi)

Contrast (%)	Aperture (in.)	Minimum Resolvable Surface Dimension 40 Frames/Sec (ft)	10 Frames/Sec (ft)	4 Frames/Sec (ft)
100	10	4.3	2.15	1.36
	20	2.15	1.08	0.68
	40	1.08	0.54	0.34
25	10	17.2	8.6	5.4
	20	8.6	4.3	2.7
	40	4.3	2.15	1.36
10	10	43.0	21.5	13.6
	20	21.5	10.8	6.8
	40	10.8	5.4	3.4

* The material contained in this table is included in RAND Report R-217 (see footnote 1. . .).

Table 1*

RESOLUTION OF CLOUDS BY SUNLIGHT

(Image orthicon f/10 camera operated at 20:1;+ signal-to-noise ratio at rates of 40, 10, and 4 exposure frames/sec; and a satellite height of 350 mi)

Contrast (%)	Aperture (in.)	Minimum Resolvable Surface Dimension 40 Frames/Sec (ft)	10 Frames/Sec (ft)	4 Frames/Sec (ft)
100	0.5	200±	100±	64±
	1.0	100±	50±	32±
	2.0	50±	25±	16±
	5.0	20±	10±	6±
25	0.5	800	400±	250±
	1.0	400	200±	125±
	2.0	200	100±	64±
	5.0	80	40±	25±
10	0.5	2,000	1,000	640
	1.0	1,000	500	320
	2.0	500	250	160
	5.0	200	100	64
2.5	0.5	8,000	4,000	2,500
	1.0	4,000	2,000	1,250
	2.0	2,000	1,000	640
	5.0	800	400	250
1	0.5	20,000	10,000	6,400
	1.0	10,000	5,000	3,200
	2.0	5,000	2,500	1,000
	5.0	2,000	1,000	640

* The material contained in this table was prepared by Dr. R. S. Wehner and is included in RAND Report R-217 (see footnote 1 . . .).

\+ It should be noted that this table (and also Tables 2 and 3) is unrealistic in that the 20:1 signal-to-noise ratio is applicable only to 25 per cent contrast. For 10 per cent contrast, a signal-to-noise ratio of 50:1 is required. This would mean a required transmitter power increase by a factor of 2.5 (assuming a 2-in. aperture 1000 TV lines, and a frame frequency of 10 sec). This is still not prohibitive but does become so with a substantial increase in either the number of TV lines or the frame frequency.

± Values of computed resolution smaller than realizable with present commercial image orthicons.

[3]

WHAT CAN BE SEEN

Naturally, any estimate of the amount that can be seen from an extreme altitude must be a function of both the resolving power of the camera system and the area that can be scanned and recorded (or televised) and still retain usable data. Much of the discussion and most of the figures in this section are the result of previous RAND studies conducted by Dr. R. S. Wehner.

AREA COVERAGE

Fig. 1—Viewing system

Using the relation (see Fig. 1)

$$\frac{W}{F} = \frac{w}{d} = 2 \tan \frac{a}{2},$$

where W = sensitive element width, in.
w = width of surface pictured per frame, mi.
F = focal length of camera, in.
d = optical range, mi.
a = angle of view, deg.,

and using Tables 1, 2, and 3, it is possible to compute the width of square surface viewed and the angle of view for any given camera and aperture. This has been done and is summarized in Table 4. As can be seen, if a limiting resolution[6] of 500 ft is [4] set, it is still possible to obtain this resolving power under sunlight illumination with a contrast as low as 2.5 per cent (with a 5.0-in. aperture). Under moonlight, however, this resolution is possible only with 100 per cent contrast, a very fast f/1.4 lens, and a minimum exposure time of 0.25 sec; under light of the night sky illumination it is not possible at all. Assuming, then, that the chosen limiting resolution is correct, the probability of obtaining identifiable cloud photographs under any but sunlight illumination appears to be small.

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6. The term "limiting resolution," as used in the television field, refers to the greatest possible resolution attainable by a given TV pick-up tube and is wholly dependent on the structural make-up of the tube itself. As used in this report, limiting, minimum, or usable resolution is a quantity depending on scene contrast signal-to-noise ratio, aperture, f number of camera, etc., and is chosen to pick up the smallest object that it is desired to view.

Clouds, being the objects most easily discernible from extreme altitudes, become the important item and must be utilized to the utmost in forming a synoptic picture. It is apparent that from clouds alone it will be impossible to tell everything about the current synoptic situation. Combined, however, with both theoretical knowledge and that gained through experience, an accurate cloud analysis can produce surprisingly good results.

The purpose of this report is to present methods of attack on the above problem, to show what may be actually seen from high-altitude photographs (primarily a discussion on necessary resolution and area coverages), to discuss what may be determined from these photographs (both directly and indirectly), and to give some results obtained. Although all the present analysis is based on data obtained from vertically fired rockets, the experience gained therefrom permits recommendations on possible methods of forming a synoptic picture from satellite-missile photographs.

[2] THE SATELLITE VEHICLE

Owing to the ever-changing pattern of the atmosphere, the need for almost constant surveillance must be foremost in any plan to trace synoptic weather situations. Any vehicle designed for such a purpose must therefore have the ability to make many trips over the area in question. These traverses, moreover, must be made in such a fashion that they not only cover a representative portion of the area, but also complete their cycle often enough to enable an observer to notice any significant change or shift in the cloud systems.

Such a vehicle is the satellite. Flying high above the sensible part of the atmosphere, so that atmospheric drag becomes negligible, the satellite becomes an unparalleled instrument for weather reconnaissance when scope of view is considered. For the purpose of simplicity, all calculations and performance considerations in this report will be based on a satellite assumed to be circling the earth at an altitude of about 350 mi.[2] At this altitude such a vehicle[3] would have an orbital velocity equal to 24,870 ft/sec[4] and would make one complete circuit of its orbit in 1.6 hr. Also, because of the fact that this missile is theoretically moving in a stable orbit around the earth, the globe turning under the vehicle causes the trajectory of the satellite to appear to "creep" over the face of the earth, thereby increasing the area observed.[5] Depending on the efficiency of the power plant, the order of magnitude of the time period for which the vehicle could be kept operating is thought to be 1 yr. However, in attempting to decide the satellite's full worth for weather reconnaissance, the questions that must be considered are as follows: Can enough be seen from such altitude to enable an intelligent, usable, weather (cloud) observation to be made, and what can be determined from these observations?

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2. *Ibid.*
3. The actual altitude to which these figures apply is 354.6 mi.
4. The actual velocity of a projection of the satellite's image over the face of the globe is really a variable resulting from the change in angular velocity from latitude circle to latitude circle.
5. It should be noted that the concept of "repetitive traverses" is in itself complicated in that, regardless of the stability of the satellite orbit, the spatial movement and the oblate shape of the earth impart a regressive motion to the vehicle relative to fixed points on the earth. From a satellite at approximately 350-mi altitude in an orbit set tangent to a latitude of 56°, 78 days will be required for it to appear twice over the same point on earth at exactly the same time. This regressive motion can be partially corrected by an adjustment of the speed (through altitude change) of the satellite. It further imparts a limitation on successful viewing in that for approximately half of the 78-day period (assuming 12 hr of photographable time out of every 24) the desired area will have night at the time of the satellite's passage. For a complete discussion of regression of the orbit, the interested reader is referred to RAND Report R-217 (see footnote 1 . . .).

cloud and background of less than 10 per cent. An examination of the albedos from typical background objects, as presented in Fig. 2 . . ., compared with cloud albedos seems to indicate that 10 per cent contrast is available over a wide range of [vi] possible cloud-ground and cloud-cloud combinations. This, therefore, appears to establish the feasibility of cloud identification from high altitudes, at least from the standpoint of contrast and resolution.

Owing to the lack of quantitative measurements, the clouds must be utilized to their utmost in determining the synoptic weather picture. Experience and statistical climatological values play their part in forming this picture, and the process involves a "hunting technique" that oscillates between the three main tools at the analyst's command. Some detailed estimates of various parameters are possible from the visual cloud characteristics. Items, such as moisture content, temperature gradient, stability, magnitude or direction of vertical pressure gradient, wind shear, and wind direction[,] all show promise of yielding good estimates of the actual values to this type of analysis and of helping to clarify the final estimated synoptic picture. For any future operational use, this study has shown that such things as a cloud atlas of clouds viewed from above, complete climatological material on the area in question (including a possible statistical survey of fluctuations from the normal of the various parameters as attributed to synoptic systems and broken down into small regions of similar climate and topography), and perimeter weather will immeasurably help the job of the observer and analyst. An aid to getting a "feel" for the problem involved, photographs from three rocket flights were analyzed and the synoptic situation was estimated. These results and the actual weather for the corresponding times are presented in the section entitled "Results of Three Attempts at Analysis. . . ." In an attempt to correlate further the rocket photographs with the actual synoptic picture, Dr. J. Bjerknes, of U.C.L.A., independently made an analysis of photographs taken on a flight on July 26, 1948. In this analysis, all other synoptic meteorological data available for that date were utilized. . . .

[1] **INTRODUCTION**

The foundation of all meteorological forecasting systems is the weather-observing network. Whether the forecast is "local" or for the entire Northern Hemisphere, the starting point must be an appraisal of the synoptic weather picture. Since storm systems at middle latitudes generally move from west to east, a meteorologist who does not have good observations from a rather wide area (particularly to the west) is at a disadvantage; and such is often the case for coastal regions, since weather reporting over the oceans is often inadequate.

Although ship reports and weather reconnaissance by aircraft help to some extent to fill the gap, there has long been a need for extending weather observations over the oceans and inaccessible areas. A solution to this problem may lie in weather observations made by means of a television camera placed in an unmanned satellite vehicle. Such a method has the advantage of providing a means of observation of the over-all picture of the wide-scale weather situation that is lacking in normal daily weather observations, and should give new insight into the behavior of the atmosphere.

It is obvious that in observing the weather through the "eye" of a high-altitude robot almost all of the regular quantitative measurements usually associated with meteorology must fall by the wayside. It is impossible to make more than an intelligent guess at the values of temperature, pressure, humidity, and the remaining quantitative meteorological parameters. Because of this, the analyst must rely on the visible components of meteorology to ascertain to some usable degree the synoptic weather situation.

Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle

S. M. Greenfield and W. W. Kellogg

August, 1960

NOTE

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and released for open publication, August, 1960.

[v]

SUMMARY

The value of observing the weather over inaccessible areas by aerial weather reconnaissance has been recognized for many years. An alternative method of obtaining broad coverage of the weather, however, is thought to lie in the use of a special satellite vehicle which could observe cloud patterns. It is obvious that any meteorological reconnaissance utilizing only observations from such a high-altitude "eye" cannot provide quantitative values for the parameters normally associated with standard weather observation and forecasting techniques. In determining the feasibility of such a system, therefore, the questions that must be answered are (1) What extent of coverage can be expected from a satellite viewing system? (2) In terms of resolution and contrast, what can be seen from the satellite? (3) Given proper coverage and resolution, what can actually be determined regarding the synoptic weather situation from this information?

General considerations of ease of satellite launching and photographic coverage suggest an orbiting altitude of 350 to 500 mi.[1] For the purpose of the present study, however, only the 350-mi altitude was considered to any extent. At this altitude, a vehicle would have an orbital velocity of about 24,870 ft/sec and would make one complete circuit of its orbit in 1.6 hr. Assuming that any regressive motion of the satellite's orbit owing to the spatial motion and oblate shape of the earth is corrected for, and that the area it is desired to observe is in daylight during the vehicle passage for an extended period, this area will be covered and televised in a grid fashion once every 24 hr. It is visualized that, by means of mechanical scanning transverse to the path of the satellite, a continuous strip whose width is equal in order of magnitude to the altitude of the vehicle will be viewed. As an example of the sort of coverage which could be provided at middle latitudes, with a satellite at a 354.6-mi altitude the fraction of the area between 45° and 50° latitude which can be covered grid-fashion with a 100-mi wide scanning path in 24 hr is one-third, and if the width of the path is increased to 450 mi, the 24-hr coverage is complete.

Utilizing photographs from recent vertically fired rockets (V-2), an estimate of the dimensions of the smallest increment necessary for proper cloud identification was made. This was found to be approximately 500 ft and is termed the "usable resolution" in this report: Entering Tables 1, 2, and 3, which give resolution versus contrast for various values of frame speed, aperture size, and various types of illumination, showed that it was possible to obtain this value of resolution in sunlight illumination with contrast between

1. Additional information concerning the problems of satellite operation is given in the RAND Report R-217, April 1951 (out of print).

(c) Thunderstorm Areas—by location of lightning either visually (at night) or electronically (at day).

(d) Solar Radiation measurements, particularly in the ultra-violet, to correlate with weather changes in an attempt to see if unusual spells of weather are solar-controlled.

(e) Albedo Measurements—to keep a global account of the day-to-day changes in reflectivity of the Earth's surface to solar radiation from the ground and water surfaces (including snow and ice cover), clouds, atmospheric turbidity. Long-time variations in the Earth's albedo could be correlated with similar variations in climate. For example, it has been estimated that a one-point drop in Earth's albedo from its average value of 35 per cent. would lead to an average world-wide warming of 1° C. The fraction of sky covered by clouds is of such critical importance in albedo changes that it has been estimated a variation in the average world cloudiness from 0•4 to 0•6 would explain the whole range of climatic changes—from ice ages to the intervening warm periods.

(f) Meteoric Dust—samples could be obtained to test a recently proposed theory that these particles may serve as cloud-seeding agents, thus causing increases in rainfall, especially after meteoric showers. Samples of the dust to test in cold boxes, together with measurements of their natural concentration would shed direct evidence on a problem which heretofore has only been possible to treat statistically.

