COMMUNICATIONS SATELLITES

A CONTINUING BIBLIOGRAPHY

APRIL 1965

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NASA SP-7004 (01)

COMMUNICATIONS SATELLITES

A CONTINUING BIBLIOGRAPHY

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA Information System during the period May 1964–January 1965.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. **APRIL 1965**

INTRODUCTION

With the publication of this first supplement, NASA SP-7004 (01), to the Continuing Bibliography on "Communications Satellites" (SP-7004), the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace topics that are currently under intensive study. The references are assembled in this form to provide a convenient source of information for use by scientists and engineers who need this kind of specialized compilation. Continuing Bibliographies are updated periodically by supplements which can be appended to the original issue. All references included in SP-7004 (01) have been announced in either *Scientific and Technical Aerospace Reports (STAR)* or *International Aerospace Abstracts (IAA)* and were introduced into the NASA information system during the period May, 1964–January, 1965.

The transmission of information by means of communications satellites is a new technique that promises to be a powerful stimulus for effective international cooperation in the investigation of space. In their flexibility of design, communications satellites also offer a multitude of opportunities for commercial and industrial development. The contents of this bibliography exemplify this diversity by including references to such topics as television broadcasting, telemetry, outer-space systems, multistation systems, and medium-height, random-orbit systems. The economic and legal implications of communications satellite systems are represented. References are also included which describe the history and operation of individual satellites such as Advent, Courier, Echo, Relay, Score, Syncom, and Telstar, as well as several satellites used for meteorological studies.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their date of announcement in *STAR*. The second group includes journal and book references, subdivided according to their date of announcement in *IAA*.

A subject index and a personal author index are included.

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For further details please consult the *Introductions* to *STAR* and *IAA*, respectively.

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a continuing bibliography APRIL 1965

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N64-15864* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MOTION OF THE SUB-SATELLITE POINT FOR 24-HOUR ORBITS
Walter H. Stafford, Carmen R. Catalfamo, and Sam H. Harlin 22 Aug. 1963 50 p refs
(NASA TM X-54564; MTP-P&VE-F-63-13) OTS: $4.60 ph, $1.70 mf

The effects of small changes in eccentricity, inclination, and argument of perigee on the motion of the subsatellite point for 24-hour orbits were investigated. The eccentricity was varied from 0.0 to 0.1, inclination from 20° to 90°, and argument of perigee from 0° to 90°. Two additional values for the argument of perigees, 135° and 180°, were used in one case for comparison. The results show graphically the delta longitude and latitude of the subsatellite point. Author

N64-16156 Bell Telephone Labs., Inc., Murray Hill, N.J.
ELECTRONICS IN THE TELSTAR SATELLITE
R. C. Chapman and E. J. Reid *In* IEEE New Links to New Worlds, 1963 Natl. Space Electron. Symp. [1963] 7 p refs (See N64-16151 08-08)

The telemetry and command portions of the TELSTAR system provide necessary support functions for the basic communications experiment and the radiation experiment. The telemetry system uses a VHF carrier to transmit encoded information from the satellite. Data on 112 items are provided once each minute. By means of the command system, the states of 9 magnetic latching relays in the satellite are controlled from the ground. Commands are sent to the satellite by coded signals modulated on a carrier, also in the VHF band. This paper describes the overall telemetry and command systems and discusses in some detail the design of the command decoder. It also describes the command malfunction of the first TELSTAR satellite and its subsequent recovery. A brief description of the operation of the second TELSTAR satellite is also included. Author

N64-16157 Hughes Aircraft Co., Culver City, Calif.
THE ADVANCED SYNCOM COMMUNICATION ANTENNA SYSTEM—A DIRECTIVE ARRAY FOR A SPIN-STABILIZED SATELLITE
H. R. Erhardt, G. Gerson and D. C. Mead *In* IEEE New Links to New Worlds, 1963 Natl. Space Electron. Symp. [1963] 33 p refs (See N64-16151 08-08)

The Advanced SYNCOM Communication Antenna System approaches the optimum antenna pattern for a synchronous satellite while maintaining the control system simplicity of spin stabilization. This pattern, a cone which just covers the earth, is achieved by the use of a 16-element phased array. The beam, which is used for transmitting from the satellite to the earth, is held stationary in earth-satellite coordinates by electronically spinning the beam at spacecraft spin speed, in a direction opposite to spacecraft rotation. For the power levels used in the SYNCOM system, the power put into the phased array control circuits gives an increase in effective radiated power that is an order of magnitude greater than could be obtained by putting the same power directly into the transmitters. Author

N64-16161 Radio Corp. of America, New York, N.Y.
TECHNIQUES FOR DIGITAL COMMUNICATION VIA SATELLITES
F. Assadourian and E. M. Bradburd *In* IEEE New Links to New Worlds, 1963 Natl. Space Electron. Symp. [1963] 8 p refs (See N64-16151 08-08)

Synchronization techniques are treated for digital transmission over subsynchronous and synchronous satellite links that form a part of general communication networks interconnecting several nodes that perform multiplexing functions. The primary emphasis is on bit synchronization and identification on a link basis. A bit transport equation is developed to relate numbers of transmitted and received pulses, with variable path delays taken into account. When differences between clocks at the ends of a link are included, the result is useful in determining storage requirements for time buffering that can be inserted to maintain bit synchronization. In the case of subsynchronous satellites, handover techniques are discussed for the preservation of bit integrity during switching from one satellite to the next. Author

N64-16163 Philco Corp., Philadelphia, Pa.
RANDOM ACCESS STATIONARY SATELLITE RELAY COMMUNICATION SYSTEM
Z. Prihar *In* IEEE New Links to New Worlds, 1963 Natl. Space Electron. Symp. [1963] 21 p ref (See N64-16151 08-08)
(PCE-R-1152-0020A, condensed)

The paper discusses a method of operation of a random access communication system via active stationary satellite relays. Following a discussion of the proposed instructions and their flow, the operation of the Control Center is analyzed. Two service channel transmission speeds have been considered—50 bits per second and 1,200 bits per second. Using an assumed list of channel requirements, the predicted number of service channels has been computed. Queuing (waiting line)

problems have also been considered. Following a critique of the random access technique, alternative multiple access methods are discussed, and a substitution of an adaptive system is proposed for optimal performance. Author

N64-16719* Smithsonian Astrophysical Observatory, Cambridge, Mass.
CATALOG OF PRECISELY REDUCED OBSERVATIONS NO. P-10 Research in Space Science
Phyllis Stern, comp. 1 Oct. 1963. 206 p. refs.
(NASA Grant NsG-87-60)
(NASA CR-55843, SAO Special Rept. 138) OTS: $14.00 ph, $6.38 mf

Precisely reduced observations of the following are presented. (1) Satellite 1959 α 1 (Vanguard II) from January 1 through June 30, 1962. (2) Satellite 1959 Eta (Vanguard III) from January 1 through June 30, 1962. (3) Satellite 1960 ι 2 (Echo I rocket) from January 1 through June 30, 1962, and (4) Satellite 1961 δ 1 (Explorer IX) from January 1 through June 30, 1962. R.T.K.

N64-16720* Smithsonian Astrophysical Observatory, Cambridge, Mass.
SATELLITE ORBITAL DATA NO. E-3 Research in Space Science
I. G. Izsak. 30 Jan. 1964. 31 p.
(NASA Grant NsG-87-60)
(NASA CR-55851, SAO Special Rept. 141) OTS: $3.60 ph, $1.13 mf

Mean orbital elements are presented for the satellites Vanguard II, Vanguard III, Tiros I, Echo I, Explorer IX, Transit 4A, and Injun 3. The mean orbital elements have been derived from observations covering several days, and short period perturbations due to the earth's oblateness have been eliminated. E.W.

N64-16721* Smithsonian Astrophysical Observatory, Cambridge, Mass.
SATELLITE ORBITAL DATA Research in Space Science
I. G. Izsak. 31 Jan. 1964. 65 p.
(NASA Grant NsG-87-60)
(NASA CR-55853, SAO Special Rept. 142) OTS: $6.60 ph, $2.15 mf

Information on orbital elements is presented for the following: (1) Satellite 1958 Alpha (Explorer I), January 1 through April 1, 1963. (2) Satellite 1959 Alpha 1 (Vanguard II), January 1 through April 1, 1963. (3) Satellite 1959 Eta (Vanguard III), January 1 through April 1, 1963. (4) Satellite 1959 Iota 1 (Explorer VII), January 1 through April 1, 1963. (5) Satellite 1960 Iota 1 (Echo I), January 1 through April 1, 1963. (6) Satellite 1960 X_I 1 (Explorer VIII), January 1 through April 1, 1963, and (7) Satellite 1961 Delta 1 (Explorer IX), January 1 through April 1, 1963. R.T.K.

N64-17554 Joint Publications Research Service, Washington, D.C.
THE "ELEKTRON" SPACE SYSTEM
S. N. Vernov et al. 23 Mar. 1964. 23 p. Transl. into ENGLISH from Pravda (Moscow), 15 Mar. 1964, p. 3.
(JPRS 23810, OTS 64-21864) OTS: $0.75

The scientific stations, Elektron 1 and Elektron 2, were launched into circumterrestrial space for the simultaneous study of the earth's radiation belts. This article discusses the significance and the apparatus of the Elektron space system. Author

N64-18440* Westinghouse Electric Corp., Baltimore, Md. Aerospace Div.
ORBIT POSITION CONTROL SYSTEMS COMPARISON AND SELECTION STUDY REPORT Interim Report
8 Nov. 1963. 131 p.
(NASA Contract NAS1-3131)
(NASA CR-53578) OTS: $10.50 ph

A system is considered in which solar flux is used as a force to change orbital parameters of a passive communication satellite in a manner that, when controlled, will permit sufficient change of these parameters to provide means for station keeping of a satellite, with respect to others in the same orbital plane. The purpose is to be able to maintain spacing of a minimum number of these satellites in order to provide maximum communications coverage around the earth's surface (as opposed to random placement of similar satellites). The method of controlling the force upon the satellite due to solar flux is to position surfaces of varying solar force characteristics toward the sun, as a function of orbital position, by torquing against the earth's magnetic field with currents in three mutually orthogonal coils rigidly fixed to the satellite. The results of the study have shown that a vertically oriented system is more readily attainable than a dual flip system. Research activities were concentrated on control, structure, and orbital computations. Considered under these headings are feasibility, with regard to control accuracy and stability, structural weight, thermal balance, reliability and component life, optimum coil weight vs power supply weight, and mobility in terms of orbital parameters. R.T.K.

N64-19350* Smithsonian Astrophysical Observatory, Cambridge, Mass.
CATALOG OF PRECISELY REDUCED OBSERVATIONS
Phyllis Stern, comp. 27 Feb. 1964. 297 p. refs.
(NASA Grant NsG-87-60)
(NASA CR-53783, SAO Special Rept. 147, P-11) OTS: $18.50 ph

A listing of the positions of artificial satellites as obtained from the precise reduction of the films taken at 12 Baker-Nunn camera stations is presented. The catalog presented observations of the following from July 1 through Dec. 31, 1962: (1) satellite 1959 α 1 (Vanguard II), (2) satellite 1959 η 1 (Vanguard III), (3) satellite 1960 ι 2 (Echo I rocket body), (4) satellite 1961 δ 1 (Explorer IX). Also included are observations for satellite 1961 α δ 1 (Midas 4) from March 9 through Dec. 31, 1962. The information presented includes the following: (1) year, month, and day of observation, (2) time of observation, (3) topocentric right ascension expressed in hours, minutes, and seconds of time, (4) topocentric declination in degrees, minutes, and seconds of arc, and (5) number and name of Baker-Nunn station. P.V.E.

N64-19598* National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
GODDARD '63, A YEAR IN REVIEW AT GODDARD SPACE FLIGHT CENTER
Alfred Rosenthal. [1963] 154 p.
(NASA TM X-51626) OTS: $11.50 ph

Events of significance occurring at Goddard Space Flight Center, Greenbelt, Md., in 1963 are listed chronologically from January 1 through December 31. Included also are photographs of various meteorological and communications satellites, test patterns from both Relay and Syncom, reproductions of actual transmissions, and copies of addresses delivered by GSFC personnel on space exploration and tracking data and acquisition. A.W.

N64-19618* Radiation, Inc., Melbourne, Fla.
REFLECTIVITY CHARACTERISTICS OF ECHO BALLOONS Final Report
Oct. 1962 66 p ref
(NASA Contract NAS5-890)
(NASA CR-53827) OTS: $6.60 ph

Scale-model techniques were used to measure the bistatic response to the Echo I and II balloons, with the primary effort being devoted to Echo II. Test frequencies of 3,000 and 9,600 mc/s simulate data at 55.5, 178, and 890 mc/s. Measurements were made using vertical and horizontal polarizations for several bistatic angles and three model orientations. The results of the measurements indicate that, in general, the Echo II balloon is a good bistatic reflector at the frequencies simulated. Monostatic and bistatic measurements were made on the Dodecahedron balloon at 9,600 mc/s. The results indicate a high degree of scintillation and a large variation of median radar cross section for both monostatic and bistatic measurements; the Dodecahedron did not increase the average radar cross section over the response of a comparable sphere. Preliminary efforts on a spherical cap-type reflector, for the purpose of determining the feasibility of using a segment of a sphere to simulate the whole sphere, indicate that any conducting structure behind the cap can be expected to change the response of the cap. The possibility exists of dimensioning the cap to provide a response greater than that possible using a sphere of the same radius, if proper stabilization could be provided and the frequency band is restricted. R.L.K.

N64-19971 IIT Communication Systems, Inc., Paramus, N.J.
PARAMETRIC ANALYSIS OF MEDIUM-ALTITUDE ACTIVE AND PASSIVE COMMUNICATION SATELLITES
20 Sep. 1963 211 p refs Prepared by General Electric Co., Syracuse, N.Y.
(Contract AF 19(626)-5)
(ICS-63-TR-250; ESD-TDR-63-677; AD-428311)

Medium-altitude active and passive satellite-communication systems are compared technically and economically for use in a military communications network. Factors considered are current technology, operational complexity, and information-transfer capability. Active and passive satellite models, representative of the current state-of-the-art, are defined, and simple mathematical models provide weight and cost variations for the models as a function of satellite capabilities. Satellite performance, orbital altitude, and inclination angle are allowed to vary. It appears that networks having a small number of ground stations favor passive systems. As the number of ground stations is increased, active systems are likely to be more advantageous. Small satellites seem to be favored for both active and passive systems. R.L.K.

N64-20005* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STEREO PHOTOGRAPHY OF THE ECHO II BALLOONS NUMBERS 9, 11, AND 13 AT LAKEHURST, NEW JERSEY
Sol H. Genatt Nov. 1963 23 p
(NASA TM X-51654; X-524-63-259) OTS: $2.60

A description is given of the equipment and technique used to determine the deviation from sphericity of the skin of three Echo II balloon satellites at varying skin pressures. Diagrams and photographs illustrate the instrumental setup and the results of the stereophotography. Author

N64-20273 RAND Corp., Santa Monica, Calif.
JOINT COST AND PRICE DISCRIMINATION: THE CASE OF COMMUNICATIONS SATELLITES
Leland L. Johnson Jul. 1963 32 p refs
(P-2753-1)

The nature of the conflict between establishing and operating international communications satellites and establishing and operating commercial domestic industries is examined. The economic factors of differing cost and price are stressed. A.W.

N64-20511 RAND Corp., Santa Monica, Calif.
AIDS FOR THE GROSS DESIGN OF SATELLITE COMMUNICATION SYSTEMS
G. M. Northrop Aug. 1963 43 p refs
(P-2785)

A majority of the computational aids, such as charts and nomographs, that are applicable to the gross design of satellite communication systems are presented. Pertinent design equations are introduced and discussed briefly, with special emphasis placed on the limitations of the equations and ranges of the parameters. The utility of these computational aids is demonstrated in the solutions of some simple satellite-communication-system design and analysis problems. R.T.K.

N64-21136* National Aeronautics and Space Administration, Washington, D.C.
PROCEEDINGS OF THE CONFERENCE ON THE LAW OF SPACE AND OF SATELLITE COMMUNICATIONS
1964 212 p refs A Part of the 3rd Natl. Conf. on the Peaceful Uses of Space, Chicago, May 1–2, 1963; held in co-operation with Northwestern U.
(NASA-SP-44) GPO: $1.50

CONTENTS:

N64-21141* Volpe and Boskey, Washington, D.C.
MONOPOLY AND ANTITRUST ASPECTS OF COMMUNICATIONS SATELLITE OPERATIONS
Bennett Boskey *In* NASA, Washington Proc. of the Conf. on the Law of Space and of Satellite Communications 1964 p 80–110 refs (See N64-21136 14-01) GPO: $1.50

The monopoly and antitrust aspects of activities to be carried out under the Communications Satellite Act of 1962 are discussed. The aspects of this legislation that are likely to give

rise to controversy are outlined. Also discussed are the regulatory system, checks and balances, procurement matters, foreign negotiations, service rates, and the role of Congress in respect to this legislation. R.T.K.

N64-21142* Northwestern U., Evanston, Ill.
REGULATION IN ORBIT: ADMINISTRATIVE ASPECTS OF THE COMMUNICATIONS SATELLITE ACT OF 1962
Victor G. Rosenblum *In* NASA, Washington Proc. of the Conf. on the Law of Space and of Satellite Communications 1964 p 111-153 refs (See N64-21136 14-01) GPO: $1.50

Examination of the Communications Satellite Act from administrative perspectives suggests three broad problem areas for analysis. The first relates to clarity of draftsmanship and demands a detailed exploration of the ambiguities, intentional and otherwise, that are found in the act. The second focuses on the role of the Executive, who is given unprecedented power in a peacetime measure. The third centers on the conflicts that may arise among the various agencies and departments that have a role to play in the administration of the act. R.T.K.

N64-21143* Michigan U., Ann Arbor
SOME INTERNATIONAL ASPECTS OF COMMUNICATIONS SATELLITE SYSTEMS
Samuel D. Estep *In* NASA, Washington Proc. of the Conf. on the Law of Space and of Satellite Communications 1964 p 154-196 refs (See N64-21136 14-01) GPO: $1.50

Some of the problems that will be faced in making policy decisions concerning establishment of the communications satellite system are presented. Some of the legal problems that may arise from the international negotiations necessary to establish this service are discussed. Various legal, economic, and political aspects of the communications satellite system are also discussed. R.T.K.

N64-21264* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE RANGE AND RANGE RATE SYSTEM AND DATA ANALYSIS FOR SYNCOM I (1963 4A)
H. W. Shaffer, W. D. Kahn, W. J. Bodin, Jr., G. C. Kronmiller, P. D. Engles et al Washington, NASA, Jun. 1964 24 p refs (NASA-TN-D-2139) OTS: $0.75

A range and range rate system similar to the Goddard Range and Range Rate System was used to track the Syncom I through the transfer ellipse until the apogee kick motor fired. This report discusses the Syncom Range and Range Rate System operation and the data processing. The standard deviations achieved were 15.49 m in range and 0.05 m/sec in range rate with respect to the calculated orbital elements. Analysis of the data over short continuous intervals shows the data to have an accuracy better than 20 m in range, with either the 100- or 20-kc ranging tone, and a range rate accuracy within 0.05 m/sec. Author

N64-21412 General Electric Co., Syracuse, N.Y. Defense Systems Dept.
TRANSPORTABLE PASSIVE SATELLITE COMMUNICATIONS TERMINAL Final Technical Report
R. W. Kille et al Jan. 1963 164 p
(Contract AF 30(602)-2603)
(RADC-TDR-62-502; AD-297950)

The transportable terminal consists of a van-mounted 10-kw X-band transmitter and an S-band tracking-communications receiver with related auxiliary equipment. This includes antenna pedestal servodrive equipment, an optical tracker-director, data recording equipment, etc. The antenna is a sectionalized, demountable 30-ft paraboloid with pedestal and integral trailer bed for road transportability. The feed system of the Cassegrain type employs a 5-ft-diam hyperboloid mirror with disc-on-rod feed elements located near the paraboloid vertex. Unit tests and integration tests have been made to determine the capabilities of the equipment supplied. Such data are included in this report. Author

N64-22020* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE ECHO I INFLATION SYSTEM
Dewey L. Clemmons, Jr. Washington, NASA, Jun. 1964 56 p refs
(NASA-TN-D-2194) OTS: $1.50

A study was made to determine the feasibility and selection of a subliming compound to be used as an inflation system for the Echo I satellite. Primary considerations were given to the compatibility of such a system with payload weight limitations, storage in satellite, internal pressure requirements, and the minimum length of time that the inflation need be sustained. Calculations were made to determine the temperature variations of the satellite while in sunlight and shadow, the deforming loads present in the environment of space, the effects of micrometeoroids with regard to holes punctured in the satellite, the method of selecting the proper subliming compound, and the pressure time history and mass flow rate of the inflation vapors. Subliming organic compounds lend themselves very well to the initial inflation of large, thin wall, spherical configurations in orbit above the earth's atmosphere, and pressure sustenance can be achieved for periods of the order of a few weeks. A comparison between the predicted performance of the inflation system and that inferred by experimental scattering of microwave signals by the satellite is discussed; the sphericity of the satellite began to degrade after a period of 6 to 12 days after launch. Author

N64-23728 Schjeldahl (G.T.) Co., Northfield, Minn.
DESIGN AND FABRICATION OF INFLATABLE AND RIGIDIZABLE PASSIVE COMMUNICATION SATELLITES (ECHO I AND ECHO II)
In AFSC Aerospace Expandable Struct. Mar. 1964 p 576-604 (See N64-23701 16-01)

A study is made of the design and fabrication of inflatable and rigidizable passive communication satellites (Echo I and Echo II). Further study to reduce the weight of these communication satellites is under way. One technique employs a lenticular-shape reflector that is oriented by means of gravitational gradients. The simplicity, service life, and antijamming characteristics of passive communication satellites make them a very reliable communication tool. J.R.C.

