

1972

INTERNATIONAL TELEMETERING CONFERENCE

OCTOBER 10-11-12, 1972

SPONSORED BY

INTERNATIONAL FOUNDATION FOR TELEMETERING

CO-TECHNICAL SPONSORS

INSTRUMENT SOCIETY OF AMERICA
ELECTRONIC INDUSTRIES ASSOCIATION
Instrumentation Recording Equipment Section

International Hotel
Los Angeles, California

THE INTERNATIONAL FOUNDATION FOR TELEMETERING

is pleased to announce that the

INSTRUMENT SOCIETY OF AMERICA

has been appointed exclusive distributor for proceedings of the International Telemetering Conference (ITC/USA). ISA, also one of the co-technical sponsors of ITC/USA, will have the responsibility for advertising 1965-1972 ITC/USA proceedings and for selling them throughout the world. A major publisher in the field of instrumentation and automatic control, ISA publishes journals, reference books, proceedings of ISA sponsored and co-sponsored meetings and proceedings of symposia of the International Federation of Automatic Control.

All orders for proceedings should now be directed to the Instrument Society of America. However, requests for general conference information and copyright releases should be directed to the International Foundation for Telemetering, 19730 Ventura Boulevard, Suite 6, Woodland Hills, California 91364. Phone (213) 884-9567.

Copyright ©1972

By INTERNATIONAL FOUNDATION FOR TELEMETERING

Printed in the U.S.A.

Manufactured by McGregor & Werner, Washington, D.C.

Appendix A

Eleventh Annual Report of the Telemetry Standards Coordination Committee, by Hugh Pruss, Teledyne Telemetry Co., Los Angeles, California

728

743

758

768

778

782

804

808

818

828

HUGH PRUSS
Teledyne Telemetry
Los Angeles, California
Chairman

RONALD M. MULLER
Goddard Space Flight Center - NASA
Greenbelt, Maryland
Vice-Chairman
Chairman-
Time Division Subcommittee

CECIL M. KORTMAN
Martin-Marietta Corporation
Denver, Colorado
Secretary-Treasurer

APPENDIX A

TELEMETERING STANDARDS COORDINATION COMMITTEE

15 August 1972

SPONSORED BY



COMMITTEE MEMBERS

D. RAY ANDELIN
McDonnell-Douglas Corporation
Huntington Beach, California
Chairman-RF and
Frequency Division Subcommittee

KENNETH L. BERNIS
Naval Missile Center
Point Mugu, California

JACKY CATES
White Sands Missile Range
New Mexico

WALTER O. FROST
Marshall Space Flight Center-NASA
Huntsville, Alabama

LAWRENCE W. GARDENHIRE
Radiation Incorporated
Melbourne, Florida

VERNE JENNINGS
The Boeing Company
Seattle, Washington

HAROLD JESKE
Sandia Corporation
Albuquerque, New Mexico

JOSEPH F. KOUKOL
Jet Propulsion Laboratory
Pasadena, California

ROBERT S. McELHINEY
Grumman Aerospace Corporation
Calverton, New York

E. MENDEL
Office, Secretary of Defense
Washington, D.C.

RAY A. RUNYAN
Data-Control Systems, Incorporated
Danbury, Connecticut
Chairman-
Frequency Division Subcommittee

Eleventh Annual Report of the Telemetering Standards Coordination Committee

By - Hugh Pruss, Chairman 1970-1972

Introduction

Since its beginning in 1960 the TSCC has for the most part concentrated its efforts in reviewing standards published by the Range Commanders Council, IRIG. These reviews and resulting recommendations occurred prior to formal publication or formalization of the standard. It is also gratifying to note that most of the recommendations made were accepted for adoption in the printing of the standards.

In its desire to serve all facets of the Telemetering Community, the T.S.C.C. began looking into the activities of other established Governmental Agencies, besides the D.O.D., who might benefit from assistance in the form of specification reviews by the T.S.C.C.. Subsequently, the T.S.C.C. took a long "look around" and discovered that NASA, GSFC was concerning itself with tracking and data acquisition system standards as they relate to new DSN/NASA needs for the current and forthcoming Space & Earth Sciences experiments.