In summary, it can be stated without question that a satellite vehicle, moving about the Earth at the proper height and manner would be of inestimable value as a weather patrol for short-range forecasting and as a collector of basic research information for solar and geophysical studies, including long-term weather changes and climatic variations.

Document II-2

Document title: S.M. Greenfield and W.W. Kellog, "Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle," The RAND Corporation, R-365, August 1960, pp. v–vi, 1–23, 31.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

One of the possible uses of an orbital satellite that Project RAND had addressed in its 1945 report "Preliminary Design of an Experimental World-Circling Spaceship" was predicting the weather by observing cloud patterns on a large scale. Recognizing the potential of such a capability, but unsure of how useful cloud images alone would be in predicting the weather, the Air Force commissioned Project RAND to conduct a further study to determine more precisely what useful information could be gained from high-altitude observations. The fourteen figures accompanying the report are omitted here, but their captions are included.

storms, size and intensity would vary geographically. A meteorologist given a clear picture of the cloud distribution, as here portrayed, could without difficulty sketch in a very useful weather chart showing location of the various stormy and fair weather areas; in fact, he would have a much better idea of the large-scale weather distribution than his Earth-bound colleague, who is forced to rely on scattered observations taken at or near the Earth's surface.

As for obtaining two or more "fixes" on storms within 12 hours, this would be possible as the vehicle makes successive passages toward the Poles—and the closer to the Pole the storm is located the more such fixes could be made. For example, the large fully developed storm depicted over Hudson Bay would be visible first on one leg of the path, again 4 hours later on the next leg, and again 4 hours later on a third leg. This would, by reference to known surface features, enable tracking of the storm in the 12-hour interval. A word of caution is necessary since the clouds which on one hand make possible the visual identifications of the storm will hinder its location with respect to known surface features. Nor would trying to track the storm by observing the edge of its cloud shield necessarily give an accurate track, since the changing cloud pattern associated with such large, usually dissipating storms may give spurious motions, as they form on one side and dissipate on the other. Thus, there will not be too good an accuracy for tracking these large storms, but this is not too important since their speed of motion is usually slow anyway. On the other hand, the incipient or developing storm, so important for future weather developments, is faster moving and has a less extensive cloud system associated with it so that more accurate fixes should be possible. The hurricane, with its cloud bands, similar to the arms of a spiral nebula, and its open "eye" at the centre, will be a much easier storm to detect and follow accurately. Cloud systems associated with cold fronts and squall-lines will also lend themselves to accurate tracking.

As the days pass, however, and the Earth moves in its orbital motion about the Sun, the vehicle will cross each latitude about 4 minutes earlier than the preceding day. Thus, if motion northward is started at noon on March 21, this will change on June 21 to 6 a.m. moving north, and 6 p.m. moving south; in this case, the field of view in daylight will be mostly to the east (going north) and to the west (going south) and the efficiency of the vehicle as a cloud patrol will have diminished considerably. On September 21 its efficiency will increase again as it moves south at noon and north at midnight. However, on December 21 its efficiency will drop again—and to its lowest point as far as the Northern Hemisphere is concerned. It will move north at 6 p.m. and south at 6 a.m.—but because of the low solar declination at this time and consequent lack of daylight hours, its usefulness as a cloud and storm detector will be greatly impaired. This is a serious defect because the winter season is the busiest period for storms in the Northern Hemisphere. This suggests as a better [276] solution that the preceding plan, the initial movement northward or southward at noon on December 21. This will then give optimum conditions for winter weather patrol—excluding the Arctic and some distance south where little or no daylight will prevail.

This visual cloud reconnaissance might be taken automatically by a television camera in an unmanned vehicle and relayed to Earth to various collection centres for study, analysis and exchange with other forecast offices to obtain a truly global weather picture. If the vehicle could be properly manned and equipped, then other valuable geophysical and solar data could be obtained as follows:—

(a) *Temperature* of the Earth's surface and a rough average temperature of the intervening atmosphere by observing the infrared spectrum.

(b) *Precipitation Areas* (rain, snow, etc.) could be detected by radar as well as the heights of their formation above the surface; also the height of the freezing level which shows as a bright band in the radar scope.

Colour contrasts of objects on the ground tend to be suppressed in at least two ways: selective scattering of the bluer components by atmospheric molecules, and "dilution" of colours by the white diffuse component contributed by the non-selective foreign particle scattering in the atmosphere.

The effect of the first type of scattering is to deplete the blue colours relatively more than the longer wave-lengths. The over-all effect is to emphasize red [274] colour components of the objects on the ground, as compared to the blue components; and to screen both with diffuse light consisting of a relatively large blue component mixed with white light. The over-all result would be to give a bluish tinge to what is seen, since the blue scattered from the incident solar beam would more than make up for the blue-depletion of light coming from the ground.

As to the colour of the sky on the horizon, we might expect that there would be a grey layer, corresponding to the atmosphere say in the lower 10,000 ft., with an upper thin blue region in the region of substantial Rayleigh scattering, and black above that.

Thus, as a result of all these calculations, a reasonable picture was obtained of the surface features of the Earth under normal conditions of June 21 ground cover illumination, albedo and atmospheric effects, but without clouds. Over this chart was sketched a hypothetical cloud pattern normally associated with certain atmospheric disturbances. Albedo values were assigned to various cloud types and their brightness as computed. These "disturbances" included the following:—

(a) A cyclone family of three storms in various stages of development extending from Hudson Bay south-westward to Texas.
(b) The north-eastern part of another such cyclone family whose oldest member is in the Gulf of Alaska, the remaining members to the southwest being invisible.
(c) A fully developed hurricane embedded in "streets" of trade cumuli in the West Indies.
(d) The Intertropic Convergence Zone (or Equatorial Front)—a zone of interaction between the north-east trades of the northern hemisphere and the south-east trades of the southern hemisphere—extending west of Isthmus of Panama to the mid-Pacific.
(e) A "line-squall"—favourite breeding-ground of severe wind storms and tornadoes—in the eastern U.S. moving ahead of the cold front and surrounded on both sides by the cauliflowerlike cumulus congestus.
(f) Scattered cumulus clouds of varying thicknesses over the heated land areas—especially in the mountains and other areas where dynamic effects encourage the lifting of air in vertical columns.
(g) Altocumulus lenticularis or lens-shaped clouds formed by lifting of layers of moist air over mountains and usually found where the "jetstream" crosses mountains, as over the northern Canadian Rockies.
(h) Low stratus and fog found off the southern and lower California coasts, over the Great Lakes, the Newfoundland area, formed by passage of warm moist air over cold surfaces.

The cumulus cloud systems over the oceans will tend to fall in fairly regular patterns or "streets"—even more so than was observed over the rough terrain in the V2 picture. The regularity of the ocean cloud systems in the present sketch is probably exaggerated, but its breakdown into a more irregular pattern over land is believed to be real. The centres of the anticyclonic or "high pressure" areas are marked by little or no cloud.

[275] This then is the hypothetical picture visible from the 4,000-mile high vehicle over Amarillo, Texas. Some of these clouds, such as the Trade Cumuli, could undoubtedly be observed on almost any day and others, such as the hurricane, seen only rarely. The cyclone families would be observed daily, but their location, the number of individual

Such a vehicle is one which is located at 2•01 Earth's radii from the Earth's centre or about 4,000 miles from the Earth's surface and which has a period of rotation about the Earth of exactly 4 hours. If the Earth were not rotating the vehicle would move in the same meridional plane through the North and South Poles. But since the Earth does rotate as the vehicle moves, its path relative to the Earth's surface is a series of curves.

Let us assume that at noon on March 21 the vehicle is directed poleward from the Equator at the 95th meridian west, at "0" hour. Assuming no external perturbations, the orbit of the vehicle is always maintained in a plane parallel to its initial orbitary plane, but attached to the centre of the Earth in its motion through space. The Earth rotates under the vehicle in such a way that as the vehicle proceeds northwards, it crosses all latitudes at exactly noon and after one hour it passes over the North Pole; afterwards it then moves southward at all latitudes at exactly midnight. At 2 hours it is at the Equator, at 3 at the South Pole, after which it enters into the daylight hemisphere again crossing all latitudes at exactly noon in its northward passage. At 4 hours, it crosses the [273] Equator at the 155th meridian, west, and repeats a similar path on the Earth's surface, but displaced westward from its initial path. In 24 hours it returns to its initial point of departure after having made both a daylight (noon-time) and night (midnight) surveillance of the entire Earth's surface.

Twenty minutes after its departure on its first leg, when the vehicle has moved over Amarillo, Texas, its horizon will enclose an area almost identical to the weather chart used in preparation of weather forecasts for North America and adjacent oceans.

What would be seen from the vehicle at some 4,000 miles above Amarillo, Texas, at exactly noon on June 21? An attempt has been made to portray the scene below under the assumption that the Sun is directly overhead. In drawing a chart before sketching in the clouds, an attempt was made to indicate the surface features of the Earth, taking into account its normal colour and reflectivity (albedo) of sunlight, and the scattering and depleting effects on the passage of light through the Earth's atmosphere in the following way:—

(a) Normal illumination values at the surface were first entered in the chart according to zenith distance of the Sun.
(b) Next, values of the apparent illumination or "brightness" were obtained by taking the product of the surface albedoes and the illuminations. For simplicity only two albedo figures were used: 4 per cent. for water and 15 per cent. for land. This then gives the brightness field of the Earth before passage of the light up through the atmosphere.
(c) Next the Earth's surface brightness was computed after depletion by the atmosphere, values for which are known from the incoming sunlight.
(d) Next was computed the atmospheric contribution to the brightness field at the vehicle. This was done by estimating from available observations, the portion of radiation coming from the sky to the ground (i.e. the downward radiation or "skylight") and by assuming that the same fraction of illumination is scattered upward. This procedure assumes that the atmosphere is a "uniform diffuse reflector" of the brightness shown.
(e) The two brightness values—from the Earth's surface and from the atmosphere—are added together to give a total brightness.

To distinguish the over-all brightness contrast between ocean and land, for example, the fractional contrast $F = 2\frac{B_L - B_O}{B_L + B_O}$ must be larger than 1/10. The computed values of F (not shown) are considerably larger than this value, except near the periphery, indicating that for most of the observed area land can be readily distinguished from ocean.

[270] [figure omitted] FIG. 1. The Earth from an altitude of 100 miles.

This picture show the Earth's curvature and more than 200,000 square miles of the U.S.A. and Mexico, and was taken from a V2 on March 7, 1947. The view stretching to the horizon is a distance of about 900 miles, and the dark body of water near the top of the picture is the Gulf of California, about 65 miles wide. The picture also shows rivers, islands in the Gulf of California, the peninsula of lower California and part of the Pacific Ocean. The two cameras were installed amidship in the rocket as part of 2,000 lb. of scientific instruments. They operated automatically taking pictures through an infra-red filter, used to cut the haze. The time of flight from launching to the break-up of the rocket was 6 1/2 minutes.

[271] [figure omitted] FIG. 2. Diagram of area included in fig. 1.

appear, closely followed by a narrow band of cumulonimbus and then scattered fair-weather cumulus in the cold air mass well behind the cold front.

The characteristic features of the cold and warm front cloud systems plus the adjacent air mass clouds should enable unique identification of a cyclonic storm, either in its maturing or fully developed stages. The incipient, or embryonic storm will be more difficult to detect because of lack of fully developed cloud systems. However, because of the tendency of cyclonic storms to form in "families," arrayed in a southwest-northeast line with the older storms located farther northeast and with a known average spacing between storms, it may be possible to detect an incipient storm by its position relative to the more noticeable mature storms and possible clues from the cloud system.

In Fig. 1 is shown an actual cloud photograph taken from a V2 rocket at a height of 100 miles above White Sands, New Mexico, on March 7, 1947. Unfortunately there was no mature extra-tropical storm within the field of [272] view of the camera, and the clouds shown are mostly "fair-weather" clouds caused mainly by heating of the ground and lifting of the air by the mountains. The most prominent clouds are thousands of bright cumuli—arrayed in roughly parallel bands, called "cloud streets," which usually indicate direction of the wind. These clouds usually occur two to eight miles above the surface, the higher cloud tops being associated with thunderstorms. The fuzzy clouds, so transparent that the cumulus clouds are visible through them, are the high-level cirrus clouds found at heights eight to ten miles. Far to the west, off the California cost, are patches of the characteristic low California stratus clouds (height one to two miles) with parts of the ocean surface visible.

The most that a meteorologist could obtain from such a cloud view would be the negative knowledge that no major storm is present plus some indication of the wind direction at cloud height and possibly the distribution of thunderstorms.

In order to reconnoitre the weather most effectively, the Satellite Weather Station should have the following properties:—

(a) It should be located far enough away to have an instantaneous field of view comparable to North America and adjacent ocean areas—similar to the area covered by the forecaster's "working" chart.
(b) It should not be so high that cloud areas and geographical features are not readily identifiable.
(c) It should move in such a manner as to have the same cloud system in the field of view at least twice in a 12-hour period to obtain a track of the storm associated with the cloud system.
(d) It should not move so fast that individual cloud systems cannot be located accurately with respect to known ground features.
(e) It should cover the entire Earth in daylight at least once daily.
(f) It should have a westward component of motion relative to the Earth's surface so as to detect quickly new storms which usually move from west to east.

figures accompanying the article are omitted here, but their captions are included, along with the description of Figure 1. Note the British-style spellings, such as the word "centre."