N64-23730 Schjeldahl (G.T.) Co., Northfield, Minn.
ADVANCED RIGIDIZED MEMBRANE MATERIAL DEVELOPMENT
F. H. Bratton, S. J. Stenlund, and Alfred J. Wendt *In* AFSC Aerospace Expandable Struct. Mar. 1964 p 613-652 refs (See N64-23701 16-01)

The requirements for an inflatable rigidizing passive communication satellite are separated into those concerned

with: (1) structural requirements; (2) availability; (3) processability of the materials; and (4) the basic radiofrequency requirements. J.R.C.

N64-23920* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ANALYSIS OF NON-LINEAR NOISE IN FDM TELEPHONY TRANSMISSION OVER AN SSB-PM SATELLITE COMMUNICATION SYSTEM

Paul S. Hefferman Washington, NASA, Jul. 1964 30 p refs (NASA-TN-D-2365) OTS: $1.00

This report analyzes the noise produced by dynamic nonlinearity in elements of the SSB up-link, spacecraft phase modulator, and ground receiver demodulator. Worst-case channel signal-to-nonlinear-noise power ratios are developed in terms of the coefficients of a power series expressing the nonlinear characteristic. The group delay problem is not treated. Discussed in detail are the calculation of the autocorrelation function, the evaluation of spectral convolutions, the determination of the power series coefficients, and CCIR terminology and multichannel loading procedures for FDM telephony. Author

N64-23935* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

DETERMINATION OF THE TRIAXIALITY OF THE EARTH FROM OBSERVATIONS ON THE DRIFT OF THE SYNCOM II SATELLITE

C. A. Wagner Apr. 1964 57 p refs (NASA-TM-X-55003; X-621-64-90) OTS: $5.60

The triaxiality of the earth is studied from observations on the drift of the Syncom II satellite. The earth must be considered a triaxial ellipsoid for the purpose of a 24-hour satellite design, and the difference between the major and minor equatorial radii of the ellipsoid is not less than 200 ft nor greater than 225 ft. The location of the major equatorial axis of the triaxial geoid is between 13° and 25° west of Greenwich. The study of simulated 24-hour satellite drift in a triaxial earth field, influenced also by sun and moon gravity and by sun-radiation pressure perturbations, shows that the theory of longitude drift presented is substantially unaffected by all perturbation except that due to the earth's elliptical equator and possible higher order longitude-dependent earth-gravity anomalies. J.R.C.

N64-24281 Air Force Systems Command, Griffiss AFB, N.Y. Rome Air Development Center

SYMPOSIUM ON RADAR REFLECTIVITY MEASUREMENTS

Apr. 1964 557 p refs Papers Presented at Symp. Held at Lincoln Lab. (MIT), Lexington, 2-4 Jun. 1964 (RADC-TDR-64-25, Vol. I; AD-601364)

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7. TRANSMISSION LINE SCATTERING RANGE M. J. Gans (MB Associates) p 66-76 refs (See N64-24287 17-08)

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10. A COMPARISON BETWEEN LONGITUDINAL BAFFLING AND TRANSVERSE FENCE FOR REDUCING RANGE GROUND SCATTERING A. F. Kay (JPL) p 110-126 refs (See N64-24290 17-08)

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40. SURFACE ROUGHNESS AND TOLERANCES IN MODEL SCATTERING EXPERIMENTS T. B. A. Senior (Michigan U.) p 503-520 refs (See N64-24320 17-08)

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42. THE NEAR FIELD OF A STYROFOAM CYLINDER T. B. A. Senior and E. F. Knott (Michigan U.) p 527-541 (See N64-24322 17-08)

43. MODELING OF RAM-COVERED COMPLEX BODIES A. S. Thomas (A. S. Thomas, Inc.) p 542-548 refs (See N64-24323 17-08)

N64-24294 Conductron Corp., Ann Arbor, Mich.
CW MEASUREMENTS OF AN ECHO II BALLOON IN THE NEAR ZONE
R. K. Ritt and A. W. Wren, Jr. *In* AFSC, Griffiss AFB, N.Y. Symp. on Radar Reflectivity Meas. Apr. 1964 p 192-204 refs (See N64-24281 17-15)

During the months of June and July 1963, radar reflectivity measurements were performed on a full-scale Echo II balloon at the main dirigible hangar, Lakehurst Naval Station. The problems connected with efficiently instrumenting for CW measurements in a near zone situation and the treatment of the data were unique and are briefly described in this paper. A description of the measurement procedure is included. R.T.K.

N64-24858 Radio Corp. of America, Princeton, N.J.
THE POTENTIALS OF HIGH-POWER SATELLITES FOR COMMUNICATIONS
A. C. Gay and J. S. Greenberg. *In* RCA, Camden, N.J. Systems Eng. and Space Technol., [1964] p 40-49 refs (See N64-24851 17-01)

Major design considerations for a satellite communication system are the number of satellites and the orbital parameters. Most studies to date have been based on the simplest possible satellite configurations so as to enhance the life of the system and reduce the total cost of launch vehicles and satellites. In the near future, it will be necessary to evaluate the trade-off possibilities between low-powered satellites with large, costly ground terminals versus high-powered satellites with small, less costly ground terminals. High power in the satellite for two-way point-to-point communications is discussed. G.D.B.

N64-24859 Radio Corp. of America, Princeton, N.J.
OVERSEAS COMMERCIAL COMMUNICATIONS SATELLITE SYSTEMS: 1965-1975
J. S. Greenberg, S. Gubin, and M. Handelsman *In* RCA, Camden, N.J. Systems Eng. and Space Technol. [1964] p 44-48 refs (See N64-24851 17-01)

A study was made of commercial communication systems using active repeaters in earth satellites for planning purposes for RCA as an international common carrier and a supplier of electronic hardware. Discussed are traffic predictions, launch vehicles, satellite population, user rates, and other pertinent subjects. G.D.B.

N64-25047 Hughes Aircraft Co., Los Angeles, Calif. Space Systems Div.
SYNCOM 2 ELECTRICAL POWER SYSTEM
P. S. Du Pont N.Y., AIAA [1964] 8 p. Presented at the 1st AIAA Ann. Meeting, Washington, D.C., 29 Jun.-2 Jul. 1964 (AIAA Paper-64-456) AIAA: $0.50 members, $1.00 nonmembers

The electrical power system for SYNCOM 2 is performing perfectly, having already logged over 11,000 commands and over 2,000 hours of communications time. Experiments have included voice, facsimile, and television transmission. Discussion includes power system design criteria, air-mass one to air-mass zero extrapolation, and actual and predicted spacial performance. Analysis of the equivalent radiation environment is shown. The electrical power system differences between SYNCOMS 1 and 2 and SYNCOM C (scheduled for launch during the third quarter of 1964) are outlined. Author

N64-25913* National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
BUCKLING OF THE ECHO-A-12 PASSIVE COMMUNICATIONS SATELLITE
Wilber B. Fichter, Harvey G. Mc Comb, Jr., and Robert W. Leonard Washington, NASA, Jul. 1964 39 p refs (NASA-TN-D-2353) OTS: $1.00

Experimental and theoretical studies have been conducted to obtain an estimate of the buckling strength of the Echo A-12 passive communications satellite. Results of experimental investigations of buckling of complete spherical shell specimens having very high radius-thickness ratios extend considerably the scope of existing experimental information. Experimental results are extrapolated by means of the classical linear theory to obtain estimates of the buckling strength of the full-scale satellite. Author

N64-26543* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
MECHANICAL PROPERTIES OF ECHO II LAMINATE
Howard L. Price and George F. Pezdirtz Washington, NASA, Aug. 1964 40 p refs
(NASA-TN-D-2367) OTS: $1.00

Mechanical properties are presented of the aluminum-poly[ethylene terephthalate]-aluminum laminate used to fabricate the Echo II passive communications satellite, and of the aluminum foil and poly[ethylene terephthalate] film that constitute the laminate. Tensile strength, Young's modulus, and elongation of 1/2-in.-wide samples were obtained for strain rates from 0.02 in./in. per minute to 4 in./in. per minute. Tensile stress relaxation of the laminate was determined for times up to 1,000 minutes. The flexural stiffnesses of the laminate, the aluminum foil, and the poly[ethylene terephthalate] film were measured by the heavy elastica method. The effects of fabrication and handling loads on the tensile strength, Young's modulus, elongation, and flexural stiffness of the laminate were examined. Author

N64-27249* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SYNCOM ELECTRONIC PARTS RELIABILITY CONSIDERATIONS
Harry W. L. Street Dec. 1963 89 p ref
(NASA-TM-X-55012; X-600-63-260) OTS: $8.10 ph

This report briefly describes the Syncom I satellite and the manufacturer's parts reliability program, and lists the electronic parts used in its construction. G.D.B.

N64-27252* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT—TIME SYNCHRONIZATION OF REMOTE STATIONS USING SYNCOM SATELLITE
Raymond L. Granata, Peter D. Engles, and Paul F. Mc Caul Jan. 1964 6 p
(NASA-TM-X-55016; X-531-64-7) OTS: $1.10 ph

The accurate transfer of time between two remote stations is discussed. The transfer of corrected Universal Time, UT-2 time, from one Syncom station to a remote Syncom station was accomplished with the aid of Goddard Range and Range Rate equipments. The proposed system will be capable of achieving time synchronization to an accuracy of 0.5 microsecond or less. Included in this experimen is a method of verifying the time synchronization, measuring the system uncertainty, and maintaining accurate synchronization. The experiment was divided into two phases: (1) the transfer and maintenance of time from the United States Naval Observatory to the master station; and (2) the transfer and maintenance of time between the two Syncom ground stations, via the Syncom satellite. The time synchronization was accomplished by the use of a portable clock that was transferred between the stations in question. A.L.B.

N64-27262* Technical Operations Research, Washington, D.C. Washington Research Center
COMMUNICATIONS SATELLITE SYSTEMS: A COMPUTER MODEL AND RELATED ANALYSIS. VOLUME II: THE MODEL AND ITS USE
J. A. Bancroft, D. E. Muir, M. M. Spierer, E. H. Kingsley, T. W. Schwenke et al Washington, NASA, 12 Sep. 1964 44 p refs (Contract NASw-546)
(NASA-CR-55888; TOR-W63-1)

The Technical Operations communications satellite model, programed for the IBM-7090/7094, consists of six major routines and one associated subroutine. The major routines are the Launch, Orbit, Coverage, Assignment, Queue, and Cost. The subroutine is the Demand routine. Also discussed is a Ground Location Model, the purpose of which is to define a minimum-cost ground network. R.T.K.

N64-27757* National Aeronautics and Space Administration, Washington, D.C.
NASA'S SYNCOM C SATELLITE IS SET FOR LAUNCHING News Release No. 64-193
13 Aug. 1964 21 p Available from the Scientific and Technical Information Division

According to NASA, an attempt to achieve the first truly stationary orbit will be made when NASA launches Syncom C, the third synchronous-orbit communications satellite. If successful, Syncom C will appear to remain over one spot on earth rather than moving back and forth over the Equator. The choice of the equatorial orbit, Syncom C improvements, and the TAD (Thrust Augmented Delta) launch vehicle are among the topics discussed. R.T.K.

N64-28247 Gt. Brit. Dept. of Scientific and Industrial Research, Glasgow Radio Research Station
OPTICAL OBSERVATIONS OF SATELLITES RECEIVED BY THE PREDICTION SERVICE, APRIL 1964
[1964] 42 p

Orbital data from optical observations of satellites during April 1964 are tabulated, by satellite, for a large number of satellites. The coordinates of three new observing stations reporting to the Prediction Service are also given. M.P.G.

N64-28670 Aerospace Corp., El Segundo, Calif. Electronics Div.
MOMENTUM BIAS ATTITUDE CONTROL FOR A SYNCHRONOUS COMMUNICATION SATTELLITE
A. C. Barker 30 May 1964 75 p
(Contract AF 04(695)-269)
(TOR-269(4540-70)-1; AD-601807)

This study establishes the analytic feasibility of achieving adequate long-life attitude stabilization, using only the gyroscopic effect of a large pitch momentum for attenuation of roll and yaw errors. In addition, it is shown that momentum buildup in pitch will be small enough so that all corrections in pitch attitude can be made by varying the wheel speed. Thus, the entire system can operate for the required 3 years after initial acquisition without the use of gas and with only a single active control loop. Two special, but easily implemented, maneuvers will be required to achieve these results. First, during lifetime station-keeping operations, it will be necessary to add one-half the velocity increment at t_0 and to add the other half 12 hours later. Second, the execution of a daily 180° yaw turn, alternating the direction of vehicle rotation each day, must be implemented. The damper mechanization defined in this study is simple and provides for very rapid decay of vehicle nutation. The appendixes present coordinate systems and transformation matrices, and the equations of motion. I.v.L.

N64-28682* RAND Corp., Santa Monica, Calif.
THE LINK FROM A COMMUNICATION SATELLITE TO A SMALL GROUND TERMINAL
N. E. Feldman. Mar. 1964. 30 p. refs
(Contract NASr-21(02))
(P-2884)

This report deals with low-capacity point-to-point voice communications. Consistent with relatively simple, small ground terminals, calculations were made based on 10-ft-diameter antennas and 150 K uncooled parametric amplifiers. The resulting communication bandwith of one 4-kc voice channel, b, is a convenient base from which to scale for other antenna diameters and system noise temperature. Tabular data are presented that summarize the significant parameters for providing such a link, and illustrate the possibility of obtaining one voice channel with only small ground terminals. These data give the values of the following parameters: satellite radiated microwave power; satellite antenna gain; maximum slant range for 0-db gain; system losses; ground receiving-antenna diameter; ground receiving-antenna efficiency; system noise temperature; frequency-modulation index; feedback factor ($10 \log_{10} F^2$; C/N in the IF (4b) for one 4-kc channel that allows for a 6-db margin above the RC filter threshold; output S/N, $3m^2(\frac{C}{N})_{2b}$ for test tone; and average S/N for the average talker. I.v.L.

N64-28752* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AMORPHOUS PHOSPHATE COATINGS FOR THERMAL CONTROL OF ECHO II
Dewey L. Clemmons, Jr. and John D. Camp. Repr. from Electrochem. Technol., v. 2, no. 7-8, Jul.-Aug. 1964, p. 221-232. refs. previously published as N64-12597 08-33
(NASA-RP-303)

The absorptance and emittance characteristics of some amorphous phosphate coatings applied to an aluminum-foil substrate have been investigated to determine their usefulness as thermal control coatings for the Echo II satellite. The spectral absorptance was measured over the range 0.22μ to 15μ, and the total hemispherical emittance was determined for specimen temperatures in the range 0° to 100° C for coating surface densities up to 400 mg/ft^2. The equilibrium temperature control parameter, α_s/ϵ, varies over the range 7.5 to 0.82 for the surface densities investigated. The thermal radiation stability of the coating is presented for periods up to 1,250 hr in a simulated space environment. Author

N64-29153* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
RADIATION DAMAGE TO SOLAR CELLS ON RELAY I AND RELAY II
Ramond C. Waddel. *In* Penn. U. Proc. of the 4th Photovoltaic Specialists Conf. Vol. I: Radiation Effects on Solar Cells and Photovoltaic Devices. Aug. 1964. 18 p. (See N64-29152 21-06) OTS: $3.50 ph

The results of solar-cell radiation-damage experiments on board the Relay I and Relay II satellites are reported, and the degree of agreement between predictions of radiation damage, based on laboratory damage studies and flux data, and that observed in the spacecraft experiments are indicated. Conclusions drawn from the data of the Relay I and Relay II experiments include the following: (1) Unshielded silicon and gallium arsenide solar cells degrade to 75% initial short-circuit response level in less than 1 day. (2) Shields equivalent to 3 mils of Corning 0211 glass, or greater, extend time to 75% initial response by at least a factor of 100, compared to unshielded cells. (3) Heavily shielded n-p silicon cells last about 10 times as long as similarly shielded p-n cells. (4) Predicted damage to the unshielded silicon cells on Relay I agreed fairly well, in time and amount, with observed data. P.V.E.

N64-29161* Naval Research Lab., Washington, D.C.
EFFECTS OF SHIELDING ON ELECTRON DAMAGE TO SOLAR CELLS
F. J. Campbell. *In* Penn. U. Proc. of the 4th Photovoltaic Specialists Conf. Vol. I: Radiation Effects on Solar Cells and Photovoltaic Devices. Aug. 1964. 16 p. refs. (See N64-29152 21-06) OTS: $3.50 ph

A study to determine what effect the darkening of the cover glass, used to protect the solar cells used on the SYNCOM II satellite, had on the solar energy conversion efficiency of the solar-cell assembly is outlined. The study was conducted by irradiating the individual components with 1-Mev electrons and by measuring the individual parameters by various methods. P.V.E.

N64-29553* Stanford Research Inst., Menlo Park, Calif.
TECHNICAL PROBLEMS ASSOCIATED WITH COMMERCIAL COMMUNICATION SATELLITES. PART E: ECONOMIC ASPECTS OF SATELLITE COMMUNICATION SYSTEMS Final Report
Ernest D. Wenrick. Nov. 1963. 36 p. refs
(Contract NASr-49(08))
(NASA-CR-58031) OTS: $3.60 ph

The purpose of this report is to examine the economic feasibility of commercial communication satellites. The examination was based largely on the results of a survey of available literature. The following conclusions were drawn: (1) No accurate method for forecasting overseas telecommunication traffic exists at this time. (2) A period of several years will elapse from the initial operational date of a satellite communication system until the system becomes profitable. (3) Ultimate preference, on economic grounds, will be accorded the system utilizing synchronous-orbit satellites. (4) The key to system costs is reliability, as expressed by the probability of a successful launch and by the mean time to failure. (5) Voice communications will take up the bulk of overseas circuits (between 80% and 95%) for at least the next decade. (6) Television is unlikely to be a major factor in the demand for overseas communication circuits. I.v.L.

N64-29572* Goodyear Aerospace Corp., Akron, Ohio
PHOTOMETRIC MEASUREMENTS OF SURFACE CHARACTERISTICS OF ECHO I SATELLITE Final Report
Richard H. Emmons et al. 19 Jun. 1964. 87 p. refs
(Contract NAS1-3114)
(NASA-CR-58290; GER-11648) OTS: $8.10 ph

The results and techniques of a program that exploited the realistic test specimen represented by the nearly 4-year-old Echo I Satellite by measuring its present surface characteristics are described. For this purpose, the classical astronomical techniques of photometric measurement were employed by developing and utilizing equipment and procedures for the measurement of satellite-reflected light. The data obtained were analyzed to derive and evaluate the desired characteristics. Changes in specularity, reflectance degradation, overall size, and present shape of the Echo I satellite are derived by this means. Photographic and photoelectric photometry were used simultaneously. Author

N64-29609 Lincoln Lab., Mass. Inst. of Tech., Lexington
PROBABILITY DISTRIBUTION OF ANTENNA GAIN FOR SATELLITE WITH SWITCHED ANTENNA SYSTEM Technical Report No. 347

R. N. Assaly 4 Feb. 1964 50 p ref
(Contract AF 19(628)-500)
(ESD-TDR-64-28; AD-602484) OTS: $3.00

For a communication system using satellites carrying antennas tied to a switching system, the probability distribution of angles between the pointing directions of the axis of the operating antenna and of a ground receiving station is found. This study is based on the condition that the antenna pointing most nearly in the direction of a sensing signal is switched on. In the determination of the characteristics of this system, geometries of pointing directions are found, which are optimum or near optimum, for the cases of 4, 6, 8, 12, 16, 24, 32, 48, and 60 antennas. Consideration is also given to determining an optimum antenna pattern to be used with any geometry. For any pattern, a conversion from probability distribution of angles to probability distribution of gains is straightforward. The results of this study are summarized in a chart. Author

N64-30037 Lincoln Lab., Mass. Inst. of Tech., Lexington
CROSS-SECTION MEASUREMENTS OF THE ECHO II SATELLITE BY THE MILLSTONE L-BAND RADAR Group Report 1964-16
R. F. Julian and D. P. Hynek 7 Apr. 1964 12 p
(Contract AF 19(628)-500)
(ESD-TDR-64-43; AD-602751) OTS: $1.00

All cross-section measurements beginning with Rev. 4, the first observable at Millstone, display a fading pattern indicating that the balloon had not attained full sphericity, or at least contained significant surface irregularities. No essential change in the fading pattern was noted throughout the period that measurements were taken, except for perhaps more frequent fading during the later passes. Starting with Rev. 5, the first complete horizon-to-horizon measurement made, a periodicity of approximately 104 sec, was observed. This periodicity was also apparent during the later passes. The estimated average radar cross section during these observations was about one-half the theoretical 1,330 m^2. Author

N64-30342* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
COMMUNICATIONS SATELLITE TECHNOLOGY
Albert L. Hedrich *In* NASA, Washington Proc. of the 4th Natl. Conf. on the Peaceful Uses of Space 1964 p 155-170 (See N64-30326 22-01) GPO: $1.50

The advantages and disadvantages of active and passive satellite systems are compared. The versatility of the passive system is demonstrated by Echo II. Commercial advantages indicate the use of active satellites. The technology and the communications subsystems of Relay I and Syncom II are described in detail. A major accomplishment has been the developing of scheduling and operating procedures for the Relay satellite. The Syncom program has demonstrated the feasibility of a spin-stabilized, synchronous-orbit, active-communications satellite. Orbital control was achieved without difficulty. The launch by the Thor-Delta booster and the apogee motor boost resulted in the expected near-synchronous orbit. Velocity corrections and spacecraft orientation were made by the spacecraft control subsystem in a predicted manner. R.L.K.