An offer of assistance was presented to NASA, GSFC in July of 1971 and this was subsequently accepted by letter dated 8 September 1971 from the NASA/GSFC Data Systems Requirement Committee, Advanced Data Systems Division, Mission and Data Operations Directorate.

The following report on the activities of the T.S.C.C. during the past year will highlight some of the work accomplished in connection with the above.

Committee Activities

Since the preparation of the Tenth Annual T.S.C.C. Report which was published in the ITC/USA/1971 Proceedings, three T.S.C.C. meetings were held as follows:

29 & 30 September 1971	Washington, D.C.
2 & 3 February 1972	Melbourne, Florida
24 & 25 May 1972	Seattle, Washington

The meeting activities are highlighted below:

Washington, D. C.

1. Mr. R. E. Collander of the Aerospace Corp. presented an informative discussion of the Air Force's (SGLS) Space Ground Link Subsystem.
2. A technical review of the Proposed IRIG Test Procedures for Telemetry Receivers was conducted and a number of recommendations were determined.
3. Expiration dates of T.S.C.C. members' terms of office were noted and members were reminded to submit nominations for successors in ample time for committee action.
4. NASA/GSFC Standards were distributed for appropriate sub-committee review.
5. Mr. Ball Chin of W.S.M.R. was elected to replace Mr. Jacky Cates who has served the T.S.C.C. faithfully for five years.
6. Mr. W. O. Frost, NASA, MSFC was re-elected to serve another five-year term as a T.S.C.C. Committee member. Mr. W. E. Miller, NASA Headquarters, was elected as Mr. Frost's alternate.
7. Mr. D. Ray Andelin was re-elected to a five-year term as a Committee member.
8. Mr. Larry Gardenhire was requested to investigate effective types of service awards for retiring members and officers.

9. It was noted that the new IRIG Document 106-71 had incorporated nearly all of the previous T.S.C.C. recommendations.

Melbourne, Florida

1. The T.S.C.C. Subcommittees reviewed the NASA/GSFC Aerospace System Standards. Recommendations were made for revising the existing PCM standards. Since the new PCM standards were to be issued shortly, it was decided to hold comments until the new issue was available.
2. The RF and modulation standards and the Tone Command Standards were reviewed and recommendations for clarity and clearer definitions were forwarded.
3. A final report and recommendations for the T.S.C.C. retired members and past chairman's honorarium plaque was received from Larry Gardenhire. The recommendations were adopted and final approval of the plaques was reserved for the next meeting pending the submittal of final art work and total costs.
4. It was agreed to contact the SAE group on standards to determine if the T.S.C.C. could offer any assistance to their mission.
5. It was agreed that Mr. Vern Jennings would be charged with the responsibility of compiling existing application notes, interesting published data, reports, articles, etc. of interest to the Telemetering Community.

Seattle, Washington

1. The meeting was hosted by Verne Jennings at the Boeing Space Center. An interesting tour of the facilities was conducted during the two-day meeting.
2. It was reported that the plans for the NASA, GSFC-PCM standards had changed. They should now cover USB and this changes the whole picture. GSFC will probably issue two standards; one for VHF which will encompass bit rates up to 1.5 MBPS; and, then later, an S-Band standard which will include higher data rates, longer frames, variable word lengths and other items applying heavily to various types of imaging data. It was decided that the Time Division Subcommittee should discuss these items and provide some informal thoughts about them that might help in drafting such a standard.

3. The Combined RF and Frequency Division SubCommittees reviewed the IRIG Test Procedures for Telemetry Pre-Amplifiers partially and had a number of suggestions and recommendations. It was decided that these recommendations - through Section 5.3 only - should be submitted in a letter.
4. The Time Division SubCommittee reviewed approaches to the new NASA, GSFC PCM standards including the problems of video, long frame, variable word length, etc., and had some informal suggestions. Since there was no standard to review, no formal committee action was required. It was expected that the GSFC VHF low data rate standard draft would be out before the next TSCC meeting, and the High Data Rate standard would follow.
5. The Chairman talked with Mr. Cronin, SAE Standard Committee who requested more information about TSCC. This will be provided, and it was also decided to invite Mr. Cronin and any interested members of his committee to attend our next meeting - especially for the B-1 multiplex presentation.
6. The honorarium plaque design was approved and orders were authorized for the plaques to be presented at the annual ITC/USA banquet in October 1972.