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[269]

Observing the Weather from a Satellite Vehicle*

By Dr. Harry Wexler,

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Weather Bureau

Introduction

To predict the future of the atmosphere, the meteorologist must know its present state—as defined by the three-dimensional distribution of pressure, temperature, wind, humidity, clouds, precipitation, etc. To do this, at hundreds of stations throughout the Northern Hemisphere, the atmosphere is probed by balloon-borne instruments which radio back to Earth values of pressure, temperature, humidity, and whose paths can be translated into wind direction and speed of the various layers through which the balloon ascends. These observations expressed as numbers or symbols, plus auxiliary information of clouds, precipitation, etc., are plotted on weather charts and synthesized into an instantaneous picture of the atmosphere which, however, is presently incomplete because of lack of observations in large portions of the atmosphere, specially over oceans and unpopulated areas. Knowing the present state of the atmosphere and past motions of the storms enables a prediction to be made by extrapolation and other techniques.

A satellite vehicle traveling about the Earth outside the atmosphere would not assist in portraying the pressure, temperature, humidity, and wind fields by direct measurement. However, by a "bird's-eye" view of a good portion of the Earth's surface and the cloud structure, it should be possible by inference to identify, locate, and track storm areas and other meteorological features. The vehicle would then serve principally as a "storm patrol." There exists under normal conditions a characteristic cloud condition for a "typical" extra-tropical storm.

A plan view of a typical mid-latitude storm shows cold and warm fronts, whose low-pressure centre is at their vertex, and their accompanying cloud systems.

A major cyclonic storm-cloud system visible from above will be the warm front cloud from which the major portion of the storm's precipitation usually falls. In west-east vertical sections, the cloud at the extreme right is composed of high-level (5–10 miles) tenuous cirrus or cirrostratus clouds which change to denser altostratus and altocumulus and finally to thick precipitating nimbostratus as one approaches the storm. If the ascending warm air above the warm front is unstable enough, cumulonimbus or thunderstorm clouds will penetrate above the top of the nimbostratus cloud.

In the warm sector, or the area between the warm front and cold front, there will be stratus and fog, if the surface is colder than the air, or cumulus clouds, if it is warmer. Approaching the cold front the higher altocumulus clouds will [text continued on page 271 after Figure 2]

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* Presented at the Third Symposium on Space Travel, American Museum, Hayden Planetarium, New York, May 4, 1954.

Conclusion

One might anticipate that space applications programs would have been the least controversial aspects of the space program because they would seem to be the most obviously beneficial. An examination of their history, however, suggests that applications satellites raised difficult institutional policy issues, resulting particularly from the large number of interested organizations involved. A project such as Apollo served primarily public and political interests in a space race. For basic space science, NASA had a clear constituency of scientists. In the 1970s, NASA sought to control research and development for satellite applications in the same way it controlled space science, but the space agency found that user agencies expected to direct research to meet their own perceived needs. In addition, the technological potentials of the various applications fields that scientists found most interesting were not necessarily the ones with the most short-term practical value.

During the 1980s, government-funded applications satellite systems faced an increasingly difficult budgetary climate. Continuing development of satellite technology made it possible to offer more and more sophisticated services, but in a time of tremendous pressure on the federal budget, the government has been reluctant to fund more expensive systems, even if they resulted in better services.

Commercial interests in land remote sensing and international cooperation in meteorological observations have helped invigorate these two applications. As history demonstrates, land remote-sensing applications have proven more difficult to integrate into existing systems than meteorological or communications satellites had been. The obstacle was not primarily a lack of usefulness of the data produced by the satellites; rather, proponents of the Landsat program faced an intense debate over the proper role of government in developing and operating a system that benefits both public and private data users.[87] If the operation of commercial remote-sensing satellites proves successful, it may resolve not only the long-standing tensions between research and operational uses of remotely sensed Earth observation data, but also the question of the proper role of government and the private sector in supplying them.

In contrast to land remote sensing, most observers continue to support the public provision of meteorological data. However, pressure to reduce satellite system costs has endangered the robustness of NOAA's system. A changed political environment resulting in a merged civil-military system and increased international cooperation should improve the ability of the government to continue to provide high-quality meteorological data while reducing system costs.

Document II-1

Document title: Dr. Harry Wexler, "Observing the Weather from a Satellite Vehicle," *Journal of the British Interplanetary Society* 7 (September 1954): 269–276.

This article was originally presented by Harry Wexler, Chief of the Scientific Services Division of the U.S. Department of Commerce Weather Bureau, as a speech at the Third Symposium on Space Travel, held at the Hayden Planetarium in New York City on May 4, 1954. It is one of the earliest inquiries into the possible uses of satellites in forecasting weather. While correct in anticipating a satellite's utility in observing large-scale weather patterns, it is interesting that Wexler nevertheless dismisses a satellite's potential for what are now routine observations of pressure, temperature, and humidity. The two

87. Philip J. Hilts, "Landsat Satellites Termed Incapable of Profitable Operation This Century: Substantial Demand Not Enough to Sustain Business, Reports Say," *Washington Post*, March 12, 1989, p. A4.

tomers.[84] This also reduces costs compared to a system such as Landsat 7, which is designed to collect as much data as possible to provide a global archive for the future needs of scientists.

Department of Commerce officials coordinated the license application with DOD, the Central Intelligence Agency, and the Department of State. By late 1992, national security planners were more inclined than ever before to ease earlier restrictions on the resolution limits of civilian data. Their decisions were moved in part by the knowledge that the French were planning to improve the resolution of their SPOT system, and the Indian Space Agency was also moving to higher resolution instruments. Furthermore, the Russian firm Soyuzkarta had begun to market high-resolution multispectral photographic data (two-meter resolution) from the formerly secret Russian KVR-1000 sensor. On January 4, 1993, the Department of Commerce sent a license to WorldView, allowing it to operate a three-meter satellite system. [II-46, II-47, II-48].

Other companies soon filed their own applications for systems that would achieve even greater sharpness. In June 1993, Lockheed, Inc., filed with the Department of Commerce for a license to operate a system capable of achieving one-meter resolution. Shortly after, Orbital Sciences Corporation, in partnership (later dissolved) with GDE Systems and Itek, also filed a similar license request. The proposal to collect higher resolution data caused the Clinton administration to reconsider desirable policy for commercial remote sensing. Although the sale of such data abroad posed no threat of the transfer of critical technology, in the view of some, one-meter data were too close to the reconnaissance capabilities of high-flying aircraft and classified satellites.[85] Others, while recognizing the risk of marketing these data worldwide, have argued that data of high resolution can moderate potential conflict if they are available to all sides.[86]

Nevertheless, one-meter data, delivered in a timely manner, are of significant security utility for surveillance, military planning, and the creation of the up-to-date maps needed to fight battles effectively. When combined with the geolocational capabilities of the global positioning system, these data also make it possible for belligerent nations to target specific locations for cruise missile and other precision attacks. Hence, intelligence officials argued, if the data were sold globally, there would have to be some sort of control over distribution. Ultimately, after several months of discussion, officials decided that the benefits of keeping such data under the control of U.S. suppliers were greater than the risks posed by possible data misuse.

In March 1994, eight months after receiving the license application, the White House released a policy statement concerning licenses for commercial remote-sensing systems. The policy required the satellite operator to maintain satellite tasking records and to make them available so that the federal government could determine who purchased what data, if necessary. It also authorized the government to cut off or restrict the flow of data during times of crisis to protect national security interests. [II-49] The Department of Commerce has granted several licenses based on this policy, including one to Lockheed, Inc. [II-50]

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84. For EOSAT, the operator of Landsats 4 and 5, this meant collecting fewer scenes than government operators would have collected. NASA and NOAA were interested in gathering as many scenes as possible to file the archive of Landsat scenes.

85. V. Gupta, "New Satellite Images for Sale: The Opportunities and Risks Ahead," Center for Security and Technology Studies, Lawrence Livermore National Laboratory, UCRL-ID-118140, 1994, Space Policy Institute Documentary History Collection, Washington, DC.

86. B. Gordon, "The Moderating Effects of Higher Resolution Civil Satellite Imaging on International Relations," paper presented at the 1996 AFCEA Conference, Washington, DC, June 1996.

be a major customer of data from Landsat 7.

In early 1994, the question of which agency would actually operate Landsat 7 had not yet been resolved. NASA planned to use Landsat data to support its research into land use and land change as part of the U.S. Global Change Research Program. Landsat 7 is formally now part of NASA's Mission to Planet Earth. These data will also support many federal government operational programs and the data needs of state and local governments, the U.S. private sector, and foreign entities.

In May 1994, the Clinton administration resolved the outstanding issue of procurement and operational control of the Landsat system by assigning it jointly to NASA, NOAA, and the Department of the Interior. Under this plan, NASA will procure the satellite, NOAA will manage and operate the spacecraft and ground system, and the Department of the Interior will archive and distribute the data at the marginal cost of reproduction. [II-45] NASA has scheduled the launch of Landsat 7 for 1999. However, the future of government-funded land remote-sensing satellites beyond Landsat 7 is still uncertain.

The Beginning of Commercial Remote Sensing

Having failed in successfully transferring the Landsat system to private ownership and operation, government programs and policy were nonetheless in part responsible for making commercial remote sensing possible. The Land Remote Sensing Policy Act of 1992 included Title II, which sets out the terms for government licensing of private operators of remote-sensing satellite systems. Title IV of the 1984 act had included identical wording, requiring that potential private operators of remote-sensing satellites acquire an operating license from the federal government in accordance with international obligations, but until 1992, no company had taken advantage of that provision. The legislation assigned to the secretary of commerce the responsibility for considering and granting such licenses, requiring that the secretary act on such applications within 120 days, "in consultation with other appropriate United States Government agencies. . . ."[81]

In October 1992, shortly after President Bush signed the 1992 act, WorldView, Inc., applied for a license to operate a commercial remote-sensing system. WorldView's plans called for building a system capable of collecting stereo panchromatic data of three-meter resolution and multispectral data of fifteen-meter resolution in green, red, and near-infrared spectral bands, although with a narrow field of view.[82] WorldView's sensor was designed to collect stereo pairs along the satellite track as well as sideways off track, enabling a rapid revisit of areas of particular interest. Technology developed as part of Lawrence Livermore Laboratory's ballistic missile defense program supplied the instrumental basis for a commercial system. Perhaps the greatest innovation, however, was a data marketing plan based on commercial objectives, rather than on meeting government requirements. WorldView's officials judged that the ultimate market for these data was the information industry, which was planning to use the Internet, CD–ROM, and other information technologies to reach customers quickly and efficiently.[83] Such plans depended on the ability of WorldView and other companies that followed to build and operate a satellite at much lower cost than Landsat. A commercial data marketing plan involves collecting data only of sufficient quality and quantity to meet the needs of most cus-

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81. The Land Remote-Sensing Policy Act of 1992 (15 U.S.C. 5621, Sec. 201 (c)).

82. The Early Bird satellite will be capable of gathering panchromatic data along a three-kilometer swath and multispectral data along a fifteen-kilometer swath.

83. Williamson, "The Landsat Legacy," pp. 883–84.

alent data on the scale needed by federal agencies.[79] Finally, the advent of the geographic information system (GIS) and the development of other information technologies, such as high-powered computers, inexpensive storage devices, and the Internet, promised to reduce the costs and complexities of processing Landsat data.[80]

As a result of these and other pressures to continue collecting Landsat data, in 1992 the administration, with the strong support of Congress, moved to place operational control of Landsat 7 and beyond to DOD and NASA. [II-38] Under the Landsat management plan negotiated between DOD and NASA, DOD agreed to fund the development of the spacecraft and its instruments, while NASA agreed to fund the construction of the ground data processing and operations systems, to operate the satellite, and to provide for Landsat data distribution. [II-39] The Land Remote Sensing Policy Act of 1992, signed into law in October, codified the management plan and authorized approximately equal funding from each agency for the operational life of Landsat 7. [II-40]

Landsat 6 was to carry an Enhanced Thematic Mapper (ETM) having better radiometric calibration than previous TM sensors, along with an additional "sharpening" panchromatic band of fifteen-meter resolution, allowing it to deliver data with resolution nearly equivalent to SPOT data. NASA had studied this capability in the mid-1970s but dropped any plans to build higher resolution instruments as a result of national security restrictions on the sharpness of data from civilian satellites. By the 1990s, other countries had started selling fine-resolution data, so those national security concerns had become moot (see below).

Initial NASA and DOD plans called for Landsat 7 to include an ETM Plus, an improved version of the ETM under development for Landsat 6. Later, DOD began to consider adding a new multispectral sensor to the satellite, the High Resolution Multispectral Stereo Imager (HRMSI), capable of collecting five-meter resolution data particularly useful for mapping. NASA and DOD analysts estimated that developing, launching, and operating Landsat 7 for five years would equal $880 million (1992 dollars). NASA considered the additional instrument optional; in the course of discussions, DOD decided that it should be an operational requirement. However, the HRMSI sensor and additional ground operations equipment would have cost an additional $400 million. The high data rates expected for the HRMSI nearly doubled the overall required system data rate and would have added significant costs to NASA's yearly operations budget for Landsat 7.

In September 1993, Landsat 6 was launched but failed to reach orbit, raising additional concerns about the loss of data continuity. That same month, NASA officials concluded that the costs of operating Landsat 7 with HRMSI were too large, given other strains on the space agency's budget. In December 1993, DOD decided not to fund the resulting Landsat 7 budget shortfall. As a result of disagreement over the Landsat 7 requirements and budget, DOD decided to drop out of the agreement altogether. [II-41, II-42, II-43, II-44] That left NASA to fund the development of Landsat 7, carrying only the planned thirty-meter-resolution ETM Plus. After some discussion, DOD transferred $90 million to NASA to assist in developing the satellite and sensor because DOD would

79. In 1990, John Knauss, Commerce Under Secretary for Oceans and Atmosphere, stated: "Our experience with the Landsat program . . . [has] led us to the conclusion that commercialization of Landsat, as had originally been envisioned, is not possible." J. Knauss, Under Secretary for Oceans and Atmosphere, Department of Commerce, Statement before the Senate Committee on Commerce, Science, and Transportation, June 12, 1990, Space Policy Institute Documentary History Collection, Washington, DC.