N64-30797 Institute For Defense Analyses, Washington, D.C. Research and Engineering Support Div.
MULTIPLE ACCESS CAPABILITY OF A HARD-LIMITING COMMUNICATION SATELLITE REPEATER WITH SPREAD-SPECTRUM SIGNALS
Joseph M. Aein Apr. 1964 43 p refs
(ARPA SD-50)
(IDA/HQ-64-2498; P-121; AD-603027) OTS: $2.00

This paper formulates the problem of simultaneous signaling through a hard limiter with spread-spectrum sources as applied to the communications satellite. The Central Limit Theorem is liberally applied to yield approximate answers, but the framework of a more precise analysis is also outlined. A critique of the analytical assumptions and techniques concludes the paper. Author

N64-30847* Consultants and Designers, Inc., Arlington, Va.
SIMULTANEOUS TRACKING OF THE BALLOON-SATELLITE ECHO-1 FOR GEODETIC PURPOSES [SINKHRONNYYE NABLYUDENIYA ISZ "EKHO-1" DLYA GEODEZICHESKIKH TSELEY]
D. E. Shchegolev, A. G. Masevich, and B. G. Afanas'yev 4 Sep. 1964 7 p Transl. into ENGLISH from Vestnik Akad. Nauk SSSR (Moscow), no. 7, Jul. 1964 p 74-77
(Contract NAS5-3760)
(NASA-TT-F-8954; ST-SSA-10201) OTS: $1.00 fs; $0.50 mf

One of the most promising methods of solving a series of problems of higher geodesy is that of cosmic triangulation. In cosmic triangulation if only one of the summits of each resolvable triangle does not lie on the earth's surface, it coincides, at a specific moment of time, with the position of a satellite; at the same time the sides of the triangles can be equal to thousands of kilometers. Author

N64-32836* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECT OF ELECTRON IRRADIATION ON SOME PROPERTIES OF THE ECHO II LAMINATE
Thomas G. James Washington, NASA, Oct. 1964 25 p refs
(NASA-TN-D-2207) OTS: $0.75

Samples of the Echo II laminate, composed of 0.35-mil-thick plastic with 0.18-mil-thick aluminum glued on both sides, were irradiated with electrons with nominal energies of 0.075, 0.15, 0.26, 0.41, 0.66, 0.92, and 1.20 MeV. Incident fluxes up to 2×10^{13} electrons/cm^2/sec were used. The relative percent changes in the modulus of elasticity, ultimate strength, percent elongation at break, burst strength, hardness, and weight per square centimeter were used as measures of damage. The changes in these properties are given as a function of flux, electron energy, and total integrated flux. The results show that the plastic substrate receives the primary damage. The aluminum outer coating was affected only at very high total integrated fluxes and then primarily because of outgassing within the laminate. Author

N64-33073 Bendix Corp., Baltimore, Md. Bendix Radio Div.
SATELLITE COMMUNICATIONS TRANSPORTABLE GROUND TERMINAL. VOLUME I: COMMUNICATIONS EQUIPMENT Final Report, 9 Dec. 1961-1 Sep. 1963
G. E. Sanner Sep. 1963 384 p refs
(Contract DA-36-039-SC-87504; Proj. SYNCOM)
(SYN-52-07-01; AD-444240)

This report describes the design, construction, and testing of the SYNCOM ground terminal. The ground station equipment for Project SYNCOM is located in trailer-vans, thus making the system road and air transportable. A 7-Gc signal is transmitted at 20 kW, received and retransmitted at 2 Gc by the satellite, and returned to the ground where it is amplified by the low noise receiving equipment. The satellite is located, acquired, and tracked automatically by the ground antenna. The system can be operated in one of three modes—manual, remote, or auto acquire. System power is provided by three diesel engine-generator vans, each supplying 200 kW of cw power. Thus the entire ground terminal is completely self-sufficient. Author

N64-33123* California U., La Jolla
RELAY I TRAPPED RADIATION MEASUREMENTS
C. E. Mc Ilwain, R. W. Fillius, J. Valerio, and A. Dave Mar. 1964 56 p refs
(Contracts NAS5-1683; NASr-116)
(NASA-CR-59023) OTS: $3.00 fs; $0.50 mf

Instruments aboard the Relay I satellite have measured the intensities of geomagnetically trapped electrons with energies greater than 0.45 MeV and of protons in four energy ranges between one and 60 MeV over the region between 1.2 and 2.3 earth radii during the year 1963. The equatorial intensity of electrons ($E > 0.45$ MeV) was found to decrease monotonically from a maximum intensity of about 0.7×10^8 at 1.3 earth radii down to 10^5 $sec^{-1}cm^{-2}sr^{-1}$ at 2.3 earth radii. The principal maximum in the proton intensities was found to occur on consistently higher lines of force and with increasing intensities toward lower energies such that a maximum intensity of about 3×10^6 protons ($E > 1.1$ MeV) $sec^{-1}cm^{-2}sr^{-1}$ occurs at about 2.3 earth radii compared with the maximum of 1.95×10^3 protons ($E = 40$ to 110 MeV) $sec^{-1}cm^{-2}sr^{-1}$ at 1.5 earth radii. Author

N64-33371* National Aeronautics and Space Administration, Washington, D.C.
AMERICAN PROGRESS AND GOALS IN SPACE News Release
James E. Webb Available from the Scientific and Technical Information Division [1964] 18 p Presented at the Inventors' Congr. and Space Symp., Little Rock, Ark., 30 Oct. 1964

Major achievements and plans of the NASA space program are briefly discussed by James E. Webb. New scientific knowledge with wide application is stated to be produced rapidly, and technological advances are said to be tremendous in all areas as a result of the space program. The key roles of inventors and inventions in this program are emphasized, and the regional economic impact of the program is reviewed. D.E.W.

N64-33641 Bendix Corp., Baltimore, Md. Bendix Radio Div.
SATELLITE COMMUNICATIONS TRANSPORTABLE GROUND TERMINAL. VOLUME II: ANTENNA EQUIPMENT Final Report, 9 Dec. 1961–1 Sep. 1963
Sep. 1963 229 p refs
(Contract DA-36-039-SC-87504)
(SYN-52-07-01; AD-444241)

The SYNCOM ground antenna is a 30-ft-diam parabolic reflector with prime focus feed, mounted on a trailer. Two functionally independent feed systems with separate rf transmission lines provide communications: (1) Transmission is accomplished by the shf feed, consisting of a stationary finned circular waveguide horn with polarizer. (2) Reception is provided by a uhf finned circular waveguide feed that surrounds the shf horn. The antenna control system can be operated in one of three modes—manual, remote, or auto acquire—by depressing one of the main mode selector switches. The parametric amplifier provides 40 dB of gain over a 10-M bandcenter around 1817 Mc and has an excess noise temperature of 120°K maximum. Three nondegenerate, one port circulator-coupled stages are used, and the temperature of the diode mounts and circulators is maintained at 125°F. The pump source at 10.46 Gc features controlled environment and a solid-state leveler circuit to minimize gain instability. Author

N64-33847 Defense Documentation Center, Alexandria, Va
ECHO COMMUNICATION SATELLITE Bibliography, Dec. 1959–Nov. 1963
Esther E. Thompson, comp Nov. 1963 24 p refs
(AD-422849)

1965

N65-10240# Goodyear Aerospace Corp., Akron, Ohio
STUDY, FABRICATION, AND TESTING OF PASSIVE SATELLITE MODELS, GRID-SPHERE TYPE Technical Documentary Report, May 1963–May 1964
Wright-Patterson AFB, Ohio, Systems Eng. Group, Aug. 1964 127 p refs
(Contract AF 33(657)-11537)
(GER-11568; SEG-TDR-64-52; AD-607273)

The approximate vector potential solution for thin dielectric shells modified for a complex dielectric constant served as the theoretical approach. A computer solved the equations, and the results showed strong reflection at certain frequencies. The empirical investigation covered impedance measurements of flat grid panels, and backscattering tests of a 20-inch and an inflatable 14-ft grid sphere. The tests confirmed enhanced reflectivity, but did not fully agree with the theory. Scintillations showed up in all cases whereby a trend toward decreasing scintillations for increasing backscattering could be observed. True behavior of a grid sphere can only be obtained empirically by tests, or theoretically by the induced currents method. Author

N65-10534# Joint Publications Research Service, Washington, D.C.
RADIO COMMUNICATION AND SATELLITES
In its Transl. on Communist China's Sci. and Technol., No. 120 5 Nov. 1964 p 54-56 (See N65-10533 01-08) OTS: $4.00

A general discussion of the problems encountered in using vhf and microwave frequencies for communication networks is presented. The feasibility and advantages of using "stationary" satellites for relay stations are outlined. P.V.E.

N65-11860# Birdair Structures, Inc., Buffalo, N.Y.
LARGE AIR SUPPORTED RADOMES FOR SATELLITE COMMUNICATIONS GROUND STATION
Walter W. Bird *In* Ohio State U. Res. Found. Proc. of the OSU-RTD Symp. on Electromagnetic Windows, 2–4 Jun. 1964, Vol. V [1964] 12 p (See N65-11852 02-07)

Three large air-supported radomes, two with a diameter of 210 feet and one with a diameter of 160 feet, have been put into service for periods ranging up to 2 years. These radomes, having generally high rf performance and low cost, prove the practicality of air-supported radomes where superior performance is required. The development of new materials, fabrication techniques, and equipment required for radome manufacture is described. Equipment reliability and the erection of large radomes are also discussed. D.S.G.

N65-12605*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ELECTRONICALLY STEERABLE ANTENNAS FOR COMMUNICATION SATELLITES
Dennis L. Backus Oct. 1964 15 p refs Presented at the 8th Intern. Conv. on Mil. Electron., Mil-E-Con 8, Washington, 16 Sep. 1964
(NASA-TM-X-55106; X-625-64-208) OTS Prices: HC $1.00/MF $0.50

This paper presents several electronically steerable antenna techniques which, for frequencies from 1 to 35 Gc, show promise for application to communications satellites. Selected beam forming techniques are presented, and many steerable antenna designs are derived from these basic techniques. An examination of the circuitry required to implement the design is utilized to prove that the antenna is no longer solely an input or output to a given system but becomes now an inseparable part of the system. Basic problem areas of beam forming, self tracking, and scanning are outlined. Several promising techniques, namely the retrodirective and transdirective, are applied to earth space earth and space space communication links. Author

N65-12812*# California U., La Jolla.
RELAY I TRAPPED RADIATION MEASUREMENTS
C. E. Mc Ilwain, R. W. Fillius, J. Valerio, and A. Dave Washington, NASA, Dec. 1964 37 p refs Previously announced as NASA-CR-59023; see N64-33123 24-28
(Contracts NASr-116; NAS5-1683)
(NASA-TN-D-2516; NASA-CR-59023) OTS Prices: HC $2.00/MF $0.50

Instruments aboard the Relay I satellite measured the intensities of geomagnetically trapped electrons with energies greater than 0.45 MeV and of protons in four energy ranges between one and 60 MeV over the region between 1.2 and 2.3 earth radii during the year 1963. The equatorial intensity of electrons ($E > 0.45$ MeV) was found to decrease monotonically from a maximum intensity of about 0.7×10^8 at 1.3 earth radii down to 10^5 sec^{-1} cm^{-2} ster^{-1} at 2.3 earth radii. The principal maximum in the proton intensities was found to occur on consistently higher lines of force and with increasing intensities toward lower energies, so that a maximum intensity of about 3×10^6 protons ($E > 1.1$ MeV) sec^{-1} cm^{-2} ster^{-1} occurs at about 2.3 earth radii compared with the maximum of 1.95×10^3 protons ($E = 40$ to 110 MeV) sec^{-1} cm^{-2} ster^{-1} at 1.5 earth radii. Author

N65-12895# Lincoln Lab., Mass. Inst. of Tech., Lexington.
THE LINCOLN EXPERIMENTAL SATELLITE (LES) Group Report, 1964–55
D. C. Mac Lellan, H. Sherman, and P. Waldron 14 Oct. 1964 24 p
(Contract AF 19(628)-500)
(ESD-TDR-64-559; AD 449485)

A description of and a launch program for all the communications satellites and their specific functions for research in space communications are presented. Considered are the specifications for each satellite subsystem, telemetry performance, and an orbit that permits one or more hours of good visibility. All satellites will be put into orbit as "piggybacks" on Titan III launches. G.G.

1964

A64-14983
SPACE RESEARCH ACTIVITIES IN THE UNITED KINGDOM.
C. R. S. Manders (British Embassy, Tokyo, Japan).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, TOKYO, JAPAN, AUGUST 27-31, 1962, 4th, PROCEEDINGS.
Edited by Tamiya Nomura.
Tokyo, Japan and Rutland, Vt., *Japan Publications Trading Co.*, 1963, p. 9-16.

Brief description of Great Britain's activities in space research. Considered are the organization of the research program in the United Kingdom, the cost of the current program, the Skylark Program, the Anglo-American Satellite Program, the Communications Satellite, the tracking of space vehicles - radio and optical astronomy. Also discussed are the European Space Research Organization (ESRO), the European Launcher Development Organization (ELDO), and Eurospace. A table summarizes the experiments designed within the scope of the Anglo-American Satellite Program - U. K. I. It is pointed out that two lines, radioastronomy and Skylark, have been followed up intensely and successfully.

A64-15032
THE NASA COMMUNICATIONS SATELLITE PROGRAM.
Leonard Jaffe (NASA, Office of Applications, Communications Systems, Washington, D. C.).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, TOKYO, JAPAN, AUGUST 27-31, 1962, 4th, PROCEEDINGS.
Edited by Tamiya Nomura.
Tokyo, Japan and Rutland, Vt., Japan Publications Trading Co., 1963, p. 528-540.

Survey of the NASA program of research and development in communications satellites, and description of some of the latest results of this program. The need for communications satellites is mentioned, and the experimental program discussed. A chart indicates the three major communications satellite systems which offer sufficient promise to warrant continued detailed investigation. Among the satellites reviewed is the passive reflector - the radio mirror in the sky which can take many forms and for which a number of specific configurations have been suggested. The first test of NASA's passive satellite program was the Echo I project. Shown is the procedure followed in testing the Echo II sphere, the general configuration of an active repeater, the Telstar satellite, the Relay satellite, an artist's view of an Earth terminal for Telstar, and Syncom. It is noted that the experiments currently planned will investigate elements of the various methods of using artificial Earth satellites to accomplish global communications, and they will explore the environment in various regions of space. From these experiments and others which will follow, engineering data will be obtained upon which to base operational system designs.

A64-15033
THE HUGHES AIRCRAFT COMPANY'S SYNCOM SATELLITE PROGRAM.
C. Gordon Murphy (Hughes Aircraft Co., Culver City, Calif.).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, TOKYO, JAPAN, AUGUST 27-31, 1962, 4th, PROCEEDINGS.
Edited by Tamiya Nomura.
Tokyo, Japan and Rutland, Vt., Japan Publications Trading Co., 1963, p. 541-548.

Description of NASA's Syncom Mark I and Syncom Mark II communication satellites, under development by Hughes Aircraft Company. Briefly described is the method used to attain the synchronous orbit, and to control the satellite, once successful injection is carried out. The Syncom satellite will weigh 148 lbs when placed on top of the Delta booster. Included in this weight is an apogee motor with approximately 61 lbs of propellant. The apogee motor is used to circularize the orbit at the synchronous altitude. The Delta is launched in an azimuth direction of approximately 110°. The powered flight of the Delta is such that the satellite is placed in a transfer ellipse whose apogee is 22,752 nautical miles from the center of the Earth. Syncom II will be designed to be launched by the Atlas-D Agena-D rocket. The initial Syncom II satellite, when placed over the Atlantic, will be able to communicate continuously with all the countries of North America, South America, Africa, and Western Europe. A second Syncom II, placed over the Pacific Ocean, will be able to interconnect continuously the telephones of Japan, Western Asia, the Philippine Islands, Australia, Hawaii, the West Coast of South America, and the West Coast of the U. S. A third satellite, placed over the Indian Ocean, will overlap the ground coverage of the first two. In this way, a completely world-wide system of satellites could be put in place before the end of 1964.

A64-15207
THE WORLD OF THE COMMUNICATIONS SATELLITE.
Arthur C. Clarke (Bristish Interplanetary Society, London, England).
Astronautics and Aeronautics, vol. 2, Feb. 1964, p. 45-48. 6 refs.

Discussion of future applications of communications satellites. The possibilities of rapid intercontinental transmission of mail, newspapers, and telephone messages via satellites are considered, and the application of worldwide television for educational purposes is outlined.

A64-15501
THE NATIONAL PHYSICAL LABORATORY - THE USE OF ARTIFICIAL SATELLITES FOR RELATING TIME AT DISTANT POINTS.
V. T. Saunders.
Contemporary Physics, vol. 5, Dec. 1963, p. 117-119.

Description of experiments using the Telstar satellite for time synchronization between the U.S. and the United Kingdom. The experiments were carried out on August 25 and 27, 1962, to synchronize the master clocks of the Naval Observatory at Washington and the Royal Greenwich Observatory (RGO) at Herstmonceux. There are two noteworthy features of the experiments: (1) the remarkably high precision of the Telstar pulses as propagated, and (2) the very close accordance of about 1 km between the ranges given by ephemeris E2 (Aug. 31) and that obtained by multiplying the travel time by the speed of light in free space.

A64-15651
DESIGN OF THE TELSTAR COMMUNICATION SATELLITE.
R. H. Shennum (Bell Telephone Laboratories, Inc., Submarine Cable Measurements Div., New York, N. Y.).
IN: AIAA ANNUAL STRUCTURES AND MATERIALS CONFERENCE, FIFTH, PALM SPRINGS, CALIF., APRIL 1-3, 1964 (AIAA Publication CP-8).
New York, American Institute of Aeronautics and Astronautics, 1964, p. 139-145.

Discussion of the design, construction, and test of the Telstar satellite spacecraft. The basic philosophies which resulted in a particular program of design and construction are outlined and an examination is made of how research and material and component development activities influenced the design to improve the reliability of the spacecraft.

A64-15838
TELSTAR DESIGN AND CONSTRUCTION AND EARLY RESULTS OF THE SCIENTIFIC SPACE EXPERIMENTS.
H. I. Maunsell and J. W. Stafford (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).
(Institute of Electrical and Electronics Engineers, Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Canada, June 16-21, 1963, Paper 63-913.)
IEEE Transactions on Communication and Electronics, Jan. 1964, p. 28-37.

Description of the Telstar satellite, a spherical spin-stabilized satellite, which is a microwave repeater for intercontinental communications. It is an efficient non-demodulating repeater with an intermediate frequency centered at 90 mc (megacycles). Telemetry data from the communications circuits and from the radiation experiment are transmitted to the ground station, while VHF (very-high-frequency) signals from the ground actuate switches to reduce battery drain between passes. The spherical shape of

Telstar provides an isotropic solar cell array and permits a nearly isotropic microwave antenna pattern. The electronics, which are packaged inside a hermetically sealed container, are isolated thermally with respect to conductive heat transfer and vibrationally from the satellite frame. A thermally activated bellows mechanism controls the temperature of the electronics chassis.

A64-15839
THE TELSTAR COMMUNICATIONS SATELLITE EXPERIMENT PLAN.
S. B. Bennett and L. C. Thomas (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).
(Institute of Electrical and Electronics Engineers, Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Canada, June 16-21, 1963, Paper 63-952.)
IEEE Transactions on Communication and Electronics, Jan. 1964, p. 54-60.

Description of the Telstar experiment plan and objectives. The design of the communications system is described, showing the interrelation between satellite capabilities and ground station requirements. The factors determining the initial orbit and attitude; techniques for predicting satellite position, attitude, and eclipse times; and attitude measurement and control are discussed. Good correlation between predicted and measured satellite attitude is shown. The plan for acquisition and command tracking of the satellite, and a typical operations schedule of the Andover ground station are presented.

A64-16346
WOULD SYNCHRONOUS LUNAR SATELLITES BE STABLE AND USEFUL? [DES SATELLITES SYNCHRONES DE LA LUNE SERAIENT-ILS STABLES ET UTILES?].
S. Travers.
Technique et Science Aéronautiques et Spatiales, Sept.-Oct. 1963, p. 373-376. In French.

General study of the feasibility and utility of lunar satellites for interstation communication on the Moon. In view of the absence of a lunar ionosphere, radio wave communication systems are confined to line-of-sight transmission. High towers are considered impractical, hence the possibility of a synchronous lunar-orbiting satellite becomes attractive.

A64-16612
SATELLITE COMMUNICATIONS RELAY SYSTEM USING A RETRODIRECTIVE SPACE ANTENNA.
E. L. Gruenberg and C. M. Johnson (International Business Machines Corp., Federal Systems Div., Bethesda, Md.).
IEEE Transactions on Antennas and Propagation, vol. AP-12, Mar. 1964, p. 215-223. 10 refs.

Presentation of a system for relaying messages via a satellite between points on the Earth. The satellite employs an antenna of the Van Atta type which is modulated by solid-state devices inserted in each of the paths that connect conjugate array elements. A ground station located anywhere within the field of view of the antenna can receive information from the satellite by irradiating the modulated antenna. Methods of modulating the retrodirective array are discussed with emphasis on those that facilitate communications among several ground stations. Extremely high reliability is inherent in the design of the satellite electronic system, which can be made entirely from solid-state components.

A64-17091
TECHNIQUES FOR DIGITAL COMMUNICATION VIA SATELLITES.
F. Assadourian and E. M. Bradburd (Radio Corporation of America, Communications Systems Div., New York, N. Y.).
RCA Review, vol. 25, Mar. 1964, p. 67-84.

