1963 PTGAP INTERNATIONAL SYMPOSIUM

SPACE TELECOMMUNICATIONS

Program and Digest

July 9, 10, 11, 1963
National Bureau of Standards
Boulder, Colorado

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Published by the Institute of Electrical and Electronics Engineers
for
Professional Technical Group on Antennas and Propagation

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TECHNICAL PROGRAM

TUESDAY, JULY 9, 1963

7:30 - 9:00 a.m. Registration, Lobby, Radio Building

WELCOME: R. B. SCOTT, Acting Director,
Boulder Laboratories, NBS

9:15 a.m. - 12 Technical Session, Auditorium

I. SPACE TELECOMMUNICATIONS
Chairman: Dr. R. C. Hansen, Aerospace Corp.

1. Wire Film Gravity Oriented Passive Communication Satellites
   C. M. Kelly, Goodyear Aircraft

2. Lightweight Erectable Space Antennas
   James Roth, Goodyear Aircraft

3. The Use of Dual-Polarized Broad Beam Antennas to Determine the Extraterrestrial Intensity of the Cosmic Radio Noise at High Frequencies
   C. G. Little, G. M. Lerfald, NBS, and R. Parthasarathy, Geophysical Institute, College, Alaska

COFFEE BREAK

4. A Radiometer for Space Communications
   E. A. Ohm and W. W. Snell, Bell Tel. Labs.

5. Topside Sounding as a Tool for Global Ionosphere Studies
   R. W. Knecht, NBS

6. Tropospheric Absorption and Noise Temperature for a Standard Atmosphere
   L. V. Blake, NRL

7. The Radio Thermal Noise Properties of the Lower Atmosphere
   B. R. Bean, NBS

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2:00 - 5 p.m. Technical Session, Auditorium

II. PROPAGATION
Chairman: Dr. C. G. Little, NBS

1. Microwave Propagation Over A Mountain Diffraction Path
   A. B. Carlson and A. T. Waterman, Jr., Stanford U.

2. HF Propagation Characteristics in Equatorial Latitudes
   G. Jacobs, D. A. Lillie, and A. F. Barghausen, NBS

3. Long-Term Characteristics for Air-Ground Propagation in Band Nine
   R. S. Kirby, NBS

COFFEE BREAK

4. VLF Propagation in a Compressible Ionosphere
   R. B. Kieburtz, New York U.

5. Phase Instability in a Tropospheric Relay Link
   E. C. Barrows, NBS

6. A Radio-Meteorological Study
   B. R. Bean, E. J. Dutton, V. R. Frank, J. A. Lane,* and W. B. Sweezy, NBS; *DSIR(UK)

7. The Turbulent Characteristics of the Radio Refractive Index Near the Ground
   B. R. Bean and R. E. McGavin, NBS

WEDNESDAY, JULY 10th

9:00 a.m. - 12 Split Sessions

III. FEEDS AND REFLECTORS (Room 1107)
Chairman: Dr. J. Ruze, MIT-LL

1. A. Wave Polarization Converter for Circular Polarization
   D. S. Lerner, Wheeler Labs., Inc.

2. The Horn-Cluster Antenna
   J. A. Cochran, J. S. Cook, and J. N. Hines, Bell Tel. Labs.

3. Electronically Steerable Antenna Feed Techniques (ESAFT)
   W. D. White and L. K. DeSize, Cutler-Hammer, Inc.

4. Research on an Experimental Corrected Spherical Reflector Antenna Using Cosmic Radio Sources
   R. F. Trainer, Lockheed Missiles & Space Co.