Respectfully submitted,

Hugh Pruss

Hugh Pruss - Chairman
Telemetering Standards
Coordination Committee

CONTENTS

Session I—Telemetry in the 1970's

John R. Warren, TRW Systems, Inc., *Chairman*; Captain Gary Pratt, USAF,
Co-Chairman

Telemetry in the 1970's

John R. Warren, TRW Systems Inc., San Bernardino, California

1

Telemetry in the Space Programs of the 1970's

W.E. Miller, NASA Headquarters, Washington, D.C.

3

Biotelemetry in the 1970's

Roland Rader, Department of Physiology, University of Southern California

8

Automotive Telemetry in the 1970's

Loyle Baltz, Ford Motor Company, Dearborn, Michigan

*

Foreign Telemetry Applications in the 1970's

Phil Cook, TRW Systems, Inc., Redondo Beach, California

11

U. S. Air Force Telemetry in the 1970's

Major W.W. Hargrove, MINUTEMAN Systems Program Office, Norton AFB,
California

13

U. S. Navy Telemetry in the 1970's

*

U. S. Army Telemetry in the 1970's

Burton E. Norman, Instrumentation Plans and Programs, White Sands Missile
Range, New Mexico

*

U. S. Coast Guard Telemetry in the 1970's

Lt. Andrew F. Hobson, Research and Development, USCG, Washington, D.C.

*

Test Range Telemetry in the 1970's

Robert Pickett, Federal Electric Corporation, Vandenberg AFB, California

*

Session II—Urban Communication Systems

Dr. R.B. Marsten, NASA, Office of Applications, Washington, D.C., *Chairman*

The New Rural Society

Dr. Peter C. Goldmark, Goldmark Communications Corporation, Stamford,
Connecticut

842

*Invited Paper

Needs and Expectations of Users	
Boyman Cutter, Cable Television Information Center, Washington, D.C.	*
Policy Issues in Cable Communications	
Walter R. Hinchman, Office of Telecommunications Policy, Washington, D.C.	853
Problems of Local Governments in Setting Technical Standards for Cable Franchises	
N.E. Feldman, Rand Corporation, Santa Monica, California	*
Cable Systems Operations in the Urban Environment	
Hubert Schlafly, TelePrompter Corporation, New York, New York	*
Special Services to Neighborhood and Home: A Communication Telecommunications Demonstration Concept	
Calvin W. Hiibner and Alan R. Siegal, Department of Housing and Urban Development, Washington, D.C.	860
Session III—Multiple Access Communication Theory	
Professor C.L. Weber, University of Southern California, Los Angeles, <i>Chairman</i>	
Channelization and Channel Monitoring in FDMA Communications	
R.M. Gagliardi, University of Southern California, Los Angeles	15
The Role of Partial Correlation in Multiple Access	
D.R. Anderson, TRW Systems, Redondo Beach, California	24
A Distribution Control Unit for Satellite Switched Communications	
R. Cooperman and T. Dobyns, Comsat Laboratories, Clarksburg, Md.	26
Output SNR for a Limiting Random Access Repeater	
M. Nesenbergs and R.G. Peterson, Office of Telecommunications, Institute for Telecommunication Sciences, Boulder, Colorado	32
Session IV—Tape Recording Techniques	
Robert J. Youngquist, Engineering Manager, Minicom Instrumentation, Recording Project, Camarillo, California, <i>Chairman</i>	
Ultra-Wideband, Longitudinal Magnetic-Tape Recording	
Karl H. Krey, Harry Diamond Laboratories, Washington, D.C.	44