Discussion of synchronization techniques for digital transmission over subsynchronous and synchronous satellite links that are part of a general communication network. The satellite links interconnect several nodes that perform multiplexing functions. Bit synchronization and identification on a link basis are studied, and a bit-transport equation relating numbers of transmitted and received pulses is developed that takes into account variable path delays. When differences between clocks at the ends of a link are included, the result is useful in determining storage requirements for time buffering that must be inserted to maintain bit synchronization. For subsynchronous satellites, handover techniques for the preservation of bit integrity during switching from one satellite to the next are discussed.

A64-17773
SHADOWS PRODUCED BY SPIN-STABILIZED COMMUNICATION SATELLITES.
B. Paul (Ingersoll-Rand Research Laboratories, Bedminster, N.J.).
AIAA Journal, vol. 2, May 1964, p. 924-931. 7 refs.

A spin-stabilized satellite generally utilizes a so-called toroidal antenna that has a null cone surrounding the axis of symmetry (spin axis). The greatest gain over isotropic antennas occurs with the widest possible null cone. However, wide null cones may cause shadows on the Earth and prohibit communication between mutually visible ground stations and the satellite. It is shown how the size and shape of the shadowed zones may be calculated for arbitrary orientations of the spin axis. It is also shown how to find the narrowest possible antenna beam, which avoids any null-cone shadow on Earth when the spin axis is maintained perpendicular to the ecliptic plane (desirable for thermal reasons). For near polar orbits, it is not possible to escape null-cone shadow and still realize any appreciable antenna gain if the spin axis is maintained exactly perpendicular to the ecliptic plane. However, it is shown that a reasonably small tilt of the spin axis will either reduce the shadow to an acceptable level or eliminate it entirely. The critical tilt angles, for complete elimination of null-cone shadow, and the effect of nodal regression due to Earth oblateness may be found from given curves.

A64-17785
COMMENT ON "APPLICATION OF DYNAMIC PROGRAMMING TO OPTIMIZING THE ORBITAL CONTROL PROCESS OF A 24-HOUR COMMUNICATIONS SATELLITE."
Theodore N. Edelbaum (United Aircraft Corp., Research Laboratories, East Hartford, Conn.).
AIAA Journal, vol. 2, May 1964, p. 974, 975.

A64-18246
MUTUAL INTERFERENCE BETWEEN COMMUNICATION SATELLITES AND TERRESTRIAL LINE-OF-SIGHT RADIO-RELAY SYSTEMS.
J. K. Chamberlain and R. G. Medhurst (General Electric Co., Ltd., Hirst Research Centre, Wembley, England).
(International Conference on Satellite Communication, Nov. 22, 1962, Paper.)
Electronics Record, Apr. 1964, p. 524-534. 6 refs.

Examination of the mutual interference to be expected between the satellites of broadband frequency-modulated satellite communication systems and high-capacity terrestrial line-of-sight radio-relay systems in the event of their sharing the 4- and 6-Gc communication bands. By comparing the resulting interference noise power in a 3.1-kc audio channel of a telephony system with the internationally agreed upon total noise power for such a channel, maximum permissible values are derived for the power flux arriving at the Earth's surface from a satellite and for the effective radiated power of a terrestrial transmitter, which, if observed, would ensure that this interference is kept within acceptable bounds.

A64-18249
ELECTRIC DRIVE SYSTEM FOR A STEERABLE AERIAL AT A SATELLITE-COMMUNICATION EARTH STATION.
H. A. Prime, G. A. Smith, D. F. Tilsley, and W. S. Tunnicliffe (Brush Electrical Engineering Co., Ltd., Loughborough, Leics., England).
(International Conference on Satellite Communication, Nov. 22, 1962, Paper.)
Electronics Record, Apr. 1964, p. 556-564.

Description of the control and motor-drive system for the steerable aerial located at the Post Office Earth station, Goonhilly Downs, Cornwall. Specification, performance and control facilities are detailed for the purpose of establishing the general design considerations involved. The arrangement of the principal items of the closed-loop Ward Leonard drive is given briefly, and particular attention is then directed in the remaining sections of the paper to the design and performance of the servo-system. The basic linear equations of the system are developed for the major components, and the nonlinear restrictions are then introduced to establish the complete analog network for the computer analysis. The simulation of the nonlinear elements is detailed for the particular cases of saturation limits, "dead band" and backlash; a useful method of derivative-network simulation is also outlined. The introduction

of appropriate stabilizing networks, to counteract system instabilities demonstrated by the computer study, is considered, and linear networks are employed in this application. A brief review of the commissioning procedure and an example of operational performance data are included.

A64-18255
TECHNICAL ASPECTS OF THE DESIGN OF COMMUNICATION-SATELLITE SYSTEMS.
W. J. Bray (Post Office, Engineering Dept., London, England). (International Conference on Satellite Communication, Nov. 22, 1962, Paper.)
Electronics Record, Apr. 1964, p. 744-758. 12 refs.

Survey of some of the technical problems involved in the design of communication-satellite systems providing substantially world-wide coverage for the transmission of multichannel telephony and television signals. Factors affecting the choice of orbit and type of satellite are discussed, and it is concluded that attitude-stabilized, station-keeping satellites in medium-altitude circular orbits represent a desirable design objective. The operational and performance requirements for multichannel telephony and television are considered in the light of the findings of the International Radio Consultative Committee at its 10th Plenary Assembly (Geneva, 1963). Technical factors, such as the choice of frequency and modulation method, are discussed, with particular reference to the problem of providing multistation access to satellites. The limitations on satellite and terrestrial radio-relay system transmitter power imposed by the need to share the same frequency bands are examined, and the advantages of using preferred radio-frequency channeling arrangements by both systems are discussed. Finally, an outline is given of one possible approach to the design of a worldwide system using twelve station-keeping, attitude-stabilized satellites in a subsynchronous (8-hr) orbit at 14,000-km height in the equatorial plane of the Earth.

A64-18269
A PLANETARY ORBITING RELAY COMMUNICATION LINK FOR PROJECT VOYAGER.
Donald L. Hagen (General Electric Co., Valley Forge Space Technology Center, Philadelphia, Pa.).
IN: ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 10TH, BALTIMORE, MD., OCTOBER 21-23, 1963, PROCEEDINGS.
Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers and the Professional Technical Group on Aerospace and Navigational Electronics.
North Hollywood, Western Periodicals Co., 1963, p. 1.3.1-1 to 1.3.1-8.

Discussion of the Voyager spacecraft, whose launch to Venus and Mars is scheduled for the late 1960's. It is stated that these spacecraft may contain both orbiting and landing modules. Considered is the question of whether to transmit the data originating in the lander directly to Earth or to relay them through the orbiter. The theoretical, operational and environmental aspects of the problem are dealt with, and the conclusion is made that a relay link is definitely required for Venus and would be advantageous for Mars. A 100-Mc carrier frequency for the relay link is recommended, and the results of comparisons of promising modulation and multiplexing techniques are presented.

A64-18292
A DATA REDUCTION AND ANALYSIS PROGRAM FOR THE "TELSTAR" SATELLITE COMMUNICATION SYSTEM.
David A. Aaronson (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).
IN: ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 10TH, BALTIMORE, MD., OCTOBER 21-23, 1963, PROCEEDINGS.
Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers and the Professional Technical Group on Aerospace and Navigational Electronics.
North Hollywood, Western Periodicals Co., 1963, p. 2.3.5-1 to 2.3.5-7.

Description of methods employed in the reduction of raw data from the TELSTAR Communications Satellite. Data from the satellite and the Andover Earth Station are recorded in digital form on 7-track magnetic tape at the Earth Station, compressed, sent to a data center via "DATA-PHONE" and then reduced and analyzed on IBM computers 1401 and 7090. Short output tables of communication and tracking parameters are produced for each pass. Data from a 1/2-hr satellite pass require approximately 1/4 hr to be compressed, and about 3/4 hr to be transmitted. After a 1/4-hr edit on the IBM 1401, approximately 20 sec on the IBM 7090 is required to produce an analyzed output table containing one row for each minute of satellite pass.

A64-18421
ADVANCES IN SPACE SCIENCE AND TECHNOLOGY. VOLUME 5.
Edited by Frederick I. Ordway, III (General Astronautics Research Corp., Washington, D.C.; Space Science and Technology Information Center, Huntsville, Ala.).
New York, Academic Press, Inc., 1963. 334 p.
$13.

Collection of papers on space problems covering: astronomical investigations of the Sun; advances in communication relay-satellite techniques; solid-propellant rocket technology; environmental control of manned space vehicles; terrestrial, lunar, and planetary applications of navigation and geodetic satellites; and orbital operations. The advantages, disadvantages, and prospects of large solid-propellant rockets and the role of orbital operations in astronautics are also discussed. Lists of references supplement the articles, which are individually abstracted and indexed in this issue.

A64-18423
ADVANCES IN COMMUNICATION RELAY SATELLITE TECHNIQUES.
R. P. Haviland (General Electric Co., Missile and Space Div., Philadelphia, Pa.).
IN: ADVANCES IN SPACE SCIENCE AND TECHNOLOGY. VOLUME 5.
Edited by Frederick I. Ordway, III.
New York, Academic Press, Inc., 1963, p. 21-46. 23 refs.

Discussion of the techniques and advantages of communication satellites and of selected specific system proposals. Considered are the need for long range communication, satisfaction of communication demand, basic satellite communication system techniques, design factors in satellite systems, specific system proposals, and the status of experimental communication satellite programs. Two completed experimental satellite programs are dealt with, together with several others which are in progress.

A64-18754
PRELIMINARY RESULTS OF PROCESSING OF SYNCHRONOUS PHOTOGRAPHIC OBSERVATIONS OF THE SATELLITE "ECHO-1."
I. A. Kutuzov (Academy of Sciences, Moscow, USSR).
COSPAR, Meeting, 7th, and International Space Science Symposium, 5th, Florence, Italy, May 8-20, 1964, Paper. 11 p.

Presentation of results of the photographic observations of satellite Echo 1, conducted in the Fall of 1962 and Spring of 1963 with the method of synchronous photographic observations which permit the determination of the direction in space from ground stations to the satellite. The following conclusions are drawn: (1) proof has been obtained of the possibility of synchronous observations of bright artificial Earth satellites and of their application for geodetic purposes; (2) possibility of synchronous observations of satellite Echo 1 from stations located within the territory up to 3,000 km; (3) demonstration that the practical accuracy of determination of the satellite's position on negatives is not more than ± 4 sec, while the accuracy of time recording is approximately ± 0.005 sec; (4) the obtained accuracy of determination of coordinates of space triangulation points of the order of ± 100 m provides for the solution of a number of geodetic problems in the mapping of geodetically unmapped territories.

A64-18805
REDISTRIBUTION OF TRAPPED PROTONS DURING A MAGNETIC STORM.
Carl E. McIlwain (California, University, Dept. of Physics, La Jolla, Calif.).
COSPAR, Meeting, 7th, and International Space Science Symposium, 5th, Florence, Italy, May 8-20, 1964, Paper. 30 p. 9 refs.
Contracts No. NAS 5-1683; No. NASr-116; No. NsG-538.

Observation of the first change in the distribution of high-energy geomagnetically trapped protons which can be definitely attributed

to the breakdown of adiabatic motion. The work was accomplished with the aid of a scintillation detector aboard Relay 1 (1962 Beta Upsilon 1) satellite. Most of the observed variation in proton fluxes took place within 1 day centered on 0 hr UT Sept. 23, 1963, during the occurrence of the largest fluctuations in the Earth's magnetic field in almost 2 years. The intensity of protons with energies greater than 34 Mev decreased by more than a factor of ten in the region $L > 2.50$ Earth radii and $B > 0.05$ gauss, but changed by less than 10% in the region $1.80 > L > 2.10$. The character of the changes was such that previous events of this type could have produced the anomalous characteristics of the initial distribution.

A64-19690
EFFECTS OF ATMOSPHERIC REFRACTION ON RADIO WAVES IN THE EARTH-SATELLITE COMMUNICATION LINK.
Hisashi Shibata (Ministry of Posts and Telecommunications, Radio Research Laboratories, Tokyo, Japan).
Radio Research Laboratories, Journal, vol. 10, Nov. 1963, p. 423-459. 5 refs.

Study of the effects of atmospheric refraction on radio waves under various tropospheric and ionospheric conditions. Calculations of the wave path, elevation-angle error, and path-length error are made within the framework of geometrical optics. The results are presented in figures and tables which are of use in practical work. A method of calculating the orientation of an antenna so that it will receive signals from a satellite of known position is presented.

A64-19802
A SPACE PROGRAMME FOR EUROPE?
A. V. Cleaver (Rolls-Royce, Ltd., Rocket Propulsion, Derby, England).
(Royal Aeronautical Society, Manchester Branch, Chadwick Memorial Lecture, 9th, Manchester, England, Mar. 11, 1964.)
Royal Aeronautical Society, Journal, vol. 68, June 1964, p. 374-382 12 refs.

Presentation of views to support the case for a European space program. Three broad arguments are considered: philosophical, direct applications, and indirect applications. Current USSR and US positions are discussed. Within Europe, the efforts of the European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO) are reviewed, and comparison is made of US and European space expenditures as percentages of the gross national product, with the observation that Europe has the capability of larger expenditures. The implications of a division of effort between "pan-European" and "national" are considered, with expression of the view that a 60/40 ratio is a fair balance. Comments are made on current and future European developments.

A64-19899
SPACE-RESEARCH GROUND STATION.
B. Cooper and R. McClure (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 25-36.

Description of the experimental ground station for satellite communication developed at the ITT Federal Laboratories in Nutley, N.J., and completed in 1960. This fixed station was used for design studies toward the development of an air-transportable, medium-capacity, space-communication terminal. Tables are given for the station performance with active and passive satellites and the performance of the communication-receiver and antenna-tracking systems in the Telstar and Relay satellite programs and in experiments using the Moon as a passive reflector.

A64-19900
MEDIUM-CAPACITY SPACE-COMMUNICATION TERMINAL.
L. Pollack, W. Glomb, and L. Gray (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 37-48.

Description of the transportable space-communication terminal designed and produced by the ITT Federal Laboratories, Nutley, N.J. The considerations of economy, physical and operational requirements, and technological limitations are discussed at length. The first station was flown to Rio de Janeiro, where it participated in the early tests of the Relay satellite. Two additional stations in the US are working with Telstar, and a fourth station, capable of immediate switching between Relay and Telstar, is assigned to the Deutsche Bundespost (West Germany). Station lifetime is estimated at ten years. Future plans envision a fourfold increase in system sensitivity through the incorporation of supercooled parametric amplifiers and the reduction of antenna temperature.

A64-19901
SYSTEM CONFIGURATION OF TRANSPORTABLE SPACE-COMMUNICATION TERMINAL.
D. Hershberg (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 49-57.

Description of the system configuration of the transportable space-communication terminal developed and constructed by the ITT Federal Laboratories, Nutley, N.J. The station is separable into four basic units mounted in semitrailer vans. A block diagram of the equipment layout is presented, and details of the construction and systems checkout instrumentation are given.

A64-19903
MULTIFREQUENCY HIGH-POWER CASSEGRAINIAN ANTENNA-FEED SYSTEMS FOR SATELLITE GROUND STATIONS.
H. Scheiner, W. Spanos, and R. Edwards (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 73-79.

Detailed description of the Cassegrainian system used with the transportable space-communication terminal developed and constructed by the ITT Federal Laboratories, Nutley, N.J. The receiving feed is a four-horn cluster. On either side of the receiving cluster are placed two polyrod radiators, comprising the transmitting feed. Data are given for the polyrod design, and performance curves, including primary radiation patterns obtained with and without reflectors, are presented.

A64-19904
TRANSMITTER FOR SATELLITE GROUND STATION.
H. Goldman, R. Graham, and L. Gray (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 80-88.

Description of the transmitting system of the universal transportable space-communication terminal developed and constructed by the ITT Federal Laboratories, Nutley, N.J. The dual system is designed for operation at 2 and 6 Gc for the Relay and Telstar satellites, respectively, but other frequencies can be accommodated. Through June 1963, nine transmitters of this type have been placed in operation.

A64-19907
TRANSPORTABLE-STATION OPERATION WITH TELSTAR AND RELAY SATELLITES.
J. E. Drucker (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
Electrical Communication, vol. 39, no. 1, 1964, p. 113-122.
USAF-sponsored research.

Discussion of technical parameters and operational experience with the transportable space-communication terminal developed and constructed by the ITT Federal Laboratories, Nutley, N.J. Tests show that the primary causes of variation in signal level are the range and spin modulation of the satellite. Tracking errors are said to lie within $\pm 0.03^{\circ}$ and pointing errors within $\pm 0.3^{\circ}$, even in winds as high as 58 mph.

A64-19910
GRAPHIC METHODS FOR CALCULATING COVERAGE ATTAINABLE WITH COMMUNICATION SATELLITES.
R. Heppe (International Telephone and Telegraph Corp., ITT Intelcom, Inc., Falls Church, Va.).
Electrical Communication, vol. 39, no. 1, 1964, p. 132-143.

Review and extension of graphic methods used to determine the percent of time one or more satellites in various orbits will be usable by a given link. For operations between two ground stations a satellite must be visible to both simultaneously. Curves are given for the probability that a single satellite in circular polar orbit will be in a mutual-visibility region. It is indicated how similar charts may be prepared for equatorial, inclined, and elliptical orbits. Consideration is given to the question of equispaced vs randomly spaced satellite groups, and it is shown that failures penalize the random group less although the cost is higher.

A64-19911

SPACECRAFT TECHNOLOGY FOR SATELLITE COMMUNICATION SYSTEMS.

M. E. Brady (International Telephone and Telegraph Corp., ITT Intelcom, Inc., Falls Church, Va.).

Electrical Communication, vol. 39, no. 1, 1964, p. 144-154.

Discussion of the variety of choice and the optimum technical approach in the establishment of a satellite communication system. Covered are synchronous and medium-altitude systems; spin vs gravity gradient stabilization; spacecraft transmitter power systems and the problems associated with precise spacing in orbital rings, launch-success probability, and component reliability. Economic factors are considered. It is expected that the launch-vehicle portion of overall costs will decline sharply in the near future as larger carriers, such as the Atlas-Centaur and Titan III-C, become available.

A64-19996

SYNCOM 2 ELECTRICAL POWER SYSTEM.

P. S. DuPont (Hughes Aircraft Co., Space Systems Div., Los Angeles, Calif.).

American Institute of Aeronautics and Astronautics, Annual Meeting 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-456. 8 p.
Members, $0.50, nonmembers, $1.00.

Discussion of the electrical power system for Syncom 2 (1963 31A), NASA's first synchronous altitude active communication satellite. The Syncom 2, launched from Cape Kennedy with a Thor-Delta booster on July 26, 1963, is performing perfectly, having already logged over 11,000 commands and over 2000 hours of communications time. Experiments have included voice, facsimile and television transmission. The discussion includes power system design criteria, air-mass 1 to air-mass zero extrapolation, and actual and predicted spatial performance. An analysis of the equivalent radiation environment is shown. The electrical power system differences between Syncom 1 (1963 4A), Syncom 2 (1963 31A), and Syncom C (scheduled for launch during the third quarter of 1964) are outlined.

A64-20110

DESIGN DIFFERENCES BETWEEN MILITARY AND COMMERCIAL COMMUNICATION SATELLITES.

Wilbur L. Pritchard and Neil MacGregor (Aerospace Corp., Communications Satellite Systems, El Segundo, Calif.).

American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-416. 15 p. 17 refs.
Members, $0.50; nonmembers, $1.00.

Discussion of factors influencing the design of communication satellite systems, with emphasis on the differences between military and commercial approaches. A single communication satellite is first considered, and it is shown that military needs for security and survivability lead to a lower requirement for communication capacity than do commercial. Also discussed are relative-frequency selection, ground-station configuration, and data processing requirements. Major system aspects are examined, including coverage, survivability, reliability, multiple access, and launch economics. Typical system calculations are presented. The growth potentials and future interests of military and commercial systems are briefly discussed.

A64-20784

EARLY REALIZATION OF SPACE BROADCASTING.

R. P. Haviland (General Electric Co., Satellite and Space Systems, Philadelphia, Pa.).

American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-422. 12 p. 9 refs.
Members, $0.50; nonmembers, $1.00.

Description of the technical features which must be incorporated in an existing satellite in order to produce a demonstration broadcasting satellite for a space broadcasting system. The Nimbus meteorological satellite was chosen as the one which comes reasonably close to satisfying basic requirements of power level, weight, transmitting power capability, and attitude control. Important aspects of the Nimbus design are examined, and the capability in space broadcasting is developed, as are methods of using the satellite. A suitable orbit is selected, and the design of the major equipment is discussed. It is seen that, to adopt the Nimbus satellite for use as a demonstration broadcast satellite, the following gross changes must be made: deletion of the meteorological sensors, installation of the relay receiver and broadcast transmitter, installation of a folding transmitting antenna, and installation of additional batteries. On the basis of the study, it is suggested that the demonstration broadcast satellite is within present technical capabilities, and that the use of an existing platform will allow an early demonstration.

A64-21188

SYNCOM SATELLITE PROGRAM.

Richard M. Bentley and Albert T. Owens (Hughes Aircraft Co., El Segundo, Calif.).

(American Institute of Aeronautics and Astronautics, Summer Meeting, Los Angeles, Calif., June 16-20, 1963, Paper 63-264.)
Journal of Spacecraft and Rockets, vol. 1, July-Aug. 1964, p. 395-399.

Discussion of the results of the SYNCOM satellite experimental program and a summary of the design improvements incorporated into each successive vehicle as a result of space flight experience. SYNCOM is a spin-stabilized, active-repeater communications satellite utilizing redundant transponders, telemetry, command, and control systems. No problems were encountered in the operation of the command and control systems. Studies of orbital maneuvers demonstrated that: hydrogen peroxide control systems show excellent promise for extended operational use in space, adequate control is achievable with the SYNCOM pulsejet control system, less than 10 ft/sec velocity control is adequate to maintain orbital synchronization for 1 yr, and corrections to the spin axis are estimated to be less than 2°/yr. Performance of the solar cell and battery, and the design features of communications satellites now under development are also discussed.