COFFEE BREAK

5. A High Efficiency Low-Noise Antenna Feed System
   C. E. Profera, Jr., and A. F. Sciambi, Jr., RCA

6. Design of Dual Reflector Antennas with Arbitrary Phase and Amplitude Distributions
   V. Galindo, U. of California

7. The Field Distribution in the Focal Plane of a Paraboloidal Reflector
   W. H. Watson, Lockheed Missiles & Space Co.

LUNCHEON RECESS

9:00 a.m. - 12 Split Sessions

IV. SURFACE WAVES (Room 1103)
Chairman: F. J. Zuker, A. F. Cambridge Research Lab.

1. On the Solution of the Brillouin (k- β) Diagram of the Helix and its Application to Helical Antennas
   P. W Klock and R. Mittra, U. of Ill.

2. Mode-Coupling Regions in the Dispersion Curves of Radiating Perodic Structures
   A. Hessel and A. A. Oliner, Brooklyn Polytech.

3. Eigenwaves and Leaky Waves on a Lattice of Small Scatterers
   H. Kurss, Adelphi College

COFFEE BREAK

4. The Diffraction of Abstract Oblique Surface Waves
   S. N. Karp and T. S. Chu, New York U.

5. Transition Region Fields for a Class of Electromagnetic Boundary Value Problems
   J. Kane and J. P. Cretella, U. of R. I.

6. A Millimeter Antenna Excited by a Beam-Waveguide
   P. E. Mast, U. of Ill., and M. Fournier, Laval U.

7. Linear Side-loaded Transmission-line Antennas
   R. W. Kulterman, U. of Kans., R. H. Williams, and H. D. Wade, U. of N. Mex.

LUNCHEON RECESS

2:00 - 5:00 p.m. Split Sessions

V. BROAD-BAND ANTENNAS (Room 1107)
Chairman: Prof. V. H. Rumsey, U. of Calif.

1. Solutions to Spherical Anisotropic Antennas
   K. K. Mei, U. of Calif.

2. Propagation Along Periodic Monopole Arrays
   E. Hudock and P. E. Mayes, U. of Ill.

3. A Novel Log-Periodic Monopole Array
   R. F. H. Yang and L. H. Hansen, Andrew Corp.

COFFEE BREAK

4. Near-Field Measurements on the Conical Logarithmic Spiral Antennas
   J. D. Dyson and G. L. Duff, U. of Ill.

5. The Series-Fed, Log-Periodic, Folded Dipole Array
   K. G. Balmain and J. D. Dyson, U. of Ill.

6. A Class of Wire Antennas of Low Height
   G. E. Skahill and J. F. Ramsay, Cutler-Hammer, Inc.

2:00 - 5:00 p.m. Split Sessions

VI. APERTURE SYNTHESIS (Room 1103)
Chairman: H. A. Wheeler, Wheeler Labs., Inc.

1. On the Optimum Gain of Linear Arrays of Isotropic Sources and Dipoles
   C. T. Tai, Ohio St. Univ.

2. A Technique for Power Pattern Synthesis
   J. E. Morison and A. C. Schell,
   AF Cambridge Res. Lab.

3. The Optimum Line Source for the Best Mean-Square Approximation to a Given Radiation Pattern
   D. R. Rhodes, Radiation, Inc.

4. Dynamic characteristics of a Focused Antenna
   John J. Stangel, Sperry Gyro. Co.

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5. Fresnel Zone Diffraction Efforts at 50 Gc/s. Determined From Measured Aperture Field Data
   R. C. Baird, NBS

6. Wide Angle Radiation Due to Rough Phase Fronts
   C. Dragone and D. C. Hogg, Bell Tel. Labs.

7. Description and Operation Characteristic of a Short-Pulse, Oblique Radar Cross-Section Range
   Malcolm Yaffe, G. E.

6:00 p.m. Shuttle Bus Service To Country Club Begins
7:30 p.m. Banquet Served

SPEAKER:

THURSDAY, JULY 11th

9:00 a.m. - 12 Split Sessions

VII. ELECTROMAGNETIC THEORY (Room 1107)
Chairman: Dr. L. B. Felsen, Brooklyn Polytech.

1. Line Source Image for Hertz Dipole Above Plane Earth
   V. H. Rumsey, U. of Calif.

2. A General Formulation for Scattering by Loaded Objects
   R. F. Harrington, Syracuse Univ.

3. Backscattering of Electromagnetic Waves by Inhomogeneous PlasmaWakes
   T. H. Lee, Lockheed Missiles & Space Co.

COFFEE BREAK

4. Oblique Propagation of Radio Waves Across a Coast Line with a Sloping Beach
   J. R. Wait, NBS

5. The Terminated Insulated Antenna in a Conducting Medium
   K. Iizuka and R. W. P. King, Harvard U.

6. Leaky Waves Supported by Uniaxial Plasma Layers
   G. Meltz, Sperry-Rand Res., R. A. Shore, AF Cambridge Res. Lab.

7. An Introduction to Lambda Functions and Transforms
   J. F. Ramsay, Cutler-Hammer, Inc.

LUNCHEON RECESS

9:00 a.m. - 12 Split Sessions.

VIII. ARRAYS
Chairman: J. L. Allen, MIT-LL

1. High Resolution Antenna Arrays with Randomly Spaced Elements
   Y. T. Lo, U. of Ill.

2. Broadband Antenna Arrays by Unequal Spacings
   A. Ishimaru and Y. Chen, U. of Wash.

3. Thinned, Unequally Spaced Arrays Designed by Dynamic Programming
M. I. Skolnik,* G. Nemhauser,** L. C. Kefauver,* and J. W. Sherman,*
*Electronic Com., Inc.;
**Johns Hopkins Univ.

COFFEE BREAK

4. Wide Angle Impedance Matching Calculated for a Phased Array Antenna
P. W. Hannan, D. S. Lerner, and G. H. Knittel, Wheeler Labs., Inc.

5. Compensation Coupling Between Elements in Array Antennas
J. S. Cook and R. G. Pecina, Bell Tel. Labs.

6. The Large 50 Mc/s Dipole Array at Jicamarca Radio Observatory
G. R. Ochs, NBS

7. Electronic Scanning for Large Radiotelescopes
Tom Clark, NBS

LUNCHEON RECESS

2:00 - 5:00 p.m.: Technical Session

IX. PLASMAS
Chairman: J. R. Wait, NBS

1. Radiation Resistance of an Electric Dipole in a Magneto-Ionic Medium
H. Weil and D. Walsh, U. of Mich.

2. Interaction of a Radiating Source with a Plasma-Effect of an Electroacoustic Wave
Kun-Mu Chen, U. of Mich.

3. The Impedance of a Short Dipole Antenna in a Magnetoplasma
K. G. Balmain, U. of Ill.

COFFEE BREAK

4. Radiation from a Directive Antenna Embedded in an Anistropic Half Space
L. B. Felsen and B. Rulf, Brooklyn Polytech.

5. Free-Space Microwave Measurements of Plasma Properties
M. P. Bachynski and G. G. Cloutier, RCA, Montreal, Canada, Ltd.

6. Radiation from an Electromagnetic Source in a Half-Space of Compressible Plasma-Surface Waves

S. Seshadri, Harvard U.

SYMPOSIUM ENDS

INDEX OF AUTHORS

1963 PTGAP INTERNATIONAL SYMPOSIUM
DIGEST OF PAPERS

I. SPACE TELECOMMUNICATIONS

1.1: GRAVITY ORIENTED PASSIVE COMMUNICATION SATELLITES

C. M. KELLY
Goodyear Aircraft Corporation, Akron, Ohio.

Recent studies have shown that[1] because of long life expectancy, passive communication satellite systems using satellites with a reflection cross-section-to-mass ratio equal to Echo I (approximately 70 sq.ft. per pound) are more economical to implement and operate than active communication satellites. This advantage is contingent on a passive satellite life of about 20 years and an active satellite life in the 5- to 15-year range, and based on today's state-of-the-art active satellite hardware weights.