80. Ray A. Williamson, "The Landsat Legacy: Remote Sensing Policy and the Development of Commercial Remote Sensing," *Photogrammetric Engineering and Remote Sensing* 63 (July 1997): 877–85.

iting Shuttle payloads to those requiring the unique characteristics of the Shuttle.[75] This caused NOAA to direct EOSAT to prepare for launch on an expendable launch vehicle. Other disagreements between the administration and Congress delayed a decision to fund the Landsat system until the spring of 1988.[76] By that time, it had become fully apparent that the subsidy ($219 million) would cover only the development and construction of one spacecraft. The Reagan administration and Congress nearly terminated EOSAT's operation of Landsats 4 and 5 several times for lack of a few million dollars of operating funds.[77]

Part of the difficulty arose because, in the 1980s, proponents of land remote sensing faced the same problem they had experienced in the 1960s. No single agency was willing to commit funding ($15–30 million per year beyond EOSAT's revenue from data sales) to continue system operations. Unlike the weather satellites, which NOAA operated to provide data for its own National Weather Service, the Department of Commerce had no internal constituency for collecting remotely sensed land data. The Carter administration had selected NOAA because of the agency's experience in operating the weather satellite systems. Congress expressed only lukewarm interest in supporting NOAA's long-term operation of Landsat. This lack of commitment to a continuously operated remote-sensing system undermined what little confidence data customers had in the Landsat system. Relatively few customers were willing to develop the necessary processing infrastructure and training programs or make other investments that depended on the routine delivery of Landsat data.

NOAA and EOSAT expected to launch Landsat 6 in 1992, with the federal government providing most of the funding for building and launching the satellite. However, even if Landsat 6 successfully reached orbit and operated as designed for five years, this plan still left the United States with the prospect of entering the late 1990s with no capability to collect Landsat data. It soon became clear that even if the data market doubled or tripled, EOSAT would not earn sufficient revenue to build Landsat 7. To resolve growing concerns over the future of the Landsat program, President Bush "directed the National Space Council and the Office of Management and Budget to review options with the intention of continuing Landsat-type data collections after Landsat 6." [II-37]

The Land Remote Sensing Policy Act of 1992

By the early 1990s, several circumstances led to the decision to return Landsat system operation to the government. First, the U.S. military made extensive use of Landsat and SPOT data to create maps used in planning and executing U.S. maneuvers during the 1991 Gulf War.[78] Second, Landsat proponents worried that failing to develop Landsat 7 would give SPOT full control of the international market for multispectral satellite data. Third, global change researchers began to appreciate that the twenty-year Landsat data archive would allow them to follow environmental change on parts of Earth's surface. Fourth, the attempt to commercialize the Landsat system had faltered badly, and policy makers began to feel that no private company was soon likely to be able to provide equiv-

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75. The White House, "Statement on the Space Shuttle," August 15, 1986, Space Policy Institute Documentary History Collection, Washington, DC.

76. U.S. Congress, Congressional Research Service, "Future of Land Remote Sensing System (Landsat)," 91-685-SPR, pp. 6–7, Space Policy Institute Documentary History Collection, Washington, DC.

77. M. Mitchell Waldrop, "Landsat Commercialization Stumbles Again," *Science* 246 (January 9, 1987):155–56; Eliot Marshall, "Landsat: Cliff-hanging, Again," *Science* (October 20, 1989): 321–22.

78. B. Gordon, Statement before the U.S. House of Representatives, Joint Hearing of the Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, Scientific, Military, and Commercial Applications of the Landsat Program, Hearing Report 102-61, June 26, 1991.

place.[68] During that time, two additional Landsat satellites were launched to provide continuity of data delivery, but the development of a more advanced operational system was put on hold. These satellites did carry one new instrument, the Thematic Mapper (TM), which was a significant improvement over the Multispectral Scanner that had been carried on the initial satellites. The most provocative proposal to come from private industry was from Comsat in July 1981 to take on full responsibility for both Earth resource and meteorological satellites.[69] [II-33] Many observers had doubted that commercialization could protect the public interest in meteorological satellite data; similar concerns were voiced with respect to Earth resource satellites.[70] [II-34]

President Reagan proved an even stronger supporter of the transfer of government projects to private industry than President Carter had been. In March 1983, Reagan announced a decision to transfer Landsat, the meteorological satellites, and future ocean observation satellites to private industry.[71] As already mentioned, Congress rejected the idea of transferring the meteorological satellite program to private industry. [II-35] However, the Department of Commerce proceeded with a request for proposals from private industry for operational control of the Landsat system.[72] Congress passed a bill setting the terms for transfer in 1984, and the Earth Observation Satellite Company (EOSAT), a joint venture of Hughes and RCA, won the competition. [II-36]

This 1984 legislation supported the concept of providing sufficient subsidy to continue Landsat operations while EOSAT built a market for data. Department of Commerce officials envisioned that with government help, EOSAT would build Landsats 6 and 7. Eventually, administration and congressional supporters believed, the data market would grow large enough to support entirely private ownership and operation of future Landsat systems. NOAA's 1985 Commercialization Plan called for continued government funding of $250 million to build Landsats 6 and 7.[73] To assist in this process, EOSAT began building its own operations control and receiving station in Norman, Oklahoma.

In the fall of 1985, EOSAT complicated negotiations over the amount of subsidy by proposing to fly the TM on a spacecraft designed to be launched by the Space Shuttle.[74] Despite the loss of the orbiter *Challenger* in January 1986, NOAA agreed to the proposal in March 1986; in August of the same year, the Reagan administration issued a decision lim-

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68. William H. Gregory, "Free Enterprise and Landsat," *Aviation Week and Space Technology* 113 (July 14, 1980): 13; Ed Harper to Craig Fuller and Martin Anderson, "Resolution of Issues Related to Private Sector Transfer of Civil Land Observing Satellite Activities," July 13, 1981; National Oceanic and Atmospheric Administration, "Transfer of the Civil Operational Earth Observation Satellites to the Private Sector," draft, January 19, 1983. The last two documents are located in the Space Policy Institute Documentary History Collection, Washington, DC.

69. Communications Satellite Corporation News Release, "Comsat President Proposes Bold Restructuring of Earth Sensing Satellite Systems," July 23, 1981, Space Policy Institute Documentary History Collection, Washington, DC.

70. David A. Stockman, Office of Management and Budget, to Malcolm Baldridge, Secretary of Commerce, May 9, 1983. See Pamela E. Mack, "Commercialization, International Cooperation, and the Public Good," in Daniel S. Papp and John R. McIntyre, eds., *International Space Policy: Legal, Economic, and Strategic Options for the Twentieth Century and Beyond* (Westport, CT: Quorum Books, 1987), pp. 195–202.

71. "Statement by Dr. John V. Byrne, Administrator, National Oceanic and Atmospheric Administration, U.S. Department of Commerce," March 8, 1983, Space Policy Institute Documentary History Collection, Washington, DC.

72. U.S. Department of Commerce, "Request for Proposals for Transfer of the United States Land Remote Sensing Program to the Private Sector," January 3, 1984.

73. Landsat proponents argued that nearly double this amount was necessary to ensure adequate support for the commercialization process, but David Stockman, director of the Office of Management and Budget under President Reagan, would agree only to the $250 million.

74. At the time, NASA envisioned being able to launch the Shuttle into polar orbit from Vandenberg Air Force Base in California. Landsat satellites then would have been serviced in orbit by Shuttle crews.

tial users did not want to invest in the information systems necessary to process and analyze Earth resources satellite data until they knew that the data would continue to be available in the future, while the Office of Management and Budget did not want to fund an operational program until it was clear that enough users would participate to justify it.[63] As delays mounted, Landsat technology became increasingly out of date; in 1986 France launched an Earth resources satellite named SPOT (*Satellite Pour l'Observation de la Terre*) that in some ways was more sophisticated.

Instead of choosing which federal agency would house an operational program, an alternative approach gained increasing attention: that private industry should take over Earth resource satellites because it had communications satellites (instead of retaining the program as a government function as had been done with meteorological satellites). The impetus for the idea came primarily from those interested in reducing the federal budget; unlike communication satellites, the potential profitability of Earth resource satellites was so uncertain that private industry had only limited interest in taking over the whole system.[64] [II-29, II-30] In October 1978, President Jimmy Carter issued Presidential Decision 42, which asked NASA and the Department of Commerce to find ways to encourage private industry participation in civilian remote sensing (including Landsat, weather satellites, and ocean observation satellites).[65]

Some type of decision about an operational Landsat program had to be made, but privatization raised many difficult questions. Presidential Decision 42 led to the creation of an interagency task force to study the problems of and potential for private-sector participation in remote sensing, with a particular focus on Landsat. The task force report addressed issues ranging from cost to potential international sensitivity about private-sector control of data. It concluded that privatization of the whole system or of the space segment was premature, but that private industry should be encouraged to make proposals for investment in any part of the system.[66] This resulted in Presidential Decision 54 in November 1979, giving NOAA temporary responsibility for managing an operational Landsat system and asking NOAA to study ways to encourage private participation. Presidential Decision 54's long-term goal was eventual operation by the private sector.[67] [II-31, II-32]

A lengthy debate followed concerning whether and how privatization might take

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62. James C. Fletcher to James T. Lynn, Office of Management and Budget, September 15, 1976, Space Policy Institute Documentary History Collection, Washington, DC.

63. Bruno Augenstein, Willis H. Shapley, Eugene B. Skolnikoff, "Earth Information from Space by Remote Sensing," report prepared for Dr. Frank Press, Director, Office of Science and Technology Policy, June 2, 1978; see Document II-30. This document also addresses another obstacle: controversy over which agency would control the operational system. See Mack, *Viewing the Earth,* pp. 204–05.

64. Privatization meant the development of something similar to Comsat—a private corporation that would purchase satellites, pay for launch services, manage the working spacecraft, and process and sell data, all at its own risk. This is different from the small industry that had developed to sell analysis and special processing of Landsat data. That industry did not want the government providing too many services, but it did want the government to provide the basic data. See J. Robert Porter, Jr., President, Earth Satellite Corporation, "Statement before the House Subcommittee on Space Science and Applications," June 23, 1977, Space Policy Institute Documentary History Collection, Washington, DC.

65. Also in October, Senator Harrison Schmitt introduced a bill calling for the creation of an Earth Resources Information Satellite Corporation modeled on Comsat. No action was taken on the bill. Science Policy Research Division, Congressional Research Service, *United States Civilian Space Programs. Volume II, Applications Satellites,* prepared for the Subcommittee on Space Science and Applications of the Committee on Science and Technology, U.S. House of Representatives, May 1983, pp. 249–50.

66. "Private Sector Involvement in Civil Space Remote Sensing," draft, June 4, 1979, Space Policy Institute Documentary History Collection, Washington, DC.

67. *United States Civilian Space Programs, Volume I,* pp. 238–42. For issues relating to the transition to an operational system, see the letter from Richard D. Lamm to George S. Benton, NOAA, April 30, 1980, with attached: "Recommendations of the National Governor's Association, National Conference of State Legislatures, Intergovernmental Science, Engineering & Technology Advisory Panel, National Resources & Environment Task Force, for the Final Transition Plan for the National Civil Operating Remote Sensing Program (first draft April 10, 1980)," April 30, 1980.

to apply the data, then the project would not bring the benefits promised.[57] [II-25]

NASA therefore became involved not only in promoting the use of Landsat data, but also in supporting research to develop approaches to their use. One major project involved agricultural surveys, because better prediction of harvests was one use of Landsat data that the space agency had predicted would bring significant benefits.[58] The Large Area Crop Inventory Experiment (LACIE) involved NASA, the National Weather Service, and the Department of Agriculture in an attempt to develop and test a crop forecasting system using Landsat data. The data, it was claimed, could provide two things: information on how much land had been planted in a given crop (assuming one could differentiate among crops in the data) and information on crop health (because badly stressed vegetation reflected less infrared light). The project achieved reasonable success, but the problem of identifying and differentiating crops from satellite imagery turned out to be much more difficult than expected.[59] [II-26] Furthermore, the Department of Agriculture chose not to adopt the system developed by the LACIE project for operational use.[60] Several other experiments were more successful, but use of Landsat data for operational applications continued to develop more slowly than its promoters had hoped.[61] A NASA-sponsored technology transfer and utilization program involving universities, state and local governments, and industry could not reverse this reality.

Operational Landsat Program

The development of an operational program became the subject of a series of political debates. Different groups proposed at least three different alternatives. First, the federal government could develop an operational Earth resources program on the model of the operational weather satellite program, providing satellite data for the public good. Second, a private company might take over the existing Landsat system and run it as a business, an option usually called privatization. Third, a private company might develop and launch a new and separate Earth observations satellite, an option usually called commercialization.

Despite the somewhat disappointing growth of Landsat data use, the Department of the Interior wanted an early transition to a government-sponsored operational satellite program, but the agency faced a number of obstacles. [II-27] First, the Office of Management and Budget questioned whether Landsat had yielded enough benefits to justify a continued government-funded program.[62] [II-28] This issue posed a dilemma: poten-

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57. James C. Fletcher to Frank E. Moss, February 20, 1973; Hans Mark to Clifford E. Charlesworth, July 31, 1973; William E. Stoney to Distribution, "Summary Thoughts on Earth Resources Transfer Meeting," June 27, 1975. All of these documents are in the Space Policy Institute Documentary History Collection, Washington, DC.

58. Carroll G. Grunthaver, U.S. Department of Agriculture, to Leonard Jaffe, Deputy Associate Administrator, NASA, August 22, 1973, discusses a new research and development study to develop a computer-based system for spring wheat yield estimation.

59. James L. Mitchell, Office of Management and Budget, to Richard E. Bell and Don Paarlberg, Department of Agriculture, "Large Area Crop Inventory Experiment," October 8, 1976, Space Policy Institute Documentary History Collection, Washington, DC.