A64-21673

THE NASA RELAY I EXPERIMENTAL COMMUNICATION SATELLITE.

J. D. Kiesling (Radio Corporation of America, Astro-Electronics Div., Princeton, N.J.).

RCA Review, vol. 25, June 1964, p. 232-261.

Discussion of the Relay communications satellites that are designed to explore the technological problems of long haul microwave communications using medium-altitude, active satellites. These technological problems, which include the environment of outer space, ground station performance, and compatibility with existing communication facilities are discussed in relation to satellite design trade-offs. The operating functions of the Relay satellites are: the relaying of wide-band microwave signals by means of a heterodyne repeater; the telemetering of data indicating the status of circuits, components, and environment; and the transmission of beacon signals to assist in the acquisition and tracking of the satellite. The various subsystems of the Relay satellite are described, and the in-orbit experience with Relay I and Relay II is reviewed.

A64-21717

COMMUNICATION OPERATIONS WITH SYNCOM II.

William T. Tobias, Rollin G. Keyes, and Thomas R. Gleason (U.S. Army Satellite Communications Agency, Fort Monmouth, N.J.).
(Institute of Electrical and Electronics Engineers, International Convention, New York, N.Y., Mar. 23-26, 1964.)
IEEE International Convention Record, vol. 12, pt. 6, 1964, p. 71-106. 11 refs.

Review of operational experience with the 24-hr communications system established with the Syncom 2 (1963 31A) active satellite in synchronous orbit. The Syncom satellite and its supporting ground system are described, and results of the first 1600 hrs of demonstration and performance tests are discussed. These tests include the successful use of echo suppressors to overcome delay effects for voice communications.

A64-21719
LIGHTWEIGHT SATELLITE COMMUNICATIONS LINK TERMINAL.
G. J. Goubeaud (U.S. Army Satellite Communications Agency, Ground System Dept., Fort Monmouth, N.J.).
(Institute of Electrical and Electronics Engineers, International Convention, New York, N.Y., Mar. 23-26, 1964.)
IEEE International Convention Record, vol. 13, pt. 6, 1964, p. 117-124.

Discussion of the feasibility of using link-terminals which are lightweight, highly transportable, and have low installation times, as the ground stations for satellite communications systems. Generalized expressions are developed which relate the communication capability of a link-terminal to the various system parameters. A highly-transportable link-terminal which has been designed for use with Syncom 2 (1963 31A) is described.

A64-21720
RESULTS OF SYNCOM COMMUNICATION EXPERIMENTS.
George Silverman, John W. Lockett, and John C. Cittadino (U.S. Army Satellite Communications Agency, Fort Monmouth, N.J.).
(Institute of Electrical and Electronics Engineers, International Convention, New York, N.Y., Mar. 23-26, 1964.)
IEEE International Convention Record, vol. 12, pt. 6, 1964, p. 125-145. 11 refs.

Description of data reduction and analysis procedures used for the Syncom 2 (1963 31A) 24-hr synchronous satellite communications experiments. The various data reduction methods are reviewed, and qualitative and quantitative tests on single- and multi-channel telephony and teletype, on simultaneous telephony and teletype, and on the relay of picture fascimiles, are discussed. Also considered are tests on the link characteristics of the system, including the signal-plus-noise to noise distributions for various operating modes and ground stations.

A64-21721
DESIGN OF THE VOICE PORTION OF THE SYNCOM GROUND STATION.
N. W. Feldman and G. P. Tripp (U.S. Army, Electronics Research and Development Laboratory, Communications Dept., Fort Monmouth, N.J.).
(Institute of Electrial and Electronics Engineers, International Convention, New York, N.Y., Mar. 23-26, 1964.)
IEEE International Convention Record, vol. 12, pt. 6, 1964, p. 146-153.

Description of the design layout for the voice channel portion of the Syncom 2 (1963 31A) communications system. The components between the telephone set and radio transmitter at one ground station, and the radio receiver and telephone set at the other ground station, are noted, and their characteristics described. Optimum power levels for voice signals and for teletype signals are determined. The possibility of using a compandor, a device composed of a compressor and an expandor for transmission away from and towards a telephone, is considered for improving the SNR of the transmission facility.

A64-22500
THE DEFENSE COMMUNICATIONS AGENCY - A PANEL DISCUSSION.
IN: NATIONAL CONVENTION ON MILITARY ELECTRONICS, 7TH, WASHINGTON, D. C., SEPT. 9-11, 1963, PROCEEDINGS.
Conference sponsored by the Professional Technical Group on Military Electronics, Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
New York, Institute of Electrical and Electronics Engineers, 1963, p. 121-125.

Description of the Defense Communications Agency, an agency of the Department of Defense under the direction, authority, and control of the Secretary of Defense. It has responsibilities in the areas of operations, engineering, planning, programming, and research and development, as well as specific responsibility for operational direction of the Defense Communications System, and other assigned responsibilities. The Communications Satellite Project Office, working directly with the Army and Air Force, will ensure compatibility and program coordination in meeting the objectives of the DOD Communications Satellite Program, which are to provide a means of meeting critical and survival communication needs and also to provide another means of service to all users of DCS.

A64-22514
A DETERMINISTIC APPROACH TO SYSTEMS OF COMMUNICATION SATELLITES.
M. Mannos, B. A. Forest, and R. H. Greene (MITRE Corp., Bedford, Mass.).
IN: NATIONAL CONVENTION ON MILITARY ELECTRONICS, 7TH, WASHINGTON, D. C., SEPT. 9-11, 1963, PROCEEDINGS.
Conference sponsored by the Professional Technical Group on Military Electronics, Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
New York, Institute of Electrical and Electronics Engineers, 1963, p. 268-271.
Contract No. AF 19(628)-2390.

Presentation of a theory for the creation of the means of simulating the motion of a system of satellites in order to make comparisons among a large variety of dissimilar systems. It is stated that a general computer program is now being written to determine the communication potential of a system of satellites for any preselected pair combinations of prescribed stations, any of which may be either in space or on the ground. For the special case where all stations are motionless on the ground, the program has been completed and used to give the percentage time of possible communication between all desired station pairs of a specified system of communication satellites. Numerous systems of communication satellites moving in one or more orbit planes have been studied and evaluated.

A64-22516
A TRANSPORTABLE TRACKING AND COMMUNICATION TERMINAL FOR PASSIVE SATELLITES.
Robert F. Stone (General Electric Co., Syracuse, N. Y.).
IN: NATIONAL CONVENTION ON MILITARY ELECTRONICS, 7th, WASHINGTON, D. C., SEPT. 9-11, 1963, PROCEEDINGS.
Conference sponsored by the Professional Technical Group on Military Electronics, Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
New York, Institute of Electrical and Electronics Engineers, 1963, p. 276-280.

Description of the first transportable passive satellite communications terminal (TPSCT). This facility will be utilized in an experimental test program using passive spherical satellites of the "ECHO" type. The transportable terminal consists of a van-mounted 10 kw X-band transmitter and an S-band tracking/communications receiver with related auxiliary equipment. This includes antenna pedestal, servo-drive equipment, an optical tracker, data recording equipment, etc. The antenna is a sectionalized, demountable, 30-ft paraboloid with pedestal and integral trailer-bed for road transportability. The feed system, of the Cassegrain type, employs a 5 ft-diam hyperboloid mirror with disc-on-rod feed elements located near the paraboloid vertex.

A64-22539
ATTITUDE CONTROL FOR COMMUNICATION SATELLITES.
J. E. Metzger (International Telephone and Telegraph Corp., Intelcom, Inc., Bailey's Cross Roads, Va.).
IN: NATIONAL CONVENTION ON MILITARY ELECTRONICS, 7TH, WASHINGTON, D.C., SEPT. 9-11, 1963, PROCEEDINGS.
Conference sponsored by the Professional Technical Group on Military Electronics, Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
New York, Institute of Electrical and Electronics Engineers, 1963, p. 443-446.

Presentation of the approach to improve the gain of the critical link in a satellite communication system through the use of attitude control to permit directive satellite antennas. The following conclusions are made: (1) the realization of an attitude control system of reasonable performance characteristics could materially increase the performance of active communication repeaters at medium and higher altitudes, (2) the selection of an attitude-control system of reasonable performance characteristics could reduce the need for the use of complex and/or sophisticated link terminals and improve the capability of mobile installations, and (3) gravity gradient stabilization is the most attractive method of achieving attitude control with the required reliability at a medium altitude.

A64-22790
SYSTEMS ENGINEERING AND SPACE TECHNOLOGY.
New York, Radio Corporation of America, 1964. 64 p.

CONTENTS:

THE ENGINEER AND THE CORPORATION - SYSTEMS ENGINEERING. I - THE ROLE OF SYSTEMS ENGINEERING AT RCA. N. I. Korman (Radio Corporation of America, Princeton, N. J.), p. 2, 3.

THE ENGINEER AND THE CORPORATION - SYSTEMS ENGINEERING. II - COMMUNICATIONS SYSTEMS ENGINEERING. R. Guenther (Radio Corporation of America, Camden, N. J.), p. 4-9.

SYSTEMS CONSIDERATIONS FOR ICBM COMMAND AND CONTROL. C. G. Arnold (Radio Corporation of America, New York, N. Y.), p. 10-13. 7 refs. [See A64-22791 19-08]

DESIGN OF A DATA COMMUNICATIONS COMPUTER SYSTEM. W. A. Levy and A. E. DiMond (Radio Corporation of America, Camden, N. J.), p. 14-20.

THE DYNAMICAL DESIGN OF THE RELAY SATELLITE. C. C. Osgood (Radio Corporation of America, Princeton, N. J.), p. 21-25. [See A64-22792 19-32]

REVIEW OF ELECTRIC PROPULSION. T. T. Reboul and S. Fairweather (Radio Corporation of America, Princeton, N. J.), p. 26-33. 25 refs. [See A64-22793 19-27]

SEER - SYSTEMS ENGINEERING, EVALUATION, AND RESEARCH. D. Shore (Radio Corporation of America, Moorestown, N. J.), p. 34.

TOOLS AND TECHNIQUES FOR SPACE SURVEILLANCE STUDIES. J. Breckman, A. Franz, and S. G. Miller (Radio Corporation of America, Moorestown, N. J.), p. 35-39. [See A64-22794 19-29]

THE POTENTIALS OF HIGH-POWER SATELLITES FOR COMMUNICATIONS. A. C. Gay and J. S. Greenberg (Radio Corporation of America, Princeton, N. J.), p. 40-43. 6 refs. [See A64-22795 19-32]

OVERSEAS COMMERCIAL COMMUNICATIONS SATELLITE SYSTEMS 1965-1975. J. S. Greenberg, S. Gubin, and M. Handelsman (Radio Corporation of America, Princeton, N. J.), p. 44-48. 25 refs. [See A64-22796 19-08]

A HIGH-RESOLUTION RANGE COUNTER. L. C. Drew (Radio Corporation of America, Burlington, Mass.), p. 49-51. [See A64-22797 19-15]

SOME TRENDS IN ADVANCED RANGE INSTRUMENTATION. L. E. Mertens (RCA Service Co., Patrick AFB, Fla.), p. 52-55. [See A64-22798 19-15]

EVOLUTION OF THE HIGHEST-PRECISION RADAR - THE STORY OF MIPIR. J. W. Bornholdt and W. J. Rose (Radio Corporation of America, Moorestown, N. J.), p. 56-60. 8 refs. [See A64-22799 19-08]

PLASMA-MICROWAVE INTERACTIONS. James Vollmer (Radio Corporation of America, Camden, N. J.), p. 61-64. 16 refs. [See A64-22800 19-24]

A64-22792
THE DYNAMICAL DESIGN OF THE RELAY SATELLITE.
C. C. Osgood (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N. J.).
IN: SYSTEMS ENGINEERING AND SPACE TECHNOLOGY.
New York, Radio Corporation of America, 1964, p. 21-25.

Discussion of the dynamical design considerations for the RELAY (1962 Beta Upsilon 1) satellite occasioned by such factors as the presence of sensitive components and their positioning, the various static and vibratory loads, and the limitations on total weight. Primary conditions which the configuration of the RELAY payload had to meet were spin stabilization, compatibility with an existing fairing, and maximized surface area. The design of vibration damping devices is considered. Vibration tests indicated that the maximum allowable transmissibility for the receiver and encoder was about 10 for a 10.7-g input in the 50-to-500-cps band. Therefore, the design goal of the damper was a transmissibility between 3 and 5 for a narrow band which included the resonant frequency. The general approach, which is outlined, is based on that introduced by Hartog. Briefly reviewed are other methods of providing control of transmissibility, chiefly the effects of various modes of fabrication of essentially all-metal structures.

A64-22795
THE POTENTIALS OF HIGH-POWER SATELLITES FOR COMMUNICATIONS.
A. C. Gay and J. S. Greenberg (Radio Corporation of America, Advanced Military Systems, Princeton, N. J.).
IN: SYSTEMS ENGINEERING AND SPACE TECHNOLOGY.
New York, Radio Corporation of America, 1964, p. 40-43. 6 refs.

Consideration of the feasibility and requirements for high-powered synchronous communication satellites. The system model discussed is shown in a chart, and the signal power, jammer power, and noise power received at the satellite are calculated. It is shown that, because all traffic must pass through the satellite, 300 mobile terminals, each with a single channel capability, will require a satellite capable of radiating about 200 watts or approximately 1 to 2 kw of prime power. This power requirement is independent of the type of ground transmitter terminal. One hundred portable terminals, each with a single channel capability, require a satellite capability of only 50 watts of radiated or 250 to 500 watts of prime power. It is concluded that high power in the satellite is a distinct advantage when small terminals are required.

A64-22796
OVERSEAS COMMERCIAL COMMUNICATIONS SATELLITE SYSTEMS - 1965-1975.
J. S. Greenberg, S. Gubin, and M. Handelsman (Radio Corporation of America, Advanced Military Systems, Princeton, N. J.).
IN: SYSTEMS ENGINEERING AND SPACE TECHNOLOGY.
New York, Radio Corporation of America, 1964, p. 44-48. 25 refs.

Review of a study of commercial communication systems using active repeaters in Earth satellites. Briefly discussed is an analysis of satellite configurations, orbit injection, stabilization, station-keeping, capability and availability of launch vehicles, and ground terminal equipment. This analysis shows that initial operation by 1966 is possible for two configurations: a synchronous system which employs satellites orbiting in the equatorial plane at 36,000-km altitude, and a medium-altitude system in which the satellites are in random orbits at altitudes of about 11,000 km. The SSB modulation, proposed for the synchronous system, is seen to provide direct access to all users. Available test data indicate that the synchronous system should pose no major problem to voice communications.

A64-22878
SILICON P-N JUNCTION RADIATION DETECTORS FOR THE TELSTAR SATELLITE.
T. M. Buck, G. H. Wheatley, and J. W. Rodgers (Bell Telephone Laboratories, Inc., Murray Hill., N.J.).
(Scintillation and Semiconductor Counter Symposium, 9th, Washington, D.C., Feb. 26-28, 1964.)
IEEE Transactions on Nuclear Science, vol. NS-11, June 1964, p. 294-301. 15 refs.

Description of the development and testing of the silicon p-n junction nuclear particle detectors used in the radiation experiments of the Telstar communication satellite and the Relay and Explorer 15 (1962 Beta Lambda 1) satellites. The sensitive element of the detector is a diffused mesa diode of 10,000- to 20,000-ohm-cm p-type silicon. The radiation experiments for these satellites required diodes of small size, rugged construction, high sensitivity, low noise, fast response, and high reliability, particularly surface reliability in the space environment. The detector diode design and processing procedures are described, as are its counting behavior and reliability. The chemical control of current-voltage characteristics and noise is considered, along with methods for the control of long-term aging. Some of the performance experience obtained with these detectors is noted.

A64-23227
THERMAL DATA FROM THE TELSTAR SATELLITES.
A. M. Wittenberg (Bell Telephone Laboratories, Inc., Environmental Engineering Dept.).
IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, PHILADELPHIA, PA., APRIL 13-15, 1964, PROCEEDINGS.
(Annual Symposium on Space Environment Simulation, 4th, Los Angeles, Calif., May 22, 23, 1963.)
Mt. Prospect, Ill., Institute of Environmental Sciences, 1964, p. 513-521. 7 refs.

Discussion of the thermal properties of Telstars I and II, the Bell System communications satellites, which were studied prior to launch in a space simulation chamber. The average α/ϵ of the external surfaces was determined, and tests were performed to evaluate the overall thermal design of the satellites and to accept them for space operation. The results of these tests are discussed and compared with data telemetered from the satellites in orbit.

A64-23244
THERMAL GRADIENT SPACECRAFT VACUUM CHAMBER TESTS.
G. D. Gordon and H. P. Strickberger (Radio Corporation of America, Astro-Electronics Div., Princeton, N.J.).
IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, PHILADELPHIA, PA., APRIL 13-15, 1964, PROCEEDINGS.
Mt. Prospect, Ill., Institute of Environmental Sciences, 1964, p. 625-630.
Contract No. NAS5-1272.

Description of a steady-state vacuum chamber test for spacecraft in which the walls surrounding the vehicle are maintained at different temperatures. To simulate flight temperatures in the vacuum chamber, the spacecraft's external surfaces are subjected to thermal inputs that are identical to those expected for chosen orbits and spacecraft attitudes. The test does not make use of any predicted temperatures within the spacecraft. The vacuum chamber has black walls so that none of the radiation emitted by the spacecraft is returned to it. The chamber simulates the following sources of incident radiation: direct sunlight, reflected sunlight from the Earth, and the Earth-emitted irradiance. The method of data analysis and the sources of error such as intensity variation and extraneous radiation are discussed. The techniques used in performing this test with the Relay communications satellite, including the computations required and the geometry of the vehicle in the chamber, are explained.

A64-23245
SOLAR SIMULATION FOR THERMAL VACUUM TESTING.
H. P. Strickberger and G. D. Gordon (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).
IN: INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL TECHNICAL MEETING, PHILADELPHIA, PA., APRIL 13-15, 1964, PROCEEDINGS.
Mt. Prospect, Ill., Institute of Environmental Sciences, 1964, p. 631-636.
Contract No. NAS5-1272.

Discussion of tests performed on the Relay communication satellite, using a solar simulator consisting of two carbon arc lights. The solutions to practical problems developed in setting up and conducting the test are presented, including the necessity for measuring, monitoring, and adjusting the absolute intensity, and the difficulty in obtaining full electrical power from the spacecraft solar cells. The method of calibrating the intensity of the carbon arc simulator and the accuracies attained are discussed. Based on experience derived from the gradient test, solar simulation test and flight data, a comparison of solar simulation testing vs gradient testing (IR) is made. It is shown that for the Relay spacecraft, gradient testing is an adequate technique for simulating the thermal environment.

A64-23648
THE RELAY COMMUNICATIONS SATELLITE - FACT VS. THEORY.
H. L. Wuerffel and R. P. Dunphy (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).
IN: AMERICAN SOCIETY FOR QUALITY CONTROL, ANNUAL CONVENTION, 18TH, BUFFALO, N.Y., MAY 4-6, 1964, TRANSACTIONS.
Edited by Irving W. Burr.
Milwaukee, American Society for Quality Control, Inc., 1964, p. 54-72. 5 refs.

Description of the relay communications satellite mission, and consideration of the design, reliability, and quality effort required to convert the system into a real, high-reliability spacecraft, meeting all the mission requirements. A comparison of performance in orbit with predicted performance is briefly discussed. Tables of requirements and results supplement the text. The experimental results obtained from in-orbit operation are said to indicate a close correlation to prelaunch measurement, and that the spacecraft has contributed appreciably to man's knowledge about the space surrounding him.

A64-24550
SEVEN NATIONS INTO SPACE.
Hawker Siddeley Review, Summer 1964, p. 1-48.

Discussion of the European effort to orbit a communications satellite. The organizations involved are described. Considered are the satellite test vehicle, being developed under the authority of the Italian government, the three-stage rocket to launch it, which consists of a first-stage Blue Streak IRBM built by Great Britain, and a second and third stage, to be built by France and Germany, respectively. The firing range as well as the down range guidance system and the long-range telemetry system, the contributions of Belgium and the Netherlands, are discussed. Communication satellite problems and prospects are mentioned along with the impact of space exploration on world industry.

A64-24573
TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964. 441 p.
$14.50.

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PROJECT TELSTAR. Staff of Bell Telephone Laboratories, Inc., Murray Hill, N.J., p. 52-83. [See A64-24576 20-32]

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THE COURIER COMMUNICATIONS SATELLITE SYSTEM. James E. Bartow, Thomas P. Mottley, and Walter P. Teetsel (U.S. Army, Fort Monmouth, N.J.), p. 156-183. [See A64-24579 20-32]

PROSPECTS FOR EUROPE - THE UNITED KINGDOM GROUND STATION AND THE TELSTAR AND RELAY TESTS AND DEMONSTRATIONS. W. J. Bray (General Post Office, London, England), p. 184-205. [See A64-24580 20-08]

DESIGN OF GROUND STATIONS. H. A. Prime (Brush Electrical Engineering Co., Ltd., Loughborough, England), p. 206-241. 9 refs. [See A64-24581 20-08]

A DESIGN STUDY FOR AN EQUATORIAL, CIRCULAR-ORBIT, COMSAT SYSTEM (GPO/RAE). A. W. Lines, E. G. C. Burt, and A. G. Earl (Ministry of Aviation, Farnborough, Hants., England), p. 242-282. [See A64-24582 20-32]

A DESIGN STUDY FOR AN EQUATORIAL, CIRCULAR-ORBIT, COMSAT SYSTEM (BSDC). G. K. C. Pardoe (British Space Development Co., Ltd., London, England), p. 283-317. [See A64-24583 20-32]

POWER UNITS AND PROPULSION PROBLEMS IN TELECOMMUNICATIONS SATELLITES. M. Vernet-Lozet and G. de Clavière (Société d'Etude de la Propulsion par Réaction, Villejuif, Seine, France), p. 318-345. [See A64-24584 20-06]

THE ECONOMICS OF SATELLITE SYSTEMS. Alan H. Stratford (Hawker Siddeley International, Ltd., London, England), p. 346-364. 10 refs. [See A64-24585 20-08]

ECONOMICS OF SATELLITE DESIGN - AN AMERICAN ASSESSMENT. Samuel Gubin and Joel S. Greenberg (Radio Corporation of America, Camden, N.J.), p. 365-410. 28 refs. [See A64-24586 20-08]

THE FUTURE OF SATELLITE TELECOMMUNICATIONS. N. I. Korman and M. Handelsman (Radio Corporation of America, Camden, N.J.), p. 411-431. 14 refs. [See A64-24587 20-32]

INDEX, p. 433-441.