With radio cross-section-to-mass ratios larger than Echo I, it is expected that the economic attractiveness of passive satellites will be even more pronounced.

Past effort has been primarily on isotropically reflecting spheres, because they have certain distinct advantages; however, they also have some limitations. This paper describes primarily a gravity-gradient lenticular communication satellite that incorporates the advantages of the spherical reflector while negating the unattractive features. An artist's concept of a lenticular passive satellite as shown in Figure 1.

LENTICULAR SATELLITE

The gravity-oriented lenticular passive satellite is deployed by inflation techniques and consists of two segments or disks of radar-reflective spherical surfaces. These surfaces have very large radii of curvature and are joined together back to back. Weights or masses are extended outward normal to the center of these disks by inflatable beams or booms (see Figure 2). This mass distribution orients the satellite properly with respect to the earth by the gravity/centrifugal-force-field gradient. Therefore, because the satellite is oriented by completely passive means, there are no electronic components or power supplies to fail. The microwave radio relay is accomplished by reflection off the large-radius lenticular disk; thus, the strength of the returned signal is much greater than that from a complete sphere of equal surface area and weight.

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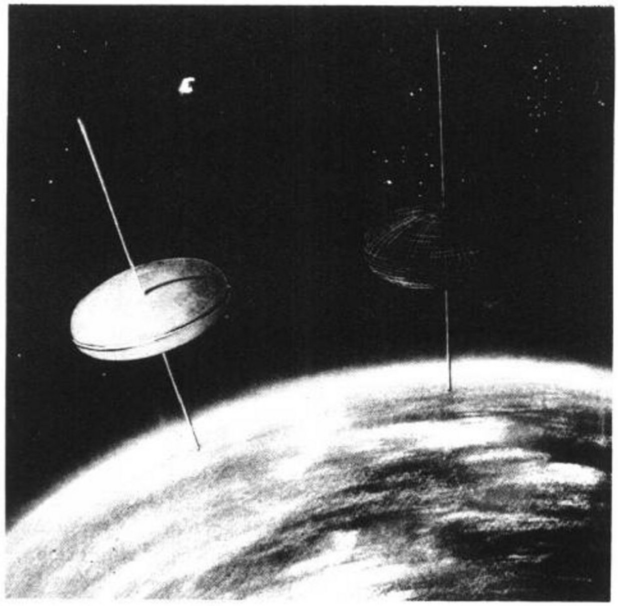
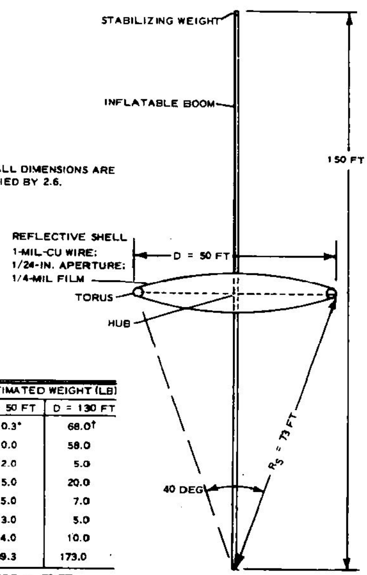


Figure 1 - Artist's Concept of Gravity-Oriented Lenticular Passive Communication Satellite



ITEM	ESTIMATED WEIGHT (LB) D = 50 FT	ESTIMATED WEIGHT (LB) D = 130 FT
SHELL	10.3*	68.0†
TORUS	10.0	58.0
BOOM	2.0	5.0
STABILIZATION	5.0	20.0
INFLATION	5.0	7.0
HUB	3.0	5.0
MISCELLANEOUS	4.0	10.0
TOTAL	39.3	173.0

*RADIUS OF CURVATURE = 73 FT
†RADIUS OF CURVATURE = 190 FT

Figure 2 - Configuration and Weight Breakdown of Gravity-Oriented Lenticular Passive Satellite