60. Mack, *Viewing the Earth*, pp. 146–58.

61. For a story with a successful outcome see John P. Erlandson, Army Corps of Engineers, to R. B. MacDonald, Johnson Space Center, March 16, 1976, Space Policy Institute Documentary History Collection, Washington, DC; Mack, *Viewing the Earth*, p. 130. For the reasons of slow adoption, see letter from Sally Bay Cornwell, National Conference of State Legislatures, to Allen H. Watkins, EROS Data Center, December 3, 1977, and letter from Allen H. Watkins to Sally Bay Cornwell, December 22, 1977, Space Policy Institute Documentary History Collection, Washington, DC.

untested technology.[51]

Data processing and distribution provided even more serious challenges: a satellite taking pictures of the entire Earth, even at a spatial resolution of about 100 meters, would quickly produce an overwhelming amount of data. Effective use, particularly coverage of large areas and repeated coverage of the same scene to observe changes, would require analysis by computer rather than by a human photointerpreter. However, technology for such large-scale image processing had not yet been developed in the civilian world.[52]

Budgetary constraints proved even more serious than technical problems. Facing declining support for the space program once NASA reached its Apollo goal, the space agency's leaders attempted to capitalize on the usefulness of space to promote applications programs.[53] [II-18, II-19, II-20] The strategy did not work; the Bureau of the Budget repeatedly deleted the ERTS project from the budgets of NASA and the Department of the Interior. [II-21] In fact, the strategy of promoting usefulness may have backfired: the Bureau of the Budget (Office of Management and Budget after 1970) repeatedly asked NASA to prove that the benefits of Landsat would exceed the costs. NASA sponsored the required studies and also appealed cuts in the project's budget directly to the president.[54] The Department of the Interior obtained funding to build a data processing and distribution center only with the help of Republican Senator Karl Mundt of South Dakota. Senator Mundt had become a major supporter of the project when the Department of the Interior decided to locate its data processing center in Sioux Falls, South Dakota.[55] [II-22]

Despite all the discord, the first satellite proved a technical success. NASA launched Landsat 1 on July 23, 1972, and scientists quickly found many uses for the data. Prior to the satellite's launch, NASA had received more than 600 proposals from scientists and others requesting funding to investigate uses of data from the satellites. More than 200 proposals from U.S. investigators and 100 from overseas were funded; these scientists stood ready to use Landsat data as soon as they became available.

The use of Landsat data raised a number of issues. Developing countries had initially worried about the misuse of data gathered without their consent, but when satellite data began to arrive, they found it of considerable value in providing information on areas that were inadequately mapped. [II-23] Despite these benefits, debate continued over international political and legal issues associated with remote sensing. [II-24] Landsat data proved useful to scientists of many sorts, for everything from searching for oil to mapping ice.[56] Yet unlike meteorological satellites, whose data proved more useful to weather forecasters than to research scientists building models, Landsat data were quickly used by researchers, and much more slowly such data found widespread operational use. NASA leaders discovered that if the space agency did not find ways to convince potential users

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51. Mack, *Viewing the Earth,* pp. 66–79. NASA was not allowed to use better tested technology that had been developed for reconnaissance satellites.

52. Badgley to Distribution, "Meeting of Earth Resources User Agency Representatives, April 20, 1967," May 4, 1967; Mack, *Viewing the Earth,* pp. 107–18.

53. Leonard Jaffe to the Record, "Commentary Delivered by Mr. Leonard Jaffe at the Airlie House Planning Seminar, June 1966," July 8, 1966, Space Policy Institute Documentary History Collection, Washington, DC.

54. Mack, *Viewing the Earth,* pp. 80–93. This issue continued even after launch. See Paul A. Vander Myde to George M. Low, February 25, 1975, Space Policy Institute Documentary History Collection, Washington, DC.

55. Press release from the office of Senator Karl E. Mundt, March, 30, 1970, Space Policy Institute Documentary History Collection, Washington, DC; David L. Stenseth, "EROS—The Local Story," *IDEL Earth Trak* 1 (June 1974): 4–5; Mack, *Viewing the Earth,* pp. 132–45.

56. Anthony J. Calio to Director, Johnson Space Center, "Earth Resources Briefing for Petroleum Industry Representatives," November 12, 1973; Charles D. Centers to Mathews, February 15, 1973. Both documents are located in the Space Policy Institute Documentary History Collection, Washington, DC.

The idea for a civilian Earth resource satellite had two sources. DOD had an active reconnaissance satellite program growing out of experience with reconnaissance aircraft dating back to World War I. Scientists who investigated new technology for the classified reconnaissance program often had training in geology or geography, and they saw much potential for civilian use of the classified data they studied. In addition, NASA hired significant numbers of geologists to prepare the scientific program for Apollo, and some of them became interested in looking at the Earth as well as the Moon from space.[47] In 1965, NASA started to investigate the potential of studying Earth resources from space using instruments flown in its own aircraft. [II-13] The space agency wanted to involve the U.S. Geological Survey (a branch of the Department of the Interior) and the Army Corps of Engineers in remote-sensing research.

NASA proceeded slowly, testing a variety of sensors from aircraft before planning an experimental satellite. In a pattern similar to the debate over Nimbus, the space agency's initial plans for Earth resource satellites called for a large, sophisticated experimental satellite. [II-14] Meanwhile, scientists at the Department of the Interior had become convinced of the value of satellite data for applications and wanted an early operational satellite instead of elaborate experiments. [II-15] Impatient with NASA's lack of action, a group of scientists at the U.S. Geological Survey persuaded Secretary of the Interior Stewart L. Udall to announce in September 1966 that the Department of the Interior would start its own operational satellite program.[48] [II-16] When the Weather Bureau pulled out of its meteorological satellite agreement with NASA, it made an alternative alliance with DOD. The Department of the Interior, on the other hand, was unable to find a partner with space expertise; thus its announcement was more a bureaucratic maneuver than a realistic plan. Nevertheless, the resultant publicity forced NASA to commit to faster action on an experimental project to build the kind of small satellite the Department of the Interior wanted.[49] [II-17] NASA initially called the project the Earth Resources Technology Satellite (ERTS), but it changed the name to Landsat in 1975. General Electric won the prime contract for both the Nimbus and Landsat programs, and the Nimbus platform that had been developed and flown by NASA was also used for Landsat.

Many problems remained after the agreement on what kind of satellite NASA would build. The interested agencies continued to disagree over a variety of management and technical issues and over the proper balance between an experimental and an operational program.[50] The Department of the Interior and the Department of Agriculture wanted different kinds of sensors; Interior preferred a return-beam vidicon (a type of television camera), while Agriculture desired a multispectral scanner. Both sensors involved relatively

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47. Pamela E. Mack, *Viewing the Earth: The Social Construction of the Landsat Satellite System* (Cambridge, MA: MIT Press, 1990), pp. 31–42. To see how an Earth observation program grew out of research on the other planets, see Peter C. Badgley, "The Applications of Remote Sensors in Planetary Exploration," paper presented at the Third Annual Remote Sensing Conference, Ann Arbor, Michigan, October 14, 1964.

48. The Department of the Interior called its program Earth Resources Observation Satellites (later Systems), or EROS.

49. W.T. Pecora, Director, Geological Survey, to Under Secretary, Department of the Interior, "Status of EROS Program," draft, June 15, 1967, Space Policy Institute Documentary History Collection, Washington, DC. For more details, see Mack, *Viewing the Earth*, pp. 56–65.

50. Peter C. Badgley, Program Chief, Earth Resources Survey, to Distribution, "Meeting of Earth Resources User Agency Representatives with Space Applications Staff Members and Advanced Manned Missions Staff Members, April 20, 1967," May 4, 1967; Jacob E. Smart, Assistant Administrator for Policy, NASA, to Dr. Seamans, "Meeting with Representatives of Department of Agriculture and Interior Earth Resources," September 11, 1967, with a confidential second memo of same subject and date; Jacob E. Smart, Assistant Administrator for Policy, NASA, to Dr. Mueller, *et al.*, "Earth Resources Survey Program," October 3, 1967; Edgar M. Cortright for George E. Mueller, Associate Administrator for Manned Space Flight, Memorandum to Assistant Administrator for Policy, "Earth Resources Study Program," November 17, 1967; Harry J. Goett to Daniel G. Mazur, December 3, 1967. All of these documents can be found in the Space Policy Institute Documentary History Collection, Washington, DC.

the determination of several elements of the administration and Congress to follow through on their program commitments.

4. *Maintaining close international cooperation*. Cooperating with EUMETSAT and in time possibly other nations in operating a fleet of operational environmental satellites poses additional challenges for the three agencies. EUMETSAT policies and funding mechanisms will continue to be driven by the needs, philosophies, and funding mechanisms of its member weather organizations, which are likely to be different than those of the IPO. Maintaining the system and high-quality data delivery over time will require continued flexibility on the part of the IPO in negotiating system upgrades. Adding additional organizations to the system will further complicate such negotiations, although this could increase system capability and further reduce U.S. costs.

Despite these challenges, the attempt to consolidate NOAA's and DOD's meteorological programs is more likely to succeed than past efforts because of the confluence of several factors. First, continuing pressures to maintain reduced agency budgets will encourage agency officials to continue to seek program efficiencies. Cost savings are also an important factor in resolving possible frictions among congressional oversight and appropriations committees over programmatic aspects of the converged system. Second, earlier plans by NOAA and DOD to upgrade both the DMSP and POES instruments and spacecraft shortly after the turn of the century will support technical convergence. Third, the changed international security environment will cause DOD analysts and managers to continue to moderate their historical objection to shared military-civilian systems. In addition, the opportunity to involve EUMETSAT and perhaps other nations or organizations in providing environmental data could further reduce overall program costs. Finally, including NASA explicitly in the partnership provides the opportunity to plan ongoing innovation and the transition of research instruments built in support of NASA's Earth Science activities to operational status for the converged system.

Earth Resource Satellites

Earth resource satellites suffered many of the same kinds of controversies in their transition from research to operations as meteorological satellites, with worse results. Part of the tension over this transition resulted from worries about whether a program to collect images of the Earth for civilian purposes would threaten the secrecy surrounding DOD's reconnaissance satellite programs. Another more important source of difficulty was a fragmented data user community; the images taken from Earth resource satellites were useful for geologists, hydrologists, agricultural scientists, city and regional planners, geographers, and people from other disciplines. Yet, a system serving all these disciplines was unable to meet the needs of any one extremely well. Even within the federal government, two agencies with different interests, the Department of the Interior and the Department of Agriculture, sought to shape the program. Another problem was that Earth resource satellite projects started later than meteorological satellites. With a first launch in 1972, the Earth resource satellite program began only after enthusiasm for Apollo had waned; at this point, NASA's budget was subject to much more intense scrutiny from the Office of Management and Budget and Congress.

Research Program

METOP. NOAA and EUMETSAT began to develop explicit plans to operate the METOP satellite series as morning-crossing spacecraft carrying three U.S. instruments: the Advanced Very High Resolution Radiometer (AVHRR), the High-Resolution Infrared Sounder (HIRS), and the Advanced Microwave Sounding Unit. On May 6, 1994, NOAA formally invited EUMETSAT to participate in the converged U.S. system. [II-11, II-12]

Under the convergence plan, by about 2005 or 2007, the United States will keep two satellites in orbit at all times: a polar orbiter that will cross the equator early in the morning to obtain early cloud data of particular interest to DOD and an afternoon-crossing orbiter that will provide the atmospheric soundings that the National Weather Service needs to support data inputs to its predictive models. METOP-1 will cross the equator in the late morning to collect data of particular interest to EUMETSAT's European data users.

One important issue that had to be decided was the data policy for METOP. In keeping with its long-standing U.S. data policies articulated in Office of Management and Budget Circular A-130, the United States has insisted that data from its sensors not be controlled even if they fly on the spacecraft of other nations.[46] In keeping with its data policy, EUMETSAT wishes to control the data from the satellite to assure that the countries benefitting from the system contribute to its funding. On the other hand, the United States wants the power to deny data delivery to an adversary in times of crisis or war.

The three U.S. agencies will need the long period between the convergence decision and operational status of the system to resolve several technical, programmatic, and institutional issues:

1. *Developing new sensors and spacecraft.* Because DOD and NOAA have different data requirements, it will be challenging to meet all the primary data requirements and still reduce program costs. The IPO, for example, may find it difficult to satisfy DOD's need for images of constant resolution across the field and maintain the radiometric quality that NOAA desires. NOAA also has a requirement for sounding data of higher quality than DOD's.

2. *Incorporating new capabilities in operational sensors.* NASA's involvement in the integrated program could lead to interesting opportunities to incorporate improved sensors or new data types in DOD's and NOAA's operational programs, derived from experience with NASA's Mission to Planet Earth research efforts. However, the sensors designed to tackle research problems are generally much more expensive and capable than those designed for routine data collection. Hence, making the transition to operational status also presents special challenges to designers in making cheaper instruments capable of meeting operational requirements. Data users will also have to adjust their operations to make efficient use of more complex, but more useful data.