A64-24574

BACKGROUND AND PROSPECTS.
Kenneth W. Gatland.
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 1-13.

Review of the launches of the various communications satellites, and discussion of the Communications Satellite Act of 1962. It is stated that, so far, in terms of television, a type of communications satellite has been discussed which depends on a ground receiving station to acquire and process the incoming signals before channeling them into the established national networks for retransmission to home receivers. The big hope for the future is that communications satellites can be established in synchronous orbit which have sufficient broadcasting power to rediffuse sound and vision direct to domestic aerials. It is noted that not only will this bring television more cheaply to a world audience by eliminating expensive ground stations, but it has the prospect of opening up enormous opportunities in the underdeveloped countries.

A64-24575

COMMUNICATIONS ORBITS.
W. F. Hilton.
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 14-51. 5 refs.

Consideration of the worldwide demand for communications satellites. The topics discussed include demand for intercontinental communications, distribution of demand by place and time, use of larger rockets for launching, demand on television relays, the 24-hr stationary orbit and its periodic time and coverage, telephonic lag or delay times and echo, launching into equatorial and stationary orbits, outage and spare satellites, equatorial, circular orbits, and attitude stabilization by gravity gradient. Other subjects treated are polar and inclined circles, representation of coverage circles on maps, optimum numbers of satellites and ground stations, equatorial ellipses, and elliptical orbits in the 63^{o} slot.

A64-24576

PROJECT TELSTAR.
Staff of Bell Telephone Laboratories, Inc., Murray Hill, N.J.
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 52-83.

Description of the objectives and results of Project Telstar. The aspects of Telstar 1 (1962 Alpha Epsilon 1) considered include power supply, electronics chassis, broadband communications circuit, radiation and solar aspect measurement, telemetry, command, test program, orbit, ground stations, communications results, analysis of initial breakdown, radiation measurements, and radiation in space. A short paragraph describing Telstar 2 (1963-13A) is included. It is stated that Telstar 2, externally similar to Telstar 1, was made more resistant to radiation damage by isolating transistors in the command circuit. The transistors concerned were evacuated of gas that might otherwise be ionized by radiation in the Van Allen belts.

A64-24577

THE SPACECRAFT OF THE RELAY PROJECT.
Raymond M. Wilmotte (Radio Corporation of America, Advanced Space Communications Systems, Camden, N.J.).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 84-129.

Description of the Relay (1962 Beta Tau 1) experimental communications spacecraft designed for measurements of the behavior of communications equipment in a space environment. The subjects treated include requirements for Relay spacecraft, overall system, design approach, areas of ignorance and confidence, power supply, microwave repeater, traveling-wave tube, telemetry, tracking and command, microwave antenna, and antenna system. Other aspects discussed are testing of spacecraft and subassemblies, initial orbits, relay operation, spacecraft components, horizon scanner and Sun-aspect indicator, and measurements and tests in the spacecraft.

A64-24578

SYNCOM.
Donald D. Williams and Roger W. Cole (Hughes Aircraft Co., Syncom Project Office, Culver City, Calif.).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 130-155.

Description of the first series of Syncom satellites. The topics considered include synchronous orbit, transfer orbit, effects of errors on the orbit, perturbations of a synchronous orbit, control-system objectives, operation of the control system, attitude sensing, and Syncom 1 (1963 4A) and 2 (1963 31A). It is stated that future plans are proposed for an advanced synchronous communications satellite which will have an 8:1 increase in volume and mass over the present Syncom type of satellite.

A64-24579

THE COURIER COMMUNICATIONS SATELLITE SYSTEM.
James E. Bartow, Thomas P. Mottley, and Walter P. Teetsel (U.S. Army, Electronics Research and Development Laboratory, Fort Monmouth, N.J.).

IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 156-183.

Description of the system design considerations of the Courier (1960 Nu 1) communications satellite system, designed as an experimental system to demonstrate the feasibility of using satellites for providing a solution to global communications problems. It was designed to store teletype messages and transmit them at high speed while the satellite is in view of a ground station. The system used an active repeater satellite, approximately 500 lb in mass, orbiting the Earth at an altitude of 690 miles. The orbit achieved was almost circular and was inclined with respect to the equator at an angle of 28°. The Thor-Able Star booster configuration was used to launch the satellite into orbit on Oct. 4, 1960. It is stated that the results obtained during orbital tests indicated a sharp threshold for error-rate measurements which was correlated to the received signal level. In addition, error-rate bursts were observed which could be correlated to satellite spin rate. An average error rate of approximately 1/3000 characters was observed.

A64-24580
PROSPECTS FOR EUROPE - THE UNITED KINGDOM GROUND STATION AND THE TELSTAR AND RELAY TESTS AND DEMONSTRATIONS.
W. J. Bray (General Post Office, Post Office Research Station, London, England).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 184-205.

Discussion of European participation in satellite communications systems and experimental testing. The subjects considered include a cooperative program with the US, the British Post Office satellite communications system ground station, preliminary results of tests and demonstrations using Telstar (1962 Alpha Epsilon 1, and 1963 13A), and preliminary results of tests and demonstrations using Relay (1962 Beta Tau 1). It is concluded that the results obtained from these tests and demonstrations to date have confirmed the expectation that communications satellites could provide high-quality stable circuits both for television and multichannel telephony. The good results obtained with the transmission of color television signals, and in the tests involving 600 simulated telephone circuits, are said to be particularly noteworthy.

A64-24581
DESIGN OF GROUND STATIONS.
H. A. Prime (Brush Electrical Engineering Co., Ltd., Loughborough, England).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 206-241. 9 refs.

Assessment of the characteristics of a satellite communications system which are relevant to the specification of the ground-station facility and to the station equipment necessary to fulfill the operational requirement. The topics considered include operational limitations, communications-system data, antenna-system data, orbital, structure, and drive and control characteristics, digital control requirements, auto-tracking requirements, installed equipment, antenna and mechanical equipment, drive equipment, control modes, servo equipment, digital equipment, and performance. An appendix provides an analysis of orbital tracking requirements.

A64-24582
A DESIGN STUDY FOR AN EQUATORIAL, CIRCULAR-ORBIT, COMSAT SYSTEM (GPO/RAE).
A. W. Lines, E. G. C. Burt, and A. G. Earl (Ministry of Aviation, Royal Aircraft Establishment, Space Dept., Farnborough, Hants., England).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 242-282.

Description of a complete study of a satellite communications system, involving the satellite, as well as launching and communications problems, in all their possible aspects, to satisfy the requirement for a worldwide civil telephone and video communications system. The topics considered include the civil communications requirement, consideration of satellite orbits to fulfill the requirement, circular polar and equatorial orbits, elliptical orbits at 63.4°, attitude stabilization using naturally occurring control torques, attitude stabilization by active control, some factors affecting satellite design, and conclusions on the main factors in system design. Other subjects discussed are a possible system and satellite design, the station-keeping accuracy to be achieved, overall design of the satellite, design of the control system, proposed development program, proposed operational system, the communications requirement, cost of the operational system, and future system development.

A64-24583
A DESIGN STUDY FOR AN EQUATORIAL, CIRCULAR-ORBIT, COMSAT SYSTEM (BSDC).
G. K. C. Pardoe (British Space Development Co., Ltd., London, England).
(International Astronautical Federation, Congress, 13th, Varna, Bulgaria, Sept. 1962.)
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 283-317.

Description of investigations of the entire problem of communications satellites, performed by the British Space Development Company since 1961, with a view to providing full global service, with emphasis on British Commonwealth and European interests. The subjects treated are Commonwealth and European requirements, system and performance standards, launch vehicle and launching site, factors affecting choice of orbit, equatorial systems, world trunk route, orbit height, the North Atlantic route, summary of satellite network, system mechanics, analysis of traffic and satellite loading, and satellite requirement. Other subjects considered are modulation and telecommunications system, general criteria of telecommunications performance, characteristics of telecommunications design, coexistence of the system with current microwave services, ground station aerials, ground stations and facilities, master technical control center, zone control stations, factors affecting satellite design, satellite configuration, and control system. The discussion includes solar-cell array, telecommunications repeaters, system costs and revenue, and expansion of system with synchronous system.

A64-24584
POWER UNITS AND PROPULSION PROBLEMS IN TELECOMMUNICATIONS SATELLITES.
M. Vernet-Lozet and G. de Clavière (Société d'Etude de la Propulsion par Réaction, Villejuif, Seine, France).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 318-345.

Discussion of the problems connected with the establishment of a telecommunications satellite. The subjects considered are point-to-point telecommunications, production of electrical energy, chemical-energy generators, electrical-energy storage systems, solar-energy generators, photoelectric generators, thermodynamic cycle generators, conclusions about solar-energy generators, nuclear-energy generators, radionuclides, fission reactors, and orbiting problems for telecommunications satellites.

A64-24585
THE ECONOMICS OF SATELLITE SYSTEMS.
Alan H. Stratford (Hawker Siddeley International, Ltd., London, England).

IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 346-364. 10 refs.

Survey of the principal lines of thought being pursued in the economics study of communications satellites both in Europe and in the US. The topics considered include prospects for Europe, estimating the growth of telecommunications, comparison of satellite repeaters and underwater cables, principles of the economics analysis, influence of parametric changes, operating costs and possible improvements in economy, traffic potential and the prospects for growth, and assessment of future telecommunications demand. It is concluded that studies in the U.K. and US suggest that a very adequate and expanding market for the use of high-quality telecommunications facilities of all kinds exists on the North Atlantic and between Europe and British Commonwealth and other overseas territories which, up until now, have not enjoyed high standards of communications service.

A64-24586

ECONOMICS OF SATELLITE DESIGN - AN AMERICAN ASSESSMENT.
Samuel Gubin and Joel S. Greenberg (Radio Corporation of America, Defense Electronic Products, Advanced Military Systems, Camden, N.J.).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 365-410. 28 refs.

Study of the economics of a commercial satellite system. The following conclusions are made: (1) the projected traffic exceeds installed and presently planned facilities by 1965. A satellite system can provide for this growing transoceanic traffic load thereafter; (2) the synchronous system will be more economical than the medium-altitude system, or any other known means of communications including the overseas cables; (3) if system toll rates are determined by large ground terminals, profitable operations by small terminals competing for the same traffic may not be possible for either system, particularly for the medium-altitude system; (4) the periods for the initial investment and traffic growth are such that the better part of a decade may elapse before the Satcorp shows reasonable earnings; and (5) unrestricted access for all users into the satellite communications system is best provided by single-sideband modulation for transmission from the ground to the satellite; worldwide connectivity between users is better provided by the synchronous system.

A64-24587

THE FUTURE OF SATELLITE TELECOMMUNICATIONS.
N. I. Korman and M. Handelsman (Radio Corporation of America, Defense Electronic Products, Advanced Military Systems, Camden, N.J.).
IN: TELECOMMUNICATION SATELLITES.
Edited by Kenneth W. Gatland.
London, Iliffe Books, Ltd.; Englewood Cliffs, N.J., Prentice-Hall, Inc., 1964, p. 411-431. 14 refs.

Discussion of the likelihood that some sort of communications satellite system will be put into use in the latter part of the 1960 decade for transoceanic telephone traffic. The subjects considered include the high-power communications satellite, application to point-to-point communications, application to television broadcasting, other uses for the 1970 high-power communications satellite, and communications satellites beyond the 1970 decade. It is stated that, whereas in the 1960's only the more wealthy nations will be able to afford communications by satellite, in the 1970's smaller nations and large cities can be served, and in the 1980's and beyond, smaller and smaller communities will progressively have direct access to this service.

A64-24658

SOME RESULTS AT PLEUMEUR-BODOU DURING TRANSMISSION TESTS USING THE TELSTAR SATELLITE.
J. P. Houssin (Centre National d'Etudes des Télécommunications, Issy-les-Moulineaux, Seine, France).
(International Conference on Satellite Communication, Nov. 26, 1962, Paper 4237 E.)
Electronics Record, Aug. 1964, p. 1407-1410.

Review of the principal results of telecommunications tests with Telstar 1 conducted at the French Pleumeur-Bodou satellite-tracking station. The acquisition and tracking equipment of the station, which uses a 20-m-diam. horn reflector antenna, are described. Experiments concerning the received signal power, noise power at radio frequencies, thermal noise generated in the transmission channel, and distortion are discussed.

A64-24722

ESTABLISHMENT AND REPLENISHMENT COMPARISON OF SYNCHRONOUS AND MEDIUM ALTITUDE SATELLITE SYSTEMS.
I - SIMULATION APPROACH.
G. C. Sponsler (International Business Machines Corp., Federal Systems Div., Rockville, Md.), R. J. Heppe (International Telephone and Telegraph Corp., Intelcom, Inc., Falls Church, Va.), R. A. Gilbert (USAF, Systems Command, Research and Technology Div., Weapons Laboratories, Kirtland AFB, N. Mex.), M. H. Stripling (U.S. Naval Ordnance Laboratory, Washington, D. C.), and W. C. Thompson (Control Data Corp., Rockville, Md.).
I - ANALYTIC APPROACH. R. J. Heppe (International Tlephone and Telegraph Corp., Intelcom, Inc., Falls Church, Va.)
IEEE, Proceedings, vol. 52, July 1964, p. 756-769. 8 refs.

Presentation of equations and graphs which relate the growth and replenishment of a population of unrepairable equipments to the mean time before failure, replacement strategy, and other significant variables involved. Results are presented in a satellite system context, but it is believed that they may readily be generalized to other applications. In Part I, results are given which were obtained by simulation of various systems on digital computers. Part II contains not only analytical equations and approximations relating the quantities of interest but also a discussion of an alternative computer approach. Results of the analytical approach are said to confirm conclusions arrived at by the Monte Carlo method presented in the first part, with minor differences.

A64-24870

ATTITUDE DETERMINATION AND PREDICTION OF SPIN-STABILIZED SATELLITES.
L. C. Thomas (Bell Telephone Laboratories, Inc., Murray Hill, N.J.) and J. O. Cappellari (Bellcomm, Inc., New York, N.Y.).
Bell System Technical Journal, vol. 43, July 1964, p. 1657-1726. 22 refs.

Presentation of techniques for both attitude determination and prediction for spin-stabilized satellites. Their use is demonstrated using Telstar I and II satellite data. It is shown that an inclined dipole model of the Earth's magnetic field and the method of averaging the gravitational and magnetic torques over each anomalistic period of the satellite permit attitude predictions to within a few tenths of a degree of determined values in most instances. In the few cases where departures are above 1°, explanations are presented to show the reason for such discrepancies. The usefulness of combining optical-flash and solar-sensor data for attitude determination and their inherent accuracy are demonstrated. It is stated that optical-flash data can provide loci with a resolution of 0.1°. Solar-sensor loci are resolved to within 1°. It is noted that all techniques described have been consolidated into working computer programs which follow closely the mathematical analysis presented.

A64-25030

EXOSPHERIC DENSITIES DEDUCED FROM SATELLITE DRAG DATA.
M. Roemer (Bonn, Universität, Universitäts-Sternwarte, Bonn, West Germany).
IN: SPACE RESEARCH IV; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 4TH, WARSAW, POLAND, JUNE 4-10, 1963, PROCEEDINGS.

Organized by the Committee on Space Research (COSPAR) and the Polish Academy of Sciences.
Edited by P. Muller.
Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 244-256. 30 refs.

Presentation of exospheric densities in the altitude range of 900-1500 km derived from Echo 1 drag data taking full account of the diurnal density variation. A diurnal dependence of the amplitude of the 27-day density variation due to the solar activity effect is found for this altitude range, and an empirical correlation formula is presented. The densities derived are higher than those of the appropriate Harris-Priester model by a factor of about 3. The most probable explanation for this discrepancy is seen in a higher concentration of helium. If the amount of helium is increased by a factor of 2.5 at the boundary of 120 km, the agreement of the observed data and the Harris-Priester model is found to be very good.

A64-25301
TORQUES AND ATTITUDE SENSING IN SPIN-STABILIZED SYNCHRONOUS SATELLITES.
Donald D. Williams (Hughes Aircraft Co., Project Syncom, System Design Dept., Culver City, Calif.).
IN: TORQUES AND ATTITUDE SENSING IN EARTH SATELLITES.
Edited by S. Fred Singer.
New York, Academic Press, Inc., 1964, p. 159-174. 5 refs.

Description of the attitude-control procedures for the spin-stabilized Syncom satellites. The launch procedures and subsequent operations of the synchronous Syncom are outlined. The Syncom attitude-sensing system is reviewed, and consists of a solar sensing system on the satellite, and RF sensing from the ground. The nutation, or free-body torque-free deviation from uniform spin for Syncom, is derived, and the Syncom nutation damper is described. The precession effects due to jet pulsing for attitude control are examined. Other disturbing torques, including gravity-gradient effects, are also considered.

A64-25485
COMMUNICATION SATELLITES.
G. E. Mueller and E. R. Spangler (Space Technology Laboratories, Inc., Redondo Beach, Calif.).
New York, John Wiley and Sons, Inc., 1964. 280 p.
$10.

A general review is made of the available technology for the establishment of communication satellite systems. The technical feasibility is granted and is found to rest on eight factors: rocket vehicle hardware and techniques which have been developed largely in the ballistic missile programs; the improvement of performance and reliability through advanced rocket-development programs; the experience in building, launching, and communicating with satellites in space; a gradually improving knowledge of the space environment and its effects on equipment; electric power supplies which derive their energy either from the Sun or from nuclear or chemical fuels; very low-noise receivers; techniques for sensing and controlling vehicle attitude in space; and the ground tracking equipment and high-speed computers needed for accurate ephemeris determination and control. Topics covered include active vs passive satellites, orbit coverage and control, structure and temperature control, choice of frequency, telemetry, tracking, and command, reliability, and costs.

A64-25901
POTENTIAL PASSIVE SATELLITE COMMUNICATION SYSTEM FOR ALL NATIONS.
Charles M. Kelly (Goodyear Aerospace Corp., Astronautics Systems Dept., Akron, Ohio).
International Astronautical Congress, 15th, Warsaw, Poland, Sept. 1964, Paper. 45 p. 8 refs.

Presentation of data concerning the growth potential and characteristics of the lenticular gravity-gradient-stabilized passive communication satellites that are presently being developed by NASA and Goodyear Aerospace. A communication system is described that exploits recent advances in space and communications technology, as well as the many natural capabilities of passive communication satellites, such as: long life, wide communications bandwidth, solar sail station keeping, high radio reflectivity to weight ratio, and terminal sharing. Information concerning gravity gradient stabilization and orbit position control by solar sailing is also presented. Parametric curves and tables relating link bandwidth, SNR, transmitter power, antenna gains, receiver noise temperature, path length, and satellite weight and diameter are included. Low (2000 nautical miles) and synchronous orbit applications are discussed that use passive satellites in the 50- to 1100-ft diam. range. The expectation is expressed that the system could fulfill most of the satellite communication requirements on this planet for the rest of the century.

A64-26202
ORBITAL ASPECTS OF NONSYNCHRONOUS COMMUNICATION SATELLITE SYSTEMS.
Hans K. Karrenberg and R. David Lüders (Aerospace Corp., Astrodynamics Dept., El Segundo, Calif.).
(American Institute of Aeronautics and Astronautics, Astrodynamics Conference, New Haven, Conn., Aug. 19-21, 1963, Paper 63-397.)
IN: CELESTIAL MECHANICS AND ASTRODYNAMICS (PROGRESS IN ASTRONAUTICS AND AERONAUTICS. VOLUME 14).
Edited by Victor G. Szebehely.
New York, Academic Press, Inc., 1964, p. 203-255. 7 refs.
Contract No. AF 04(695)-169.
[For abstract see Accession no. A63-21714 21-29]

A64-26242 •
SYNCHRONOUS OBSERVATIONS OF THE "ECHO-1" ARTIFICIAL EARTH SATELLITE FOR GEODETIC PURPOSES [SINKHRONNYE NABLIUDENIIA ISKUSSTVENNOGO SPUTNIKA ZEMLI "EKHO-1" DLIA GEODEZICHESKIKH TSELEI].
D. E. Shchegolev, A. G. Masevich, and B. G. Afanas'ev (Akademiia Nauk SSSR, Astronomicheskii Sovet, USSR).
Akademiia Nauk SSSR, Vestnik, July 1964, p. 74-77. In Russian.

Outline of the design principles and description of the technique used in observation of the American satellite early in May 1961, by the Pulkovo, Tashkent, Kharkov, and Nikolayev photographic stations. The method developed and used by the stations permits an accuracy in time measurements of ±2 millisec. The stations follow a single program so that within fixed time intervals a sequence of photographs is made with one film. The moments of all photographs are translated into a system of standard time identical for all stations. The observations of the satellite were repeated in 1963 on a larger scale to determine the accuracy of improved techniques.