SYSTEM CONSIDERATIONS

This discussion considers a communications network in which one station transmits a radar-type signal to a passive earth satellite that reflects the signal back to a receiving station on earth. If the first station transmits at a power P_T, the power P_R received by the other terminal can be expressed by

$$P_R = \left(\frac{PG_T}{4S_T^2}\right)\left(\frac{\sigma}{4\pi}\right)\left(\frac{G_R\lambda^2}{4\pi S_R^2}\right),$$

where

G_T and G_R = gains of the transmitting and receiving terminal antennas, respectively;

σ = bistatic radar cross section of the satellite;

λ = wave length; and

S_T and S_R = distances from the satellite to the transmitting and receiving terminals, respectively.

For a given communications network, the design of the particular satellite can influence the signal strength only by modifying the value of σ. For a specular reflecting spherical body, $\sigma = \pi\rho^2$, where ρ is the radius of curvature of the reflecting body. Therefore, the signal strength at the receiving station increases with the square of the effective radius of the satellite.

An analysis based on physical optics indicates that the segment on the sphere that controls the radiation in a particular direction is only a small patch. For example, at X band (3-cm wave length) the segment on a 31-m-diameter (100-ft) sphere has an equivalent aperture of only 1 m. Therefore, two ground terminals cannot detect the difference in signal strength if the 100-ft-diameter sphere is replaced by a properly oriented, very small spherical section with the same 50-ft radius.

In addition to the signal strength parameter described above, a communication system's transmission rate depends upon the signal-to-noise ratios (SNR) and band width (B).

The amount of power P_R corresponds to a signal-to-noise ratio in a certain band width at the input of the receiving terminal, SNR is determined by

$$SNR = \frac{P_R}{KT_R B},$$

where

K = Boltzmans constant - 1.38×10^{-23} w sec at K^o and

T_R = effective noise temperature of the entire receiving system

Because of the small aperture of the spherical segment, f-m and c-w communication techniques can be used and a data transmission rate compatible with television thus can be achieved easily. Figure 3 shows a plot of the information capacity of a passive satellite link versus ground antenna diameter.

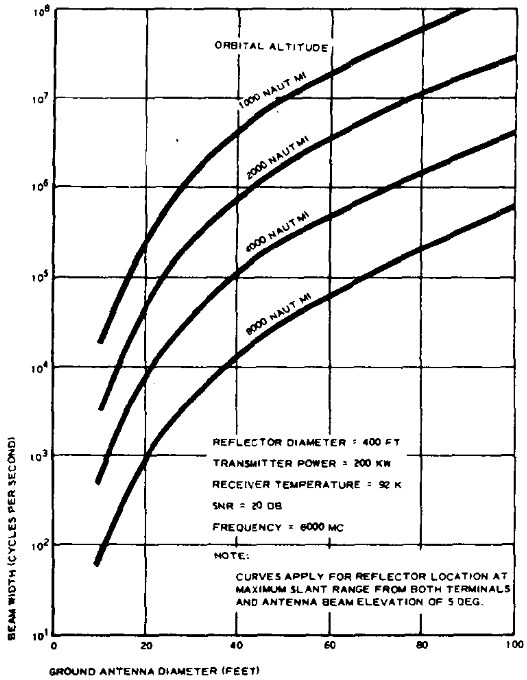


Figure 3 - Capacity of Passive Communication Satellite vs Antenna Diameter

Other types of passive satellites that exhibit gain over a specular reflector generally obtain this gain by reflecting the signal with space diversity techniques so that the data transmission rate is limited by multipath. In addition, the spherical reflector is not frequency selective, so that very broad band width can be used or a variety of signals at a number of frequencies can be transmitted simultaneously. This means that the spherical reflector communication system is relatively jam proof and can simultaneously service a number of ground stations transmitting independent messages.

Figure 4 indicates the reflection cross section of various sizes of lenticular satellites with respect to that of Echo II.