3. *Maintaining institutional collaboration among U.S. agencies.* The three agencies in the IPO have worked diligently to establish a collaborative working relationship. However, each agency's budget is subject to radically different priorities and is overseen within the Office of Management and Budget by different examiners. In addition, each receives oversight and its appropriation from different congressional committees and subcommittees. Hence, continued progress in maintaining the IPO will depend on

46. International Space University, *Toward an Integrated International Data Policy Framework for Earth Observations: A Workshop Report*, ISU/REP/97/1 (Illkirch, France: International Space University, January 1997).

million through the year 2000 and $1 billion over a decade by creating a converged environmental satellite system. The National Performance Review also recommended that NASA

> *assist in ongoing efforts to converge U.S. operational weather satellites, given the benefits of streamlining the collection of weather data across the government... By considering [Mission to Planet Earth] research activities in context with operational weather satellite programs, cost savings are possible through convergence of the current operational satellite fleets. Convergence of the National Oceanic and Atmospheric Administration (NOAA) Polar Metsat and NASA's EOS-PM (Earth Observing System Afternoon Crossing [Descending] Mission) will eliminate redundancy of measurements, enhance the capability of NOAA's data set and potentially result in cost savings.*[43]

After further study, Vice President Gore's initial proposition resulted in a plan detailed in a May 1994 Presidential Decision Directive (also known as NSTC-2) on the "Convergence of U.S.-Polar-orbiting Operational Environmental Satellite Systems." [II-10] This decision directive called for an Integrated Program Office (IPO) that will "be responsible for the management, planning, development, fabrication, and operations of the converged system." The IPO was set up in October 1994. NOAA gained the lead responsibility for operations, with DOD leading systems acquisition and NASA leading new development and the insertion of new technologies.

One of the important considerations in exploring the exact terms of convergence was prior interest at NOAA in cooperating more closely with Europe in NOAA's polar-orbiting program. Europe had been contributing instruments to NOAA's POES spacecraft since 1978. During the early 1980s, the Reagan administration attempted to reduce the two-satellite constellation (one morning-crossing, one afternoon-crossing) to a single afternoon-crossing spacecraft. NOAA officials became extremely concerned that maintaining only a single orbiter would greatly reduce the reliability of data delivery. Hence, the agency began discussions with other countries, forming the International Polar Orbiting Meteorological Satellite Group (IPOMS) to promote a more equitable sharing of the burden of maintaining polar-orbiting meteorological satellites. Membership in IPOMS included most of the major remote-sensing satellite operators. Within IPOMS, the European Space Agency (ESA) together with the newly created European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) expressed interest in providing a European polar orbiter that could replace one of NOAA's spacecraft.[44]

Under the strategy developed during the 1980s, NOAA planned to provide several instruments for a European orbiter, which would replace the morning-crossing NOAA satellite. Originally, this satellite was to be a large ESA spacecraft carrying both global change research instruments and operational meteorological instruments.[45] By 1992, this plan had evolved into one in which Europe would orbit two spacecraft: an ESA global change research satellite, Envisat, and a EUMETSAT meteorological operational satellite,

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43. Office of Vice President, *National Aeronautics and Space Administration, NASA05: Clarify the Objectives of the Mission to Planet Earth Program, in Accompanying Report of the National Performance Review* (Washington, DC: Office of the Vice President, September 1993).

44. Minutes of the Fourth IPOMS Plenary and First Administrative Working Group Tokyo, Japan, November 12–13, 1987, IPOMS Reports, National Environmental Data and Information System, National Oceanic and Atmospheric Administration, 1987, Space Policy Institute Documentary History Collection, Washington, DC.

45. This spacecraft was originally conceived to be one of an international fleet of large research and operational polar orbiters, launched and serviced by the Space Shuttle. With the loss of *Challenger* in January 1986 and the subsequent change of U.S. policy toward the use of the Space Shuttle, these plans were abandoned.

Key Sensors and Priorities for NOAA's and DOD's Polar Meteorological Programs

Agency and Data Acquired	*Sensor*	*Attributes*
NOAA		
Multispectral imagery (cloud, vegetation)	Advanced Very High Resolution Radiometer (AVHRR)	Calibrated, multispectral imagery
Temperature and humidity (initialize numerical weather prediction model)	TIROS Operational Vertical Sounder (TOVS)	High spatial resolution, cross-track scanning (PM equator crossing)
DOD		
Visible and infrared cloud imagery (cloud-detection forecast, tactical imagery dissemination)	Operational Linescan System (OLS)	Constant field of view; low-light (early AM crossing)
Microwave imagery (ocean winds, precipitation)	Special Sensor Microwave/Imager (SSM/I)	Conical scan
Temperature and humidity (electro-optical propagation, initialize numerical weather prediction models)	Special Sensor Microwave/ Temperature Sounder (SSM/T-1); Special Sensor Microwave/ Water Vapor Sounder (SSM/T-2)	Low spatial resolution, cross-track scanning

Source: Office of Technology Assessment, U.S. Congress, *Civilian Satellite Remote Sensing: A Strategic Approach,* OTA-ISS-607 (Washington, DC: U.S. Government Printing Office, September 1994), p. 79.

In February 1993, Representative George Brown, then chair of the House Committee on Science, Space, and Technology, sent a letter to NOAA Administrator D. James Baker, requesting a review of the NOAA and DOD polar-orbiting programs to explore possible cost savings. [II-7] As a result of this initiative and similar interest within the Clinton administration, the two agencies began to examine the two programs once again. A few months later, Senator James Exon, chair of the Senate Subcommittee on Nuclear Deterrence, Arms Control and Defense Intelligence, sent a similar request to Commerce Secretary Ron Brown. [II-8] A report of the U.S. Congress Office of Technology Assessment also offered consolidation of the two programs as an option for reducing federal spending.[42]

By July 1993, the two major convergence studies were consolidated into a single tri-agency study involving DOD, NASA, and NOAA. With input from this study, by September 1993, Vice President Al Gore's National Performance Review made a firm proposal to integrate the two systems. [II-9] This proposal estimated that the government would save $300

42. Ray A. Williamson, "NASA's Mission to Planet Earth," Statement before the Space Subcommittee of the House Committee on Science, Space, and Technology, May 6, 1993; U.S. Congress, Office of Technology Assessment, *The Future of Remote Sensing: Civilian Satellite Systems and Applications,* OTA-ISC-548 (Washington, DC: U.S. Government Printing Office, July 1993), p. 16.

Although the civilian and military polar-orbiting meteorological satellite programs have followed separate paths, there have been several attempts to bring them together over the years. Officials within several administrations kept hoping that a merged system could meet the requirements of both NOAA and DOD (because each had a need to acquire imagery of clouds) while providing an overall savings to the government. However, NOAA and DOD weather systems acquire varying kinds of data at different times of the day to support distinct types of uses. For example, DOD is interested in cloud image data acquired in the early morning to support tactical and strategic operations; NOAA is more interested in atmospheric soundings in the early afternoon, which the National Weather Service feeds into its predictive weather models. Furthermore, until the 1980s, DMSP data were not shared with civilian users.

In 1973, a national space policy study led by the Office of Management and Budget and the National Security Council[40] examined the fiscal and policy implications of conducting separate DOD and NOAA operational weather satellite systems. This study based its assessment of the technical feasibility and costs of a converged system on NOAA, NASA, and DOD analyses, concluding that no option could maintain performance levels and also reduce costs significantly. In addition, policy concerns regarding the open distribution of weather data useful to potential adversaries argued for separate programs.[41] The 1973 review did, however, result in the Nixon administration directing NOAA to use the DMSP Block SD spacecraft bus, then under development by the Air Force, as the basis for the next-generation series of polar-orbiting satellites. In addition, NOAA and DOD were instructed to coordinate more closely the management of the separate programs.

On seven other occasions since 1972, the Department of Commerce and DOD studied the potential for integrating their programs. These studies did not lead to merged programs, but they did result in a number of modest economies, including the use of similar spacecraft with numerous common subsystems and components. In addition, both programs have used a common launch vehicle and have shared responsibility for creating products derived from the data. The two programs have also worked together closely on research and development efforts and provided complementary environmental information. Most of the sensors, however, remained under the design and control of each agency (see Table II–1).

Despite these efforts, until the early 1990s, foreign policy and national security concerns precluded full program integration. By that time, the drive to reduce the federal budget and increase government efficiency led a number of observers to suggest again consolidating the two systems. In addition, in October 1992, NASA and NOAA had begun to explore the potential for consolidating aspects of NOAA's Polar-orbiting Operational Environmental Satellite (POES) system and NASA's Earth Observing System satellite, EOS-PM. The latter is an afternoon equator-crossing satellite that will gather data similar to the POES afternoon satellite, but of much higher quality and complexity.

Table II–1

40. "The Meteorological Satellite Analysis Study (MSAS)," Office of Management and Budget, 1973. This study was begun in 1972.

41. The United States had pledged to maintain an open civilian weather satellite system. Also, NOAA's environmental satellites demonstrated the U.S. "open skies" policy and satisfied long-standing U.S. obligations to exchange Earth data with the meteorological agencies and scientific organizations of other nations.

Starting in 1972 with the third satellite in the ITOS series, NASA replaced the television cameras that had been carried on all earlier flights with a two-channel scanning radiometer providing visible and infrared imagery.[36] This infrared imagery was used to monitor nighttime cloud cover and to produce sea-surface temperature maps. This same satellite (designated NOAA-2) carried the first operational sounding instruments, which provided vertical temperature profiles through the atmosphere. These instruments provided the data needed to meet the third of the objectives established in 1966. Additional improvements to the low-altitude satellites made in the late 1970s resulted in the TIROS-N design, carrying a finer resolution radiometer and sounder as well as a data collection platform and a solar energetic particle monitor.[37]

ATS-1 and -3 provided data to meet the second of the 1966 objectives, but budgetary constraints delayed the operation of a geosynchronous meteorological satellite system until the mid-1970s. In the interim, NASA funded two prototype Synchronous Meteorological Satellites, launched in May 1974 and February 1975. The space agency then launched the first Geostationary Operational Environmental Satellite (GOES) on October 16, 1975. Sounding instruments were also included in improved GOES satellites, starting with GOES-4 in September 1980.

While NASA developed new capabilities for meteorological satellites and the National Weather Service integrated the resulting data into the operational weather forecasting system, budgetary pressures continued to grow. The Reagan administration wanted to transfer operational space systems to private industry to cut the federal budget. In early 1981, Comsat proposed taking over both the Landsat (see below) and the meteorological satellite systems; officials in the Reagan administration responded with enthusiasm. Congress, however, disagreed strongly with the idea of privatizing meteorological satellites; members argued that the government properly provided weather forecasts as a public good and therefore should retain control of the production of meteorological satellite data.[38] Late in 1983, Congress passed and President Reagan signed an appropriations bill that included a specific prohibition against the sale of the meteorological satellite system to private industry.[39] However, the issue of charging users for weather satellite data arose again in the 1990s as a result of cooperative programs with other countries that took such an approach.

Clearly, the balance among technological possibilities, user needs, and financial limitations shaped not only the origins but also the continuing development of the meteorological satellite system. Weather forecasts improved, although not as much as meteorologists had predicted when they looked forward to the new capabilities various satellite technologies would provide. Part of the problem was that the path from a good idea to its incorporation into the operational system was inevitably slow and rocky. Probably, however, the more important factor was that predicting weather was, and continues to be, a problem of much greater complexity than scientists had anticipated.

Converged Polar-Orbiting Meteorological Satellite Systems

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35. The first TIROS satellite was an operational prototype; subsequent satellites in the series were to be renamed ESSA 10, 11, and so on, after launch. However, the new National Oceanic and Atmospheric Administration replaced ESSA, and the satellites were named NOAA. It is at this point that the Weather Bureau was renamed the National Weather Service.

36. Hill, *Weather from Above,* pp. 37–38.

37. *Ibid.,* pp. 49–51.

38. Press Release, Senate Commerce, Science and Transportation Committee, September 20, 1983; "Weather Satellites," *Congressional Record,* S. 14367, October 20, 1983; "Transfer of Civil Meteorological Satellites," *Congressional Record,* H.R. 9812-9822, November 14, 1983. See also Hill, *Weather from Above,* p. 60.

39. Office of Technology Assessment, U.S. Congress, "Remote Sensing and the Private Sector: Issues for Discussion," *Technological Memorandum* (March 1984): 22.

and the Weather Bureau were more free to think about experimental satellites to test out new instruments that might be incorporated into future generations of operational satellites. Nimbus 1, launched April 28, 1964, experienced a number of problems and operated for only a month; Nimbus 2, launched May 15, 1966, was much more successful, testing out improved cameras. NASA also tested meteorological satellite technology as part of the Applications Technology Satellite (ATS) project to orbit experimental geosynchronous satellites (used for communications experiments as well as meteorological ones). In December 1966 and November 1967, ATS-1 and -3 explored the possibility of observing weather with line scan imagers, a possibility conceived by Vernon Soumi, a professor at the University of Wisconsin; the resulting continuous coverage (images of the full Earth disc every thirty minutes) proved extremely valuable for tracking storms and even showed short-lived cloud patterns correlated to tornadoes.[31] Continuous coverage from geosynchronous orbit made it possible to observe the motion of clouds and deduce wind speed at the level of the clouds—a significant step toward the three-dimensional quantitative data meteorologists wanted. Three other satellites in the series, ATS-2, -4, and -5, also carried meteorological experiments, but all suffered launch problems.[32] ATS-6, launched in May 1974, carried a new cloud-imaging radiometer along with a more powerful transmitter that made it possible for anyone with an easy-to-build ground station to receive the images.[33]

While the ATS program tested ideas for weather satellites in geosynchronous orbit, the Nimbus program continued to test advanced instruments in low-Earth orbit, with five launches between 1969 and 1978. Nimbus 3, launched April 1969, carried five new sensors. These included the first sounding instruments using remote sensing to furnish measurements of temperature and other variables at different levels of the atmosphere for providing numerical data for climate models. The sounding instruments on Nimbus 3 measured temperature, water vapor, and ozone content of various atmospheric levels; later Nimbus satellites carried sounding instruments to measure other variables. The sensors worked well, but the data proved much less useful for weather prediction than scientists had expected. Meteorologists had hoped that data on temperature, wind speed, and other factors could be plugged into a model of how the atmosphere worked to provide weather predictions. Satellite sounding instruments provided much of the data needed with reasonable accuracy, but existing climate models were not designed to assimilate these data easily. Meteorologists discovered that they needed to perform much more research before they could use data acquired by satellite to improve the accuracy of weather predictions.[34]

In August 1966, the Weather Bureau stated the following as its objectives for an operational satellite system: "(1) [t]he establishment and maintenance of a satellite system to obtain global observations on a regular basis, (2) meteorological observations from synchronous altitude, and (3) global observations of atmospheric structure needed for numerical weather forecasting." [II-6] The first objective was met by continuing improvements in the TIROS series of low-altitude satellites, which were flown from 1966 to 1969. NASA launched an Improved TIROS Operational Satellite (ITOS) in January 1970.[35]

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31. The ATS cameras provided pictures every thirty minutes, compared to once or twice a day from the TIROS Operational System. For a discussion of the usefulness of continuous coverage, see W.L. Smith *et al.*, "The Meteorological Satellite: Overview of 25 Years of Operation," *Science* 231 (January 31, 1986): 455–62.