A64-26278 •
EXPERIMENTAL DETERMINATION OF THE NIGHT EXTINCTION FROM BRIGHTNESS OBSERVATIONS OF THE ECHO I (1960) ARTIFICIAL SATELLITE [VERSUCH ZUR BESTIMMUNG DER NÄCHTLICHEN EXTINKTION AUS HELLIGKEITSBEOBACHTUNGEN DES KÜNSTLICHEN SATELLITEN ECHO 1 (1960)].
H. Wörner.
Astronomie und Raumfahrt, no. 2, 1964, p. 60-68. 6 refs. In German.

Derivation of extinction values from photographic brightness measurements of the Echo I satellite in Potsdam in 1960. On the basis of the results obtained, it is shown that the extinction has its maximum in the southeast azimuths and east wind directions. The results of earlier measurements on stars and solar radiation are confirmed qualitatively. Some requirements are imposed on the future brightness measurements of satellites in order to obtain extinction fluctuations.

A64-26329
CONFERENCE ON SPACE SCIENCE AND SPACE LAW, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., JUNE 18-20, 1963, PROCEEDINGS.

Conference sponsored by the College of Law of the University of Oklahoma; the Business and Industrial Services of the University of Oklahoma Extension Div.; the Frontiers of Science Foundation of Oklahoma, Inc.; the Liberty National Bank and Trust Co.; and the Oklahoma Bar Association.
Edited by Mortimer D. Schwartz (Oklahoma, University, Dept. of Law, Norman, Okla.).
South Hackensack, N.J., Fred B. Rothman and Co., 1964. 176 p. $6.75.

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FORMULATION OF SPACE LAW. Martin Menter (USAF, Washington, D.C.), p. 127-137. [See A64-26344 22-01]
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LAW AND PUBLIC ORDER IN SPACE. Myres S. McDougal (Yale University, New Haven, Conn.), p. 151-176. 19 refs. [See A64-26347 22-01]

A64-26333 •
SCIENTIFIC ASPECTS OF COMMUNICATIONS SATELLITES.
Eugene F. O'Neill (Bell Telephone Laboratories, Inc., Satellite Communications Laboratory, Murray Hill, N.J.).
IN: CONFERENCE ON SPACE SCIENCE AND SPACE LAW, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., JUNE 18-20, 1963, PROCEEDINGS.
Conference sponsored by the College of Law of the University of Oklahoma; the Business and Industrial Services of the University of Oklahoma Extension Div.; the Frontiers of Science Foundation of Oklahoma, Inc.; the Liberty National Bank and Trust Co.; and the Oklahoma Bar Association.
Edited by Mortimer D. Schwartz.
South Hackensack, N.J., Fred B. Rothman and Co., 1964, p. 42-47.
Presentation of 18 photographs, diagrams, and drawings, with descriptive text for each. The first six illustrations and their text outline the principles of communications satellites. The Telstar 2 (1963 13 Alpha) satellite and its equipment are described, with three photographs: a general view, the interior of the electronics canister, and the sensors for Van Allen radiation. A map and an aerial photograph give details of the Andover, Maine, ground station. The horn reflector antenna and the command and telemetry antenna are examined. The British Goonhilly Downs antenna, the French station at Plumeur-Bodou, and the Italian station at Fucino receive attention. The Telstar orbit is depicted by a drawing, and a Telstar-transmitted photograph is presented.

A64-26334 •
COMMUNICATION BY SATELLITE.
George J. Feldman (Communications Satellite Corp., Washington, D.C.).
IN: CONFERENCE ON SPACE SCIENCE AND SPACE LAW, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., JUNE 18-20, 1963, PROCEEDINGS.
Conference sponsored by the College of Law of the University of Oklahoma; the Business and Industrial Services of the University of Oklahoma Extension Div.; the Frontiers of Science Foundation of Oklahoma, Inc.; the Liberty National Bank and Trust Co.; and the Oklahoma Bar Association.
Edited by Mortimer D. Schwartz.
South Hackensack, N.J., Fred B. Rothman and Co., 1964, p. 48-53.
Discussion of progress in extending successful experiments to the level of a working international communications system. The Declaration of Policy and Purpose of the Communications Satellite Act of 1962, setting forth the guidelines for the US effort, is quoted verbatim, and various present and future aspects of its execution are discussed. The roles of Europe, the USSR, and the UN are briefly examined. Some particulars of the Communications Satellite Corporation are presented.

A64-26335 •
WEAPONS AND SPACE.
W. E. Berg (U.S. Navy, Office of Chief of Naval Operations, Astronautics and Range Div., Astronautics Branch, Washington, D.C.).
IN: CONFERENCE ON SPACE SCIENCE AND SPACE LAW, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., JUNE 18-20, 1963, PROCEEDINGS.
Conference sponsored by the College of Law of the University of Oklahoma; the Business and Industrial Services of the University of Oklahoma Extension Div.; the Frontiers of Science Foundation of Oklahoma, Inc.; the Liberty National Bank and Trust Co.; and the Oklahoma Bar Association.
Edited by Mortimer D. Schwartz.
South Hackensack, N.J., Fred B. Rothman and Co., 1964, p. 54-59.
General discussion of military aspects of space science, but with exclusion of ballistic missiles. The importance of meteorological, communications, navigational, geodetic, and other data-gathering satellites in military planning is examined in some detail. The concept of using unmanned, orbiting, data readout stations to measure sea conditions, water and air temperatures, cloud cover, and precipitation in remote areas is discussed. In discussing the evolution of space law, it is considered that this will be governed by the characteristics of the space environment. Parallels with maritime law are discussed. Comment is made that it is difficult to classify all military space systems as weapons and all non-military satellites as peaceful tools.

A64-26336 •
WEAPONS AND SPACE.
Kenneth W. Schultz (USAF, Directorate of Development Planning, Space Development Plans Div., Washington, D.C.).
IN: CONFERENCE ON SPACE SCIENCE AND SPACE LAW, UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., JUNE 18-20, 1963, PROCEEDINGS.
Conference sponsored by the College of Law of the University of Oklahoma; the Business and Industrial Services of the University of Oklahoma Extension Div.; the Frontiers of Science Foundation of Oklahoma, Inc.; the Liberty National Bank and Trust Co.; and the Oklahoma Bar Association.
Edited by Mortimer D. Schwartz.
South Hackensack, N.J., Fred B. Rothman and Co., 1964, p. 60-67.

Discussion of the military implications of space and the military space system possibilities which are considered to be of interest from the aspect of space law. Effort is being made to satisfy two broad objectives: (1) to develop space systems which will augment present military capabilities on land, sea, and in the air, and (2) to seek capabilities permitting man to conduct operations in space itself. The first objective involves communications systems and reconnaissance systems, a military meteorological survey system, a ballistic missile defense, and an early warning system. The second objective involves detection and tracking of objects in space, satellite inspection, satellite interception, and space environment monitoring. Also discussed are the problems of man in space, the Gemini 2-man spacecraft, the X-20 space glider, the military orbital development system, the Titan III booster, and certain complex space systems of the future.

A64-26402
COMMUNICATION SYSTEMS USING SATELLITES.
W. J. Bray (General Post Office, Post Office Research Station, London, England).
(British Association for the Advancement of Science, Section G - Engineering, Meeting, Southampton, England, Aug.-Sept. 1964, Paper.)
Engineering, vol. 198, Sept. 11, 1964, p. 344-346.

Brief survey of the technical problems involved in the design of a worldwide satellite communications system. Several alternative approaches to the design of such a system are examined. The possibility of providing a flexible highly efficient transmission system is demonstrated by examples of the Telstar, Relay, and Syncom satellites. A worldwide system using 12 satellites in an equatorial 14,000-km (8-hr) orbit is discussed, and a schematic diagram of satellite communications equipment is presented.

A64-26590 •
OPTIMIZATION OF RANDOM SATELLITE SYSTEMS THROUGH THE USE OF INTEGER PROGRAMING TECHNIQUES.
Nathan Tonelson and Mark Wall (International Telephone and Telegraph Corp., ITT Communication Systems, Inc., Paramus, N.J.).
(American Institute of Aeronautics and Astronautics, Astrodynamics Conference, New Haven, Conn., Aug. 19-21, 1963, Paper 63-398.)
Journal of Spacecraft and Rockets, vol. 1, Sept.-Oct. 1964, p. 563-565.
[For abstract see Accession no. A63-21715 21-32]

A64-26623 •
SPACE-TECHNOLOGY PROBLEMS OF A COMMUNICATIONS SATELLITE [RAUMFAHRTTECHNISCHE PROBLEMSTELLUNGEN BEIM NACHRICHTENSATELLITEN].
W. v. Maydell and H. E. Sass (Bölkow-Entwicklungen KG, Ottobrunn, West Germany).
Wissenschaftliche Gesellschaft für Luft- und Raumfahrt and Deutsche Gesellschaft für Raketentechnik und Raumfahrtforschung, Jahrestagung, Berlin, West Germany, Sept. 14-18, 1964, Paper. 15 p. In German.

Discussion of problems associated with the synchronization of the orbit, the attitude stabilization, the lifetime, and the power supply of a communications satellite. It is assumed that the satellite is in an equatorial orbit, is stabilized with respect to the local vertical, and has a lifetime of 3 years. The initial correction of the orbital period to provide an exact 24-hr orbit, and the subsequent corrections of the orbital parameters to eliminate disturbance effects are examined. Passive stabilization methods are reviewed, with emphasis on gravity-gradient stabilization. With respect to power supply, it is shown that a radio-isotope battery, when used in combination with gravity-gradient stabilization, has advantages over solar cells, in that it is insensitive to radiation and eliminates the need for storage. V. P.

A64-26683
INTERNATIONAL PLANNING FOR COMMUNICATIONS SATELLITES.
Philip J. Farley (Department of State, Washington, D.C.).
IN: ADVANCES IN THE ASTRONAUTICAL SCIENCES. VOLUME 11, AMERICAN ASTRONAUTICAL SOCIETY, ANNUAL MEETING, 8TH, WASHINGTON, D.C., JANUARY 16-18, 1962, PROCEEDINGS.
Edited by Horace Jacobs.
North Hollywood, Western Periodicals Co., 1963, p. 446-452.

Review of the planning developments for international communications by means of satellites. The following accomplishments are listed: (1) technical development and experimentation by private industry and government; (2) the enabling international technical arrangements, such as the construction and operation of tracking stations and other ground facilities, and the international planning for frequency allocations; (3) the policy pronouncement of the President; (4) preparations for the creation of a US entity to own, create, operate, and direct the US interest; (5) the establishment in the United Nations of a broad basis for international impetus, preparation, and participation; (6) keen congressional interest and participation. M. M.

A64-26739
RELIABILITY ENGINEERING REVIEW - A SATELLITE TRANSPONDER.
William W. DeVille (Philco Corp., Western Development Laboratories, Palo Alto, Calif.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D.C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 31-35.

Report of reliability-engineering studies that accompanied the development of a space-communications subsystem which was conceived as high-reliability, long-life, Earth-orbiting satellite equipment employing state-of-the-art circuitry and parts. Aspects of the reliability program include the generation of Preferred Parts Lists (PPL) and Approved Parts Lists (APL), review of a breadboard model (which involves a part-stress, failure-rate tabulation), trade-off studies (to determine the degree of redundancy required to assure survival over a 3-year orbital lifetime), and reliability improvement. In a discussion of the reliability improvement techniques employed, the discovery that a particular transistor was unsuitable for the application is described, and the decision to use Schottky Barrier diodes is explained. D. H.

A64-26757
PROSPECTIVE USE OF SATELLITE COMMUNICATIONS BY THE BELL SYSTEM.
J. R. Rae (American Telephone and Telegraph Co., Long Lines Dept., New York, N.Y.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D.C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 164-167.

Discussion of proposed increases in Bell System service by leasing from COMSAT sufficient usage of the experimental HS-303 (Early Bird) satellite to provide 100 circuits between the US and Europe. It is indicated that Bell anticipates a considerable use for

satellite circuits to complement and augment the other types of overseas facilities available. Growth plans reportedly will be based on providing cables as well. The relative number of circuits handled by satellite and by cable will depend on the cost and quality of service as well as on the need for diversity. D. H.

A64-26758
PRESENT AND FUTURE COMMUNICATIONS SATELLITE PROGRAMS OF NASA.
John J. Dougherty (NASA, Office of Space Science and Applications, Communication and Navigation Programs Div., Washington, D. C.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 168-170.

Discussion of satellite programs involving Echo 1 (1960 Iota 1), Echo 2 (1964 4A), Relay 1 (1961 Beta Upsilon 1), Relay 2 (1964 3A), Syncom 1 (1963 4A), Syncom 2 (1963 31A), and Syncom 3. Also discussed are proposed programs involving Advanced Technological Satellites (ATS). In the ATS program, five flights are contemplated involving three basically different missions, all using the same basic spacecraft. The three different missions are anticipated to provide: (1) useful data on gravity-gradient stabilization techniques; (2) data from synchronous satellite experiments in meteorology, radiation, navigation, Earth sensing, and electronically and mechanically despun antennas; and (3) a gravity-gradient stabilized, synchronous-satellite test-bed for promising technology, components systems, and subsystems. D. H.

A64-26764
THE SEARCH FOR LONG-LIFE COMMUNICATION SATELLITES.
Roy H. Beaton (General Electric Co., Missile and Space Div., Spacecraft Dept., Valley Forge, Pa.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 241-244.

Report of a study of ways to achieve a 3- to 5-yr mean time to failures (MTTF) for nonmaintainable communications satellites and thereby improve communication-satellite economics so that such systems become competitive with ground-based systems. Basic principles applied to the problem are: design simplification, redundancy of critical components, use of high-reliability parts, stringent quality control, and rigorous testing. Gravity gradient stabilization techniques and a system utilizing a Sun sensor are described, and various quality control procedures are outlined. The effects of high vacuum and solar radiation on components are studied with the GE space environmental simulator. It is believed that the work now being done will have proved its worth when operational communications systems with satellites having lifetimes of 3, 5, or even 10 years are developed. D. H.

A64-26765
FACTORS IN SYSTEM DESIGN OF MEDIUM ALTITUDE RANDOM COMMUNICATION SATELLITES.
J. D. Aronson (Radio Corporation of America, Defense Electronics Products, Astro-Electronics Div., Princeton, N. J.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 245-247.

Discussion of some factors affecting numbers and configurations of medium-altitude, random-orbit communication satellites that are necessary to achieve essentially continuous service. A system of communication satellites is characterized by multiple satellites, tracked from ground stations and used to maintain one or more links over those portions of their individual orbits when mutual visibility exists. It is determined that between 18 and 33 satellites are required for such a system - the actual number depending on the number of links desired and the degree of continuity desired. Requirements of effective radiated power and bandwidth are outlined, and limitation and effects of payload weight and radiation damage are considered. A number of graphs display data including: vehicle capacity vs altitude, effective radiated power vs voice channel capacity, and weight of solar cell shielding vs altitude. A power-system block diagram is presented. D. H.

A64-26766
ADVANCED TECHNOLOGY FOR SYNCHRONOUS SATELLITES.
H. A. Rosen (Hughes Aircraft Co., Space Systems Div., Culver City, Calif.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 248-250.

Review of the Syncom and Advanced Syncom programs. Syncom is reported to be a spin-stabilized, synchronous communications satellite developed by Hughes Aircraft Company for NASA. As a result of developmental work (concentrated on reducing the weight and increasing the efficiency of the repeater aboard these satellites) and the favorable conditions at the operating altitude, synchronous communication satellites (as exemplified by Syncom 2 - 1963 31A) are said to be proven practical. It is indicated that the launch cost has been reduced to that of a single medium altitude satellite of equivalent performance, and the availability of Syncom for handling operational traffic, military or commercial, has come more quickly than that of any other system. An outgrowth of the Syncom and Advanced Syncom programs, the Early Bird or HS-303 satellite, is also discussed. Ten illustrations are included which show the motion of the subsatellite point for Syncom 2, H_2-O_2 stabilization and antenna systems for HS-303, and detailed views of Syncom subsystems. D. H.

A64-26767
UTILIZATION OF A COMMERCIAL SATELLITE SYSTEM FOR MILITARY COMMUNICATIONS.
John A. Keyes (Philco Corp., Western Development Laboratories, Palo Alto, Calif.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 251-254.

Discussion of technical, economic, and political criteria which are thought to indicate that separate communications-satellite systems will be required for military and commercial usage. The military communications requirement calls for efficient links between various theaters of operation and the zone of the interior. Commercial requirements, on the other hand, involve links between centers of population. Other factors considered are the military need for secure, jam-proof channels and the commercial requirements that the channels be revenue producers. D. H.

A64-26778
ELECTRONICALLY STEERABLE ANTENNAS FOR COMMUNICATION SATELLITES.
Dennis L. Backus (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.

Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 369-375. 9 refs.

Description of some characteristics of communication links and antenna configurations that are possible using communication satellites with various degrees of stabilization and in various orbits. Jet (reaction) stabilization, spin stabilization, and gravity stabilization are discussed in addition to the effects of a lack of stabilization. Communications involving satellites in 22,300-mile synchronous orbits, 6000-mile orbits, and medium-altitude orbits are described. Topics outlined and illustrated are: communication-satellite antenna limitations, indiscriminant radiation of RF energy and susceptibility to noise, special properties of an electronically steered array, formation of simultaneous steerable beams by the spacecraft antenna in space-Earth and space-space data links, the simplified retrodirective principle, and retrodirective and transdirective antenna systems. Required power, required antenna gains, and expected losses are predicted for 5000- and 24,000-mile orbit communication satellites utilizing different antennas. D. H.

A64-26779

DIRECT MICROWAVE TO MICROWAVE TRANSPONDERS FOR COMMUNICATION SATELLITES.
Walter K. Allen (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: INTERNATIONAL CONVENTION ON MILITARY ELECTRONICS, 8TH, WASHINGTON, D. C., SEPT. 14-16, 1964, CONFERENCE PROCEEDINGS.
Conference sponsored by the Military Electronics Group of the Institute of Electrical and Electronics Engineers.
Edited by B. J. Goldfarb.
North Hollywood, Western Periodicals Co., 1964, p. 377-379.

Presentation of block-diagram discussions of several different techniques for receiving, amplifying, and retransmitting information-bearing RF signals between various ground terminals. The direct microwave-to-microwave transponder systems discussed are: the crystal converter re-entrant TWT amplifier, the re-entrant serrodyned TWT loop, and the active frequency converter utilizing a tunnel diode or varactor. Investigations of the crystal converter re-entrant TWT amplifier system are said to indicate that frequency conversions above 2 Gc, with information bandwidths of 200 Mc or more, are attainable in a direct microwave-to-microwave transponder. The other methods considered are believed to be impracticable, as yet, for use in a transponder. D. H.

A64-26916

APPLICATIONS OF SATELLITES [APPLICATIONS DES SATELLITES].
M. Thué (Centre National d'Etude des Télécommunications, Issy-les-Moulineaux, Seine, France) and J. Voge (Centre National d'Etude des Télécommunications, Issy-les-Moulineaux, Seine; Centre National d'Etudes Spatiales, Paris, France).
IN: ASTRONAUTIQUE ET RECHERCHE SPATIALE.
Edited by Henri Moureu and Michel Yves Bernard.
Paris, Dunod, 1964, p. 246-269. 5 refs. In French.

Discussion of the various applications of satellites. The subjects considered are the different categories of communication satellites, random-distribution satellites, synchronized and stationary satellites, experiments underway or contemplated, meteorological satellites, international cooperation, radio navigation satellites, geodetic satellites, and satellite Anna. A table gives a forecast for 1970 and 1980 of telephone communications, including cables and telex messages, between the U.S., Europe, South America, Africa, and Asia. M. M.

A64-26949 •

MILITARY VS. COMMERCIAL COMSAT DESIGN.
Wilbur L. Pritchard and Neil MacGregor (Aerospace Corp., El Segundo, Calif.).
Astronautics and Aeronautics, vol. 2, Oct. 1964, p. 70-77. 17 refs.

Discussion of facets of the design of communication-satellite systems, with emphasis on the differences between military and commercial approaches. Some of the technical decisions that must be made in the design of the spaceborne components of a military communication-satellite system are considered, together with the communications capabilities that can be obtained. The subjects treated are system capacity, link frequency, antenna limitations, noise- and ground-station considerations, coverage, survivability, establishment and replenishment, launch-vehicle selection, growth capability, and system use. It is stated that the whole medium-altitude-synchronous argument can be seen to be slanted in the direction of favoring the medium-altitude random configuration for military operation and a stationary configuration for commercial operation. M. M.

A64-27138 •

BASIC CHARACTERISTICS OF RADIO-COMMUNICATIONS SYSTEMS USING ARTIFICIAL EARTH SATELLITES [OSNOVNYE POKAZATELI SISTEM RADIOSVIAZI S ISPOL'ZOVANIEM ISKUSSTVENNYKH SPUTNIKOV ZEMLI].
N. I. Kalashnikov.
Elektrosviaz', vol. 18, Sept. 1964, p. 1-11. In Russian.

Survey of the technical characteristics of satellite-based communications systems, established during the international conferences in Geneva, Switzerland. The Geneva recommendations are taken as a basis for discussing the requirements regarding such communications systems. Specifically examined are some terminological definitions, peculiarities of satellite-based communications systems, technological principles in the utilization of frequency bands for such systems, and standards for the figures of merit of the systems. The problem of direct reception of satellite radio and TV transmissions on home sets is examined. V. P.