32. Hill, *Weather from Above,* pp. 23–26, 29–32.

33. *Ibid.*, pp. 33–35.

34. James C. Fletcher to Stuart Eizenstat, "Possible Initiatives," February 16, 1977, suggests that NASA hoped that sounding instruments would lead to a major new research initiative. Pamela E. Mack, "Cloudy Seeing: Developing New Sensors for Weather Satellites," paper presented at the Society for the History of Technology's annual meeting, London, England, August 1996.

serious problem as NASA's plans for Nimbus increasingly diverged from Weather Bureau priorities. NASA had agreed to extend the TIROS program from the original two satellites to ten so as to provide continuous data for those users who already depended on the data, but delays in the Nimbus program still created the likelihood of gaps in coverage. The possibility of experiencing a period of months with no meteorological satellite data available particularly worried DOD.[24] Critics also raised questions about the reliability of Nimbus because it constituted such a large leap in sophistication over TIROS.[25] In addition, the predicted annual cost of an operational system based on Nimbus had nearly doubled since the original plan had been submitted to Congress.[26] The Weather Bureau would be responsible for funding the operational system, but it was a small agency with a limited budget and with little chance of getting that budget expanded substantially.[27]

By the late summer of 1963, differences between NASA and the Weather Bureau had hardened into an impasse.[28] On September 27, 1963, the Weather Bureau notified NASA that it was pulling out of existing interagency agreements and pursuing an interim operational satellite system based on TIROS technology. The Weather Bureau was able to make such a stand only because it had found a partner; DOD had agreed to provide launch services for the operational TIROS system the Weather Bureau wanted.[29]

As a result, NASA found itself in a weak position. The space agency could not justify developing advanced satellites for a user that did not want them, and it could not afford to have DOD as a competitor in providing launch services for civilian satellites. NASA compromised and agreed to give the Weather Bureau a larger voice in shaping the next-generation meteorological satellite system. The compromise resulted in decisions to build a TIROS Operational System with funding provided by the Weather Bureau, to continue the Nimbus program on a purely experimental basis, and to sign a new formal agreement for cooperation between the two agencies. [II-5]

The agreement called for NASA to develop and launch the initial version of any new instrument or spacecraft and for the Weather Bureau to provide funding for operational versions. This agreement remained in force until 1982, when NASA decided to withdraw from providing operational improvements as a continuing obligation. At that time, the National Oceanic and Atmospheric Administration (NOAA), the successor agency to the Weather Bureau, assumed responsibility for development, as well as operation, of all civilian meteorological satellites. The agency lacked the capability and funding necessary for such development, and eventually it returned to informal and then formal cooperation with NASA.

The satellites of the TIROS Operational System (renamed ESSA 1 through 9[30] after launch) were less capable than Nimbus, but they did involve significant improvements over the original TIROS satellites. Some of these spacecraft used a higher resolution camera first tested on Nimbus. Others provided real-time data to users around the world through the Automatic Picture Transmission system developed for Nimbus, but first tested on TIROS-VIII in 1964.

Once they had made decisions about the scope of the initial operating system, NASA

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23. James E. Webb to J. Herbert Hollomon, June 28, 1962, with attached memo: Abraham Hyatt to the Administrator, "Weather Bureau Plan," June 25, 1962, Space Policy Institute Documentary History Collection, Washington, DC.
24. Chapman, "A Case Study," pp. 155–71.
25. *Ibid.*, pp. 210–11.
26. *Ibid.*, p. 192.
27. *Ibid.*, pp. 217–29.
28. *Ibid.*, pp. 229–42.
29. *Ibid.*, pp. 244–59.
30. The Weather Bureau had become part of a new organization, the Environmental Science Services Administration (ESSA), established on July 13, 1965.

This was the first hurricane to be identified by a satellite before being observed by then-conventional means.

Even before these successes, the usefulness of the TIROS satellites led to pressure to transform the experimental project into an operational system. To address this issue, NASA called together an interagency Panel on Operational Meteorological Satellites in October 1960. Disagreements over the future of the program quickly appeared. The Weather Bureau sought more control than NASA wanted to give up; it asked for complete authority over the operational system, including launching, data retrieval, and final decisions on the design of new operational satellites. [II-4]

The panel issued a compromise plan in April 1961 calling for a national operational meteorological satellite system (based on a second-generation satellite already under development by NASA) to be managed by the Weather Bureau.[19] This plan did not go as far as the Weather Bureau had originally proposed; NASA would maintain control of launch services and ground support and would develop and procure spacecraft under contract to the Department of Commerce (of which the Weather Bureau was a part). President Kennedy's May 25, 1961, speech to Congress titled "Urgent National Needs," in which he urged funding a program to land an American on the Moon before the end of the decade, also requested funds to put the weather satellite plan into operation. Congress approved the funding Kennedy had requested, despite continuing controversy over what would be the best division of responsibility between NASA and the Weather Bureau for operating the system.[20]

Meanwhile, NASA was working on the second-generation meteorological satellite, Nimbus, as a prototype for the operational system. Nimbus was a more sophisticated spacecraft than TIROS—stabilized so that it always pointed toward the Earth rather than continuously rotating. It was to be launched into a Sun-synchronous polar orbit so that it could collect data from the whole Earth at the same local time each day. The satellite would carry not only more sophisticated television cameras, but also a high-resolution infrared radiometer that used thermal infrared sensors to map temperature. (A simpler experimental sensor of the same type had been carried on later TIROS flights.) Plans for Nimbus also included a variety of more sophisticated sensors—most significantly, sounding instruments providing data that could be used to determine temperatures at various levels in the atmosphere.[21] These new instruments reflected the efforts of NASA scientists to meet the continuing demand from research meteorologists for basic numerical data in addition to cloud images.[22]

While researchers wanted the more sophisticated data Nimbus would provide, the Weather Bureau became concerned about its increasing cost and delays in launch. NASA and the Weather Bureau also had differing perspectives on what decisions should be made about the operational system and on which agency should make them.[23] This became a

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19. U.S. National Coordinating Committee for Aviation Meteorology, Panel of Operational Meteorological Satellites, *Plan for a National Operational Meteorological Satellite System* (Washington, DC: U.S. Government Printing Office, 1961).

20. These issues are discussed in "The National Meteorological Program," preliminary staff report of the Committee on Science and Astronautics, 87th Cong., 1st sess., July 13, 1961. For a discussion of the process of approving the plan, see Science Policy Research Division, Congressional Research Service, *United States Civilian Space Programs: Volume II, Applications Satellites*, report prepared for the Subcommittee on Space Science and Applications, U.S. House of Representatives, 98th Cong., 1st sess., May 1983, pp. 198–99; Chapman, "A Case Study," pp. 107–27.

21. Chapman, "A Case Study," p. 161.

22. Indeed, the Nimbus series continued through Nimbus 7 and provided the basic information needed to develop later research satellite systems, including the Upper Atmosphere Research Satellite and the Earth Observing System. H.F. Eden, B.P. Elero, and J.N. Perkins, "Nimbus Satellites: Setting the Stage for Mission to Planet Earth," EOS, *Transactions, American Geophysical Union* 74 (June 29, 1993): 281, 285.

Research Projects Agency (ARPA), a new organization established a few months earlier and intended to centralize military (and, temporarily, civilian) space research under tighter control by the secretary of defense. After another reconfiguration to take advantage of a larger booster, ARPA changed the name of the project from Janus II to TIROS (for Television Infrared Observation Satellite) and committed funds to final design and construction for a planned launch in the summer of 1959.[13] The U.S. Signal Research and Development Laboratory at Fort Monmouth, New Jersey, managed a contract with RCA for construction of the satellite.

The Civilian Program

NASA took over the TIROS project, upon its creation later in 1958, with the understanding that the space agency would cooperate with the Weather Bureau. However, DOD interest in weather satellite data continued, complicating the process of planning an operational program. Later in the 1960s, the Air Force began developing a separate Defense Meteorological Satellite Program (DMSP) to meet specific military needs for data to support its operations.[14] Early satellites in the DMSP differed little from TIROS, but later satellites in the program provided quantitative radiometric data designed specifically to support DOD requirements. Civilian meteorological satellites continued to be used by both civilian and military meteorologists; the eventual convergence of the two programs is discussed in the next section.

In July 1958, after President Dwight D. Eisenhower had decided that all space programs that were not clearly military should be transferred to the new civilian space agency, the White House assigned TIROS to NASA. Arranging the actual transfer posed difficulties because the program was so far along in its development, but a number of scientists and engineers agreed to move from DOD to NASA along with the project, and NASA arranged for the Weather Bureau to provide research support in meteorology.[15] A transfer agreement was signed in April 1959. [II-3]

Despite the difficulties of the transfer, NASA launched the experimental TIROS I on April 1, 1960—a spin-stabilized satellite carrying two television cameras. The results generated so much excitement among meteorologists that NASA soon set up a system to transfer the resulting cloud cover information onto standard weather maps and to send them to weather stations and to the military services.[16] Although meteorologists found satellite data difficult to integrate into the forecasting process, because their models required data on temperature, pressure, and wind speed and direction, they found that satellite images showed large-scale weather patterns so clearly that they were immediately useful.[17] Satellites also demonstrated their value for storm warning. In September 1961, a TIROS satellite helped track an extremely dangerous hurricane, Carla, bearing down on the Gulf Coast. Warnings led to the evacuation of more than 350,000 people.[18] Also in September 1961, a fully developed hurricane, Esther, was located through satellite images.

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13. *Ibid.,* pp. 36–54, 61–62.
14. In addition, the highly classified CORONA photoreconnaissance program was jointly managed by the Air Force and the Central Intelligence Agency.
15. Chapman, "A Case Study," pp. 60–64.
16. Janice Hill, *Weather from Above: America's Meteorological Satellites* (Washington, DC: Smithsonian Institution Press, 1991), pp. 9–16.
17. For a discussion of the resistance of meteorologists to the use of satellite data, see Margaret Eileen Courain, "Technology Reconciliation in the Remote-Sensing Era of the United States Civilian Weather Forecasting, 1957–1958," Ph.D. Diss., Rutgers University, 1991.
18. Patrick Hughes, "Weather Satellites Come of Age," *Weatherwise* 37 (April 1984): 68–75.

would be of much benefit to meteorologists. An April 1951 RAND report titled "Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle" considered whether the data meteorologists wanted could be derived from cloud images. [II-2] The report stated the following:

> *It is obvious that in observing the weather through the "eye" of a high-altitude robot almost all of the regular quantitative measurements usually associated with meteorology must fall by the wayside. It is impossible to make more than an intelligent guess at the values of temperature, pressure, humidity, and the remaining quantitative meteorological parameters. . . . Clouds, being the objects most easily discernable [sic] from extremely high altitudes, become the important item and must be utilized to the utmost in forming a synoptic picture. It is apparent that from clouds alone it will be impossible to tell everything about the current synoptic situation. Combined, however, with both theoretical knowledge and that gained through experience, accurate cloud analysis can produce surprisingly good results.*[8]

Starting in 1947 with imagery taken from V-2 rockets fired at White Sands, New Mexico, scientists sought to classify clouds and to deduce weather parameters from historical data and cloud patterns. They judged their results to be quite successful, but they argued that new approaches would be needed to make the best use of the data. For example, they wanted a new method of classifying clouds, rather than the traditional classification method based solely on appearance.[9]

An analysis of similar images by the Naval Research Laboratory a few years later provided more evidence of the value of weather-related observations from space. For example, Otto Berg discovered that images taken by a Navy Aerobee rocket in October 1954 had shown a major hurricane in the Gulf of Mexico—a storm that then hit the United States with no advance warning from weather stations. He argued that satellites would be immediately useful for providing storm warnings. Berg suggested that "in the more distant future, these techniques of rocket reconnaissance will be applied to investigation of other meteorological phenomena."[10]

The first weather satellite project, TIROS, resulted not just from the perceived usefulness of storm warnings but also from the existence of many different groups in the Department of Defense (DOD) that wanted a hand in space. The Air Force sponsored a number of studies to explore technology for reconnaissance satellites, leading eventually to a development contract with Lockheed for what eventually became the Satellite Military Observation System (SAMOS) reconnaissance satellite. The RCA Corporation, one of the unsuccessful bidders, then approached the Army Ballistic Missile Agency (ABMA) with a proposal to develop a satellite with a television camera for either meteorology or surveillance.[11] The ABMA initiated Project Janus to test the television concept for the purpose of reconnaissance, but in mid-April 1958, DOD assigned the satellite reconnaissance mission exclusively to the Air Force. The ABMA then changed the mission of what had become the Janus II project from reconnaissance to meteorology.[12]

In May 1958, Janus II was transferred within DOD from the ABMA to the Advanced

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8. S.M. Greenfield and W.W. Kellog, "Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle," The RAND Corporation, R-365, August, 1960, p. 1; see Document II-2. This is the unclassified version of RAND Report R-218, April 1951.
9. *Ibid.*, p. 22.
10. Otto E. Berg, "High-Altitude Portrait of Storm Clouds," *Office of Naval Research Reviews*, September 1955, Space Policy Institute Documentary History Collection, Washington, DC.
11. Richard LeRoy Chapman, "A Case Study of the U.S. Weather Satellite Program: The Interaction of Science and Politics," Ph.D. Diss., Syracuse University, 1967, pp. 20–24.
12. *Ibid.*, pp. 30–33.

uncertain terms proposals that meteorological satellites be commercialized. The debate about turning Earth resource satellites over to private industry has been long and controversial, and by the time privatization occurred, the U.S. system had fallen behind the state of the art in important aspects. This debate also contributed to the slow development of commercial remote-sensing satellite systems. (The "value-added" business for data from meteorological and land remote-sensing satellites has been more commercially successful.)

Meteorological Satellites

Today's widespread familiarity with satellite images used by television weather forecasters encourages the assumption that meteorological satellites were an eagerly awaited breakthrough in the technology underpinning weather forecasts. In fact, at the start of the space age, meteorologists were not certain satellite data would prove useful. One of the pioneers of meteorological satellites, Harry Wexler, wrote in 1954:

> *To predict the future of the atmosphere, the meteorologist must know its present state—as defined by the three-dimensional distribution of pressure, temperature, wind, humidity. . . . Knowing the present state of the atmosphere and past motions of the storms enables a prediction to be made by extrapolation and other techniques.*[3]

Wexler pointed out that a satellite could provide only a "bird's eye" view, not the three-dimensional data meteorologists needed. Therefore, a satellite would "serve principally as a 'storm patrol.'"[4] [II-1] A warning of a severe storm obviously would be of great practical value, but most of the practice of meteorology addressed more routine situations. A meteorologist's desire for three-dimensional measurements of many variables was one of the arguments for developing more sophisticated weather satellites in the 1960s and 1970s.

Because the value of gathering weather data from satellites was not immediately obvious to civilian meteorologists, early meteorological satellite proposals emphasized military uses. Ground stations and hurricane patrol airplanes provided acceptable storm warnings for the continental United States and nearby waters, but the Navy needed storm warnings in whatever remote areas ships might be operating, and the Air Force had similar needs for worldwide forecasts.

Planning for a U.S. space program began with a 1946 Project RAND report titled "Preliminary Design of an Experimental World-Circling Spaceship."[5] This report emphasized various military applications of a satellite; it noted that "perhaps the two most important classes of observation which can be made from such a satellite are the spotting of the points of impacts of bombs launched by us, and the observation of weather conditions over enemy territory."[6] In the section of the report discussing the scientific uses of a satellite, the authors commented that observations of cloud patterns "should be of extreme value in connection with short-range weather forecasting, and tabulation of such data over a period of time might prove extremely valuable to long-range weather forecasting."[7]

Later RAND studies sought to tackle the problem of whether cloud images alone

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3. Dr. Harry Wexler, "Observing the Weather from a Satellite Vehicle," *Journal of the British Interplanetary Society* 7 (September 1954) 269–76; see Document II-1.
4. *Ibid.*
5. For the history of Rand's role in early space planning, see Merton E. Davies and William R. Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology* (Santa Monica, CA: The RAND Corporation, 1988).
6. Douglas Aircraft Company, Inc., "Preliminary Design of an Experimental World-Circling Spaceship," Report No. SM-11827, May 2, 1946, p. 11, Space Policy Institute Documentary History Collection, Washington, DC.
7. *Ibid.*, p. 13.

Chapter Two

Observing the Earth From Space

by Pamela E. Mack and Ray A. Williamson[1]

Programs that apply the capabilities of space technology to needs such as telecommunications and Earth observation have brought society many concrete benefits. However, developing projects to realize those benefits has not been easy, particularly for Earth observations. Applications programs have neither the glamor and high-profile political impact of human spaceflight nor the well-organized advocacy community of the space scientists. NASA, which is primarily a research and development agency, has had an ambivalent relationship with the application of space technology to Earth-bound needs. While the space agency welcomes opportunities to prove its value in concrete ways, it recognizes that an applications program that has completed development and entered the operational phase must usually be transferred from NASA to another agency or to a private sector user; not surprisingly, NASA staff have often preferred to work on those programs that do not have to be "given away."

Although scientific and technological feasibility and accomplishment are essential to space applications, they are only part of the story. Tensions between NASA, as developer of space capabilities, and the organizations or experts who actually distribute or use the services or data provided by applications satellites also play an important part in the success or failure of applications programs. To give a few examples, some scientists were excited about the data that meteorological satellites could provide, but their enthusiasm played a smaller role in the origin of the Television Infrared Operational Satellite (TIROS), the first meteorological satellite project, than did military needs. The Kennedy administration created the Communications Satellite Corporation (Comsat) as an innovative way of bringing a new form of international telecommunications into being, but traditional communications corporations steadily increased their role in satellite communications.[2] NASA predicted large benefits from crop surveys using data from Earth resource satellites, but agricultural scientists took a different approach to using the data than the one NASA had developed.

This broad theme—that different players have different goals and expectations—also has been played out in specific controversies in different applications projects. Usually at about the time of the launch of an initial satellite, programs have often experienced disputes over whether to conduct further research or to develop an operational program immediately. Knowing that the research satellite would set much of the pattern for their operational program, users have often sought more control over the initial development of an applications satellite than NASA wanted them to have. Finally, programs have suffered from major controversies over the proper role of the government in their development and operations. Communications satellite systems became the province of private industry, but only after a bitter debate concerning whether or not to turn the fruits of government research over to private profit. Congress in the early 1980s rejected in no

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1. The authors thank Don Blersch, Russ Koffler, Rob Masters, and Brent Smith for providing information and Frank Eden for his review of a draft of this essay.

2. Communications satellites are discussed in Chapter One; they are mentioned in this chapter only in terms of their relationship to Earth observation satellite programs.

in the months following the launch of the first ERTS, NASA found that providing the specific data required by the users was in many ways more difficult than building the hardware. NASA's limited knowledge of many fields hindered its ability to specifically tailor data. Nontechnical communities, particularly state agencies, did not understand the technology well enough to realize its capabilities and limitations. Many potential users, unable to effectively communicate their precise needs to NASA and unaware of what was available, were not profiting from ERTS data. A note on Senator Anderson's letter to NASA Administrator James Fletcher refers to a "Chuck" and "Frank." "Chuck" was Charles Matthews, the NASA Associate Administrator in charge of the ERTS program, and "Frank" was Senator Anderson's aide Frank DiLuzio.

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[1] October 14, 1972

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

[handwritten note: "Chuck, I'm inclined to think Frank is right here. $ is a problem but I'm afraid NASA has to take the leadership here—JGF"]

Dear Jim:

For quite some time, this office has been following the progress of the ERTS-A Program, and, specifically, the transferring of information gathered by the cameras and sensors on board ERTS to end users. It is obvious from testimony, news stories and public news releases of NASA that the initial users of the data will be the Corps of Engineers, the Environmental Protection Agency and the Departments of the Interior, Commerce and Agriculture. These are Government agencies with statutory mission assignments that can utilize the data. It is also true that to a great degree, they have within their agencies the needed expertise to interpret and apply such data to specific programs. This is a talent which I do not believe exists in other potential user groups which need assistance and which are not being given the proper attention. These groups include state planning agencies, state regulatory agencies, regional compacts, state and regional industrial and educational groups and resource planning groups.

I firmly believe that full and profitable utilization of ERTS data will only be accomplished when it is made available to individual states, regional compacts and consortia. I further believe that unless there is a more concentrated effort to make the information available to the end users, nothing dramatic is going to happen regardless of how valuable and useful the collected data is for land use planning, flood plan control, forest land management, resources identification and development, etc.

This problem was perhaps best illustrated at a recent meeting of the Federation of Rocky Mountain States in Boise, Idaho. It was very evident that while NASA has done a fair job in setting up sources to which users could write for "imagry," [sic] the locations and capabilities of these centers were not well known. Also, the potential users did not seem to know what was available and, therefore, could not ask for specific "imagry" [sic] with a precise reference.

[2] I do not mean to criticize NASA, but merely to reiterate that it has always been very difficult to take new technology and make it easily available in understandable and useful forms to the end users. This has been true with many new technologies, and it also is true with ERTS. It is very difficult to initially inform and keep informed the several different ultimate users, and it also is difficult at times to even identify the ultimate user of such data.

al basis as possible, clearly calling for cooperation by other nations.

(b) Continued broad availability of primary digital data at a subsidized cost from a NASA R&D system in which operational continuity is assured, and in which systems configuration tradeoffs can be evaluated.

(c) Expanded public support for user application and image processing technology development.

(d) A public commitment to the policy basis for future systems, should they prove economically viable, on the basis of which international cooperation and private investment will be forthcoming.

Thus we urge that policy reflect the fact that, while further development of ERS systems—especially the ground segment—is desirable, the U.S. is not prepared to move now to an "operational" system. In accordance with (e) 3 above, [16] the U.S. should seek to establish *de facto* acceptance of Open Skies through the inevitable gradual development of the technology and a private sector institutional base for delivering ERS services both here and abroad.

The pacing elements in commercial exploitation of the ERS technology are image processing, interpretation, and service marketing. Here the U.S. enjoys the most important elements of technological exclusivity. Rapid progress in improving and disseminating the basic image data distribution will maximize the opportunity to take advantage of this uniqueness. Thus a unilateral offer of the primary data tapes to an appropriate international body may well achieve the maximum political advantage of involvement of other countries and the UN at an early stage at a minimum cost to the development of the system. In addition, we should consider some form of expanded help to developing countries in the image processing and interpretation area. In the U.S. we should develop these activities in the private sector, initially encouraged by government contracts.

This policy framework could lead to acceptable negotiated agreements with other nations. We should continue to assert the right to acquire and disseminate primary data. But to encourage applications R and D, the [U.S. government] should be willing to permit other countries to restrict joint research [17] with the U.S. to those applications that they are willing to publish. Thus NASA and other agencies would continue the policy of full disclosures of both primary and secondary data in which [the U.S. government] is involved. We would respect the right of other countries to obtain the primary data tape or read the satellite directly, if for our own purposes we energize it over their territories, and make what use of the data they will.

Finally, in order to maximize private sector confidence in the continuity of this program and to minimize political problems, the most rigid separation possible should be maintained between the organizational and managerial environments for civil ERS systems and national security systems. At the technology level only commonality in both space and ground segments can be considered to the extent that security requirements and economics permit.

Document II-25

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Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Because threatened budget cuts kept the future of NASA's ERTS program in a state of doubt, the space agency was under steady pressure to demonstrate the program's utility. NASA had campaigned for the program on the grounds that it would provide solid benefits to various user communities. However,

satellite program must be clearly foreseen.

(c) How can we take best advantage of the U.S. lead in most of the professional end-user skills (oil exploration, plant disease studies, airborne mapping, etc.) plus the lead in digital image processing? These assets may offer sufficient "exclusivity" to adequately protect national economic self interest if we move ahead to develop and apply these skills. To facilitate this process, we should make imagery generally available to encourage further development of both institutions and technology.

(d) Should primary data tapes from ERS systems be made fully available to anyone at very low cost by government, or should the operating entity be empowered to restrict dissemination, and offer exclusive access to economically motivated customers? Which approach would develop most rapidly the technology, institutions, and capital and market structures to deliver useful services? The answer hinges on [13] whether the work to date would justify private investment in a satellite and ground facility system, in which case proprietary rights in primary data might encourage investment. In our judgment, the work to date would not justify private investment; particularly since the character of most applications is such that the benefits are not capturable [sic] by individuals. When the product of an enterprise is an indivisible public good, then it is certain that governments will be the primary customers. Examples are: land-use planning, flood control, crop estimation, iceberg tracking, pollution monitoring, etc.

(e) What policy regarding acquisition and dissemination of imagery over other countries has the best chance of leading to a stable basis for global access by the U.S., maximum cooperation in the exchange of ground data, and best opportunities for U.S. firms to market services abroad? Obvious alternatives include:

(1) Unilateral assertion of satellite data acquisition rights by the U.S., coupled with either an assertion of the right not to disseminate, or a commitment to do so.

(2) Proposal for an international network (like Intelsat), with the first U.S. operational bird as the first prototype. This would doubtless produce serious delays. This is also the most aggressive form of internationalization.

[14] (3) Effort to negotiate international acceptance of "Open Skies" without asserting the unilateral right, perhaps with the commitment to share primary "(Master)" data fully and an offer of help to LDC's in image processing and interpretation as an incentive.

(4) Cancel the NASA program altogether and rely upon classified sources for U.S. national requirements.

(f) What is required to maintain the credibility of a unilateral U.S. program in which we offer to disseminate primary data internationally? If, occasionally, data are withheld, what will be the political consequences? Is there any merit to an extension of the "Master Tape" proposal to include the production and dissemination of photographs from the tape by a U.N. agency, in parallel with U.S. government distribution domestically? How can the U.S. enhance the sense of participation and equity of other countries in the new technology, as a foundation for viable international machinery in the future?

In an understandable desire to sustain or accelerate the public investment in ERS, its supporters are allowing policy authorities to underestimate the technical, institution and economic obstacles to be overcome before a widespread, cost-effective usage of remote sensing in civil applications can be sustained. The temptation to call the follow-on [15] program to ERTS-1 "operational" reflects this tendency. Political sensitivity of other nations to unilateral remote sensing both grows on and enhances this optimism. In fact, a great deal more research and, more important, more applications experience in a realistic economic environment is needed before an economically viable "operational" ERTS program can emerge. Requirements for this further experience include:

(a) Continued access to remote sensing and ground truth data on as close to a glob-