A64-27667

ELECTRON CONTENT OF THE IONOSPHERE DEDUCED FROM RADAR-SATELLITE REFLECTIONS.
G. H. Millman (General Electric Co., Syracuse, N.Y.).
IN: ELECTRON DENSITY DISTRIBUTION IN IONOSPHERE AND EXOSPHERE: NATO ADVANCED STUDY INSTITUTE, SKEIKAMPEN, NORWAY, APR. 17-26, 1963, PROCEEDINGS.
Sponsored by the NATO Science Committee and the Norwegian Defence Research Establishment.
Edited by E. Thrane.
Amsterdam, North-Holland Publishing Co.; New York, Interscience Publishers, 1964, p. 256-265. 9 refs.
Contract No. AF 30(602)-2244.

Analysis of the radar reflections from Echo I, undergoing Faraday rotation, to obtain the integrated electron density in the ionosphere. From satellite-reflected radar data, evidence is obtained that there exist horizontal ionization gradients extending over large spatial regions in the low latitudes. The observations were conducted during the early Echo-I orbits, employing the Trinidad radar at a frequency of 425 Mc. V. Z.

A64-28247

COMMUNICATIONS HANDOVER FOR MEDIUM ALTITUDE SATELLITE SYSTEMS.
Andrew Werth (International Telephone and Telegraph Corp., ITT Federal Laboratories, Nutley, N.J.).
IN: WESTERN ELECTRONIC SHOW AND CONVENTION, LOS ANGELES, CALIF., AUGUST 25-28, 1964, TECHNICAL PAPERS. VOLUME 8. PART V - COMMUNICATIONS, SPACE ELECTRONICS.
North Hollywood, Western Periodicals Co., 1964, p. 19.2-1 to 19.2-11.
Contract No. DA-36-039-SC-90886.

Discussion of the problems and solutions of communications handover in a medium-altitude multisatellite system. Various methods of handover are presented, together with a description of the geometric boundaries of the basic problem. The effect of variable path delay on voice, teletype, and data transmissions is discussed. The specific design of an instantaneous handover system is formulated on the basis of digital range measurement at each

site, applicable to medium-altitude satellite systems using digital rates of 2400 bits per second. Expansion of the system to accommodate higher rates is shown to be relatively straightforward. (Author) M. M.

A64-28430
TELECOMMUNICATIONS BY MEANS OF ARTIFICIAL SATELLITES [COMUNICAZIONI A GRANDE DISTANZA UTILIZZANDO SATELLITI ARTIFICIALI].
Luigi Pallavicino (Fabbrica Apparecchiature per Comunicazioni Elettriche Standard, S. p. A., Milan, Italy).
Missili, vol. 5, Oct. 1963, p. 277-290. In Italian.

Consideration of the problem of telecommunications by means of artificial satellites from the standpoint of long-distance telephone and telegraph communications with medium-range transportable equipment for emergency military or civilian use. A brief description is provided of the equipment able to establish communication with the active satellites Relay, Telstar, Syncom 1, satellite 24th, and with the passive satellite, Echo; calculation of the SNR is made for both the Relay and Echo satellites. Appendix I stresses the features of Cassegrainian antennas, which are particularly effective in eliminating ground interference. M. M.

A64-28525
TELSTAR ANTENNA POINTING SYSTEM - ORGANIZATION AND PERFORMANCE.
J. A. Githens, H. P. Kelly, J. C. Lozier, and A. A. Lundstrom. (Bell System Technical Journal, vol. 42, pt. 2, July 1963, p. 1213-1221.)
Automatica, vol. 2, Sept. 1964, p. 117-123. 10 refs.
[For abstract see Accession no. A63-22475 21-10]

1965

A65-10073 *
COOPERATION OF THE USSR AND THE US IN SPACE EXPLORATION [SOTRUDNICHESTVO SSSR I SSHA V KOSMICHESKIKH ISSLEDOVANIIAKH].
A. A. Blagonravov.
Akademiia Nauk SSSR, Vestnik, vol. 34, Oct. 1964, p. 82-84. In Russian.

Brief review of the Geneva talks between the USSR and the US, on the peaceful use of space conducted since 1962. Communications, magnetic and meteorological observations via satellites, and technical problems of cooperation are mentioned. Agreement is reached on the exchange of data on the magnetic observations. Recommendations are made for joint projects, and future efforts are outlined. V. Z.

A65-11003
RADIATION DAMAGE TO SOLAR CELLS ON RELAY I AND RELAY II.
Ramond C. Waddel (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IEEE Transactions on Nuclear Science, vol. NS-11, Nov. 1964, p. 60-68.

Analysis of data monitored aboard the Relay 1 (1962 Beta Upsilon 1) and Relay 2 (1964 3A). The data monitored and analyzed include the short-circuit currents from 1 ohm-cm silicon N/P, silicon P/N, and gallium arsenide solar cells - which had shields up to 60 mils thick. The currents from all cells decreased because of damage by the trapped particles in the Van Allen radiation belts. The currents from unshielded cells fell to about half of the initial values in one day. The heavily shielded silicon cells finally degraded at the rate of about 17% per decade of time. Heavily shielded N/P silicon cells lasted about 10 times as long as similar P/N cells. Tentatively, it is reported that gallium arsenide cells with 3- and 12-mil glass shields appear inferior to silicon N/P cells with 60-mil fused silica shields, while gallium arsenide cells with 30- and 60-mil silica shields appear superior. This judgment is made by comparing the times required for short-circuit current to fall to given percentages of initial values; absolute efficiencies are ignored. Where comparable, the results from Relay 1 and Relay 2 are considered to be in good agreement. The severe stepwise damage experienced by the unshielded cells is said to be in good agreement with values calculated from the expected fluxes of protons of 0.5 Mev and greater. The calculated proton damage to the heavily shielded silicon cells is somewhat greater than that observed in orbit. Electron damage, after being discounted for belt decay, is considered to be a minor contributing factor. (Author) D. H.

A65-11012 *
INTEREST IN A EUROPEAN TELEVISION BROADCASTING SATELLITE [INTERET D'UN SATELLITE EUROPEEN DE DIFFUSION DE TELEVISION].
G. Plottin.
International Astronautical Federation, International Astronautical Congress, 15th, Warsaw, Poland, Sept. 7-12, 1964, Paper. 24 p. 10 refs. In French.

Discussion of the possibility of setting up a European-wide television broadcasting system by using a cataphotic reflecting satellite in a stationary equatorial orbit. Such a satellite consists of a large reflector which intercepts most of the primary radiation beam of a ground transmitter and reflects the energy in incident direction. It is thus possible to cover a country of size comparable to that of France by means of a single transmitter located in the geographical center. It is stated that a complete and detailed study of the reflecting satellite is necessary, particularly regarding its reradiation diagram. M. M.

A65-11109 *
LARGE AIR SUPPORTED RADOMES FOR SATELLITE COMMUNICATIONS GROUND STATION.
Walter W. Bird (BIRDAIR Structures, Inc., Buffalo, N. Y.).
IN: OHIO STATE UNIVERSITY AND USAF, RESEARCH AND TECHNOLOGY DIVISION (OSU-RTD), SYMPOSIUM ON ELECTROMAGNETIC WINDOWS, 7TH, OHIO STATE UNIVERSITY, COLUMBUS, OHIO, JUNE 2-4, 1964, PROCEEDINGS. VOLUME 5.
Columbus, Ohio State University, 1964. 12 p.

Discussion of the design and development of Telstar radomes. The history of the development of air-supported radomes, from their beginnings in 1946 at the Cornell Aeronautical Laboratory, is given as an introduction into the topic. The problems associated with the Telstar radome are then considered. Material development, fabrication techniques, and equipment reliability are studied, and the approach to the erection of large radomes is discussed. M. L.

A65-11131 *
SELECTED STUDIES OF SPACE BROADCASTING.
R. P. Haviland (General Electric Co., Philadelphia, Pa.).
International Astronautical Federation, International Astronautical Congress, 15th, Warsaw, Poland, Sept. 7-12, 1964, Paper. 11 p. 15 refs.

Discussion of the problems and possibilities of space broadcasting. In particular, three groups of problems are considered: (1) the technical problem of providing a high-quality broadcast service from space; (2) the problem of providing a compatible service, which arises from differences in broadcast standards around the world; and (3) the problem of assuring equitable operation. The study is limited to television broadcasting. To show the differences in the problems, a developed and a developing area are examined first; the mainland US and the subcontinent of India are used as examples. This is followed by an examination of a multinational area, Africa being chosen as an example. In each case, attention is given to the present situation, to factors affecting the problem, and to the requirements of suitable coverage. J. R.

A65-11335
MULTIPLE ACCESS TECHNIQUE FOR COMMERCIAL COMMUNICATION SATELLITES.
W. B. Garner and H. R. Mathwich (Radio Corporation of America, Astro-Electronics Div., Princeton, N. J.).
IN: NATIONAL ELECTRONICS CONFERENCE, 20TH, CHICAGO, ILL., OCTOBER 19-21, 1964, PROCEEDINGS. VOLUME 20.
Chicago, National Electronics Conference, Inc., 1964, p. 460-465. 12 refs.

Consideration of the problem of multiple access in planning for the commercial use of communication satellites. The system requirements and applicable evaluation criteria are briefly discussed, and several of the solutions which are currently being proposed are listed. One specific technique, by which several ground stations can simultaneously use one satellite repeater, is described and illustrated. This technique consists of passing a number of independent carriers on different frequencies through a wideband active repeater. Each carrier is frequency-modulated with frequency division multiplex and voice channel traffic. It is noted that this multiple carrier FDM-FM system has multiple carrier efficiencies (in the 2- to 10-channel examples for the large-channel case) which vary between 83 and 58%. For the small-channel case the efficiency varies between 48 and 24%. M. M.

A65-11336
FM BROADCASTING FROM SATELLITES - PRELIMINARY CONSIDERATION OF STANDARDS AND SHARING.
R. P. Haviland (General Electric Co., Philadelphia, Pa.).
IN: NATIONAL ELECTRONICS CONFERENCE, 20TH, CHICAGO, ILL., OCTOBER 19-21, 1964, PROCEEDINGS. VOLUME 20.
Chicago, National Electronics Conference, Inc., 1964, p. 470-474. 11 refs.

Recommendation of two standards for signal strength for FM broadcasting from artificial satellites: (a) rural-area coverage - 50 μV/m; (b) urban-area coverage - 250 μV/m. It is stated that both are intended to provide at least 50 db signal-noise ratios when received on standard FM receivers, using outdoor antennas. Sharing between conventional and space FM broadcasting is found to be feasible under the following conditions: (1) co-channel sharing is feasible for the 50-μV/m signal, with full FCC protection ratios to the urban coverage zone of the terrestrial station; (2) adjacent channel sharing is feasible for the 250-μV/m signal with full protection to the urban coverage area of the terrestrial station, and for the 50-μV/m signal with protection to the urban and rural coverage areas of the terrestrial station; (3) alternate channel sharing is feasible for the 250-μV/m space signal with full protection to the urban and rural areas; (4) larger frequency separations are possible; (5) the presence of a terrestrial station within 800 kc of a channel occupied by a space station will produce some loss in coverage of the space signal; and (6) for the worst condition, co-channel operation and a 50-μV/m space signal, the loss in coverage amounts to about 25,000 square miles. M. M.

A65-11338
A PHASE LOCKED DEMODULATOR FOR MULTICHANNEL TELEPHONE TRAFFIC FROM SATELLITES.
Marvin Sassler (International Telephone and Telegraph Corp., ITT Federal Laboratories Div., Nutley, N. J.).
IN: NATIONAL ELECTRONICS CONFERENCE, 20TH, CHICAGO, ILL., OCTOBER 19-21, 1964, PROCEEDINGS. VOLUME 20.
Chicago, National Electronics Conference, Inc., 1964, p. 481-485.

Description of the design of a phase-locked demodulator to optimize the sensitivity of a ground station with given received signal level and receiver system noise temperature. The magnitude of the distortion resulting from tuning error is indicated, together with two possible methods of reducing it. As detailed a design procedure as possible is outlined. The results of measurements made through the Relay, Telstar, and Syncom satellites are presented. It is concluded that, while the Type 1 second-order loop is generally predictable, it appears to have serious limitations for both very narrow and moderately wideband applications. The use of higher-type and order phase-locked loops shows promise in extending both the high- and low-bandwidth applications of this versatile device. M. M.

A65-11467 #
A STUDY OF MULTIPLE ACCESS TO AN ACTIVE COMMUNICATION SATELLITE EMPLOYING HARD LIMITING.
H. M. Gibbons (Sylvania Electric Products, Inc., Sylvania Electronic Systems Div., Williamsville, N. Y.).
IN: INTERNATIONAL SPACE ELECTRONICS SYMPOSIUM, LAS VEGAS, NEV., OCTOBER 6-9, 1964, RECORD.
New York, Institute of Electrical and Electronics Engineers, Space Electronics and Telemetry Group, 1964, p. 6-c-1 to 6-c-9.

Analysis of the problem of simultaneously relaying two wideband phase-coded binary signals and one CW signal by means of a hard limiting satellite. A direct time-domain form of analysis is used. An expression for the conditional probability of bit errors at a wideband correlation receiver is derived. The expression is evaluated numerically for an assumed TW product of 100. The resultant bit-error rates are diagramed vs signal power levels. The diagrams also demonstrate a significant dependence of error rate upon the relative timing between two wideband signals and the relative phase angles of each of the signals. V. Z.

A65-11468 #
OPTIMUM DESIGN OF A SATELLITE COMMUNICATION NET.
S. S. Yau (Northwestern University, Evanston, Ill.).
IN: INTERNATIONAL SPACE ELECTRONICS SYMPOSIUM, LAS VEGAS, NEV., OCTOBER 6-9, 1964, RECORD.
New York, Institute of Electrical and Electronics Engineers, Space Electronics and Telemetry Group, 1964, p. 6-d-1 to 6-d-8. 8 refs.
Grant No. AF AFOSR 98-63.

Presentation of a minimum-cost technique for designing a satellite communication net, consisting of three successive operational steps minimizing: (a) the number of satellites used in the satellite communication net, (b) the capacities of all the satellite relay stations, and (c) the capacities of all the ground terminal stations. It is shown that a satellite communication network, satisfying a specified flow matrix, normally provides more communication capacities for certain pairs of stations than specified in the flow matrix. This redundancy is analyzed and expressed as the so-called terminal capacity matrix. The technique proposed is believed to give the most economic solution provided that the cost of setting up a satellite relay station is much higher than that of increasing the capacities of a satellite relay station which, in turn, is much higher than the cost of increasing the capacities of a ground terminal station. V. Z.

A65-11469 #
POWER CONTROL FOR COMSAT MULTIPLE ACCESS.
Frederick J. Altman (International Telephone and Telegraph Corp., Intelcom, Inc., Falls Church, Va.).
IN: INTERNATIONAL SPACE ELECTRONICS SYMPOSIUM, LAS VEGAS, NEV., OCTOBER 6-9, 1964, RECORD.
New York, Institute of Electrical and Electronics Engineers, Space Electronics and Telemetry Group, 1964, p. 6-e-1 to 6-e-5.

Discussion of the problem of multiple access, arising when two or more carriers pass through a single satellite repeater. Emphasis is placed on how to materialize a desired sharing of the satellite output power among the carriers so that range and weather differences between the links are overcome. The problem is exemplified by a particular case of 4 frequency-modulated carriers which pass through a broad-band heterodyne repeater. A solution is presented on the simplifying assumptions that: (a) power divides linearly among at least three of the carriers, (b) operation is above threshold, (c) information capacity is proportional to received capacity, (d) attenuation is equal for up and down paths, and (e) all Earth stations use the same type of antenna. V. Z.

A65-11510
THE MEASUREMENT OF THE TOTAL HEMISPHERICAL EMISSIVITY OF MATERIALS USED IN TELSTAR.
A. M. Wittenberg (Bell Telephone Laboratories, Inc., Whippany, N. J.).

IN: SOCIETY OF AEROSPACE MATERIAL AND PROCESS ENGINEERS, NATIONAL SYMPOSIUM ON MATERIALS FOR SPACE VEHICLE USE, 6TH, SEATTLE, WASH., NOVEMBER 18-20, 1963. VOLUME 3.
Seattle, Society of Aerospace Material and Process Engineers, 1963. 37 p. 15 refs.

Description of a calorimetric method for determining total hemispherical emissivity for the Telstar program. It consists of placing a sample at the center of an evacuated enclosure whose walls are blackened and cooled. The sample is heated from its interior, and the emissivity is determined at equilibrium temperature with the aid of the Stefan-Boltzmann radiation law. The method is capable of giving results which should be accurate to better than 3% for most samples. Its accuracy has been found to be dependent on the emissivity, size, and thermal conductivity of the samples.
M. M.

A65-11684 #
SATELLITE COMMUNICATIONS AND NOISE.
Francis E. O'Meara (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).
International Astronautical Federation, International Astronautical Congress, 15th, Warsaw, Poland, Sept. 7-12, 1964, Paper. 24 p. 5 refs.

Computation of SNR in satellite communications by accounting for all noise sources from the telephone transmitter to the receiver. Assuming that there is a fixed optimum ratio between power and antenna area, the antenna gain vs frequency and the consequent system losses are computed. The useable RF bandwidth and noise level due to the Sun and sky background are calculated for two representative types of modulation: single sideband and frequency modulation with feedback. The behavior of four representative types of teletype systems is estimated in the presence of noise from consideration of their basic characteristics. The systems considered are amplitude modulation, frequency modulation, phase modulation, and synchronous amplitude modulation. The binary error rate vs signal-to-noise ratio is calculated using a simple phasor analysis. From these binary error rates, machine character error rates are derived from semiempirical observations of the teletype machine behavior. The effect of error-correcting coding on these machine teletype systems is considered. The limiting characteristics of binary modulation systems are derived starting from information-theory requirements. It is then possible to estimate the loss of channel capacity in the presence of noise, how much of this channel capacity is useable in terms of acceptable reliability, and finite times for transmission and decoding.
T. V. Y.

A65-12119
CRITERIA FOR THE CHOICE OF SYNCHRONOUS OR MEDIUM-ALTITUDE SYSTEM.
Wilbur L. Pritchard (Aerospace Corp., El Segundo, Calif.).
IEEE Transactions on Communications Systems, vol. CS-12, June 1964, p. 131-137.

Examination of the peculiar requirements of a military communications satellite system as distinguished from a commercial one. The effects on the system of requiring it to operate with transportable ground stations, to be jam-resistant, and to degrade gracefully are discussed. The choice of orbit inclination and altitude along with the number of satellites is shown to be a function of booster payload capability, geometric coverage, and the communications power budget. The effect of altitude on antijamming is also considered. It is shown that the choice of a communications satellite system is critically dependent on the reliability of the booster mission, the possibility of multiple launching, and the mean time-to-failure of the satellite. A booster mission for a medium-altitude system is described in detail, as are the injection and random dispersion of satellites into a common orbit. Typical communications link calculations are shown to demonstrate the effects of key parameters on performance. A short discussion of the dependence of performance on weather, especially for very low-temperature receivers, is given. The growth of satellites from a spin to gravity-gradient stabilization without serious changes in either dispenser or spacecraft is described. The implications of this growth to system performance are outlined.
(Author) J. R.

A65-12120
MULTIPLE-CARRIER BEHAVIOR OF A FREQUENCY-SELECTIVE FERRITE LIMITER.
A. L. Berman (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).
IEEE Transactions on Communications Systems, vol. CS-12, June 1964, p. 138-150.
Communications Satellite Corp. Contract No. CSC-CS-103.

Description of a frequency-selective ferrite limiter, its limiting action, and mode of operation in a commercial or military communications satellite. The measurements made to determine the communications performance of the device are summarized. Specifically, measurements covering the steady-state and dynamic bandwidth, the limiting action for one and two FM carriers, the phase linearity, and the crosstalk between two FM carriers are presented. The measured performance of the device is found to be in reasonable agreement with the performance predicted from a simplified analytic model. The device is shown to be essentially distortionless for a single wideband FM signal. With two carriers present, the limiting factor of performance is found to be coherent crosstalk.
J. R.

A65-13098
LUNAR COMMUNICATIONS.
Eberhardt Rechtin (California Institute of Technology, Jet Propulsion Laboratory, Deep Space Instrumentation Facility, Pasadena, Calif.).
IN: LUNAR MISSIONS AND EXPLORATION.
Edited by C. T. Leondes and R. W. Vance.
New York, John Wiley and Sons, Inc., 1964, p. 425-451.

Analysis of lunar communication theory and the application of existing engineering technology, leading to the following conclusions: (1) communication to and from the Moon is practical with data rates and quality comparable to those between points on the Earth; (2) communication from the far side of the Moon is probably best achieved with five or more lunar satellites in a lunar orbit of 3500 miles or greater; (3) communication along the lunar surface for distances of more than about 10 miles is probably easiest via a lunar satellite, particularly if a link also exists between the lunar satellite and the Earth; (4) in 1963, a standard FM system is probably best for a maximum frame rate from the Moon; by 1968, SSB may be better; however, the choice of modulation technique is strongly influenced by operational constraints; and (5) optical frequencies are presently noncompetitive for lunar communications and will probably remain so, with the possible exception of applications requiring extreme directivity and very small antennas.
(Author) M. M.

A65-13541
EXPANDABLE STRUCTURES.
F. W. Forbes (USAF, Systems Command, Technical Support Div., Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio).
Space/Aeronautics, vol. 42, Dec. 1964, p. 62-68.

Discussion of seven techniques of varying the volume of structures so that they may be orbited in nose cones or cannisters and then deployed in substantially larger configurations. The seven techniques and typical applications of each are: variable geometry with rigid components (panels and sensors), variable geometry with elastic recovery (crew transfer tunnel), inflatable balloon (paraglider), airmatt (lifting-body re-entry vehicle), rigidized membrane (Echo 2), foamed-in-place (solar collector), and expandable honeycomb (expandable Mol). Properties of the various structural materials are investigated and rated according to structural merit, reliability, heat resistance, shelf life, contour accuracy, and flexibility in the choice of configuration.
D. H.

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