*Invited Paper

Effects of Tape Flutter on Notch Noise Loading Test Performance of Predetection Recording of a Frequency Modulated Carrier	
W.R. Hedeman and M.H. Nichols, Aerospace Corporation, San Bernardino, California	55
Phase Distortion in Magnetic Tape Recording	
W.R. Hedeman, Aerospace Corporation, San Bernardino, California	64
Effect of Flutter on Theoretical Bit Error Rates for Digital Recording Systems	
R.A. Byers, Jet Propulsion Laboratory, Pasadena, California	72
Recorder Parameters Affecting Bit Error Rate	
G.R. McKelvey, ITT-Federal Electric Company, Vandenberg AFB, California	80
Session V—Digital Phase Locked Loops	
Dr. Jack K. Holmes, Jet Propulsion Laboratory, Pasadena, California, <i>Chairman</i>	
All Digital Coherent Demodulator Techniques	
F.D. Natali, Philco-Ford Corporation, Menlo Park, California	89
A Simple Second Order Digital Phase Locked Loop	
C.R. Tegnalia, Jet Propulsion Laboratory, Pasadena, California	108
An All Digital Phase Locked Loop	
J. Greco, J. Garodnick, D.L. Schilling, City College of New York	119
Demodulation of FM Signals by a Discrete Phase Locked Loop	
C.P. Reddy and S.C. Gupta, Southern Methodist University, Dallas, Texas	124
Digital Phase Locked Loops with Sequential Loop Filters: A Case for Coarse Quantization	
J.R. Cessna, National Oceanic and Atmospheric Administration, Boulder, Colorado	136
Session VI—Communication Satellite Systems	
A. Owens, Hughes Aircraft Company, El Segundo, California, <i>Chairman</i>	
Design Options for Communication Satellites of the Future	
J. L. Dicks, Comsat Corp., Washington, D.C.	880
Space Communication from the Peoples Republic of China	
L.A. Greenbaum, Hughes Aircraft Co., El Segundo, California	895

The Aerosat Communication Satellite

J. Gutwein, Department of Transportation, Cambridge, Massachusetts

The Telesat Communication Satellite

M. Houterman, Hughes Aircraft Co., Culver City, California

904

Session VII—Data Coding and Processing

Dr. Pierre Blassel, Director General, EUROSAT S.A., Geneva, Switzerland, *Chairman*

Statistics for Efficient Linear and Non-Linear Picture Encoding

T. Kummerow, Technische Universitaet, Braunschweig, Germany

149

A Simple and Effective Hybrid Coding/Decoding Scheme

B. Dorsch, D.F.V.L.R., Oberpfaffenhofen, Germany

162

Data Processing for the EOLE Project

A. Dargent, Centre National D'Etudes Spatiales, Bretigny, France

171

The Introduction of a Digital Computer on Board ESRO Scientific Satellites

M. Perry, ESRO/ESTEC, Noordwijk, Netherlands

179

Contributions to the Design of Future On-Board Data Processing Systems

for Scientific Spacecraft/Experiments

H. Fröhlich and G. Schweizer, Dornier A, Friedrichshafen, Germany

188

Session VIII—Modulation Techniques (Tutorial)

Professor D.L. Schilling, City College of New York, *Chairman*

Digital Modulation Techniques

J. Salz, Bell Laboratories, Holmdel, New Jersey

Comparison of Digital Modulation Methods

D. Goodman, Bell Laboratories, Murray Hill, New Jersey

867

Digital FM Demodulation Techniques

J. Garodnick, Goldmark Communications Corporation, Stamford, Connecticut

876

Digital Speech Processing Methods

S.J. Campanella, COMSAT Laboratories, Clarksburg, Maryland

878

Session IX—Biomedical Telemetry

Dr. H.L. Stone, University of Texas Medical Branch, Galveston, Texas, *Chairman*

Coronary Flow and Left Ventricular Function During Environmental Stress

Major Howard H. Erickson, USAF, VC, Department of the Air Force,
USAF School of Aerospace Medicine (AFSC), Brooks Air Force Base, Texas

Dr. H.L. Stone, Marine Biomedical Institute, University of Texas Medical
Branch, Galveston, Texas

J.D. Adams, Department of the Air Force, USAF School of Aerospace
Medicine (AFSC), Brooks Air Force Base, Texas

Dr. Harold Sandler, NASA Ames Research Center, Moffett Field, California 206

A Narrowband, Crystal Controlled Biomedical Telemetry System

Richard M. Westbrook and Thomas B. Fryer, NASA Ames Research Center,
Moffett Field, California

214

A System of EEG Telemetry

Eldon A. Byrd, U. S. Naval Ordnance Laboratory, White Oak, Maryland

221

Intra-Oral Telemetry Control for Orthotic Power Systems

Ernest L. Bontrager, Communication, Power & Control Engineering Group,
Rancho Los Amigos Hospital, Downey, California

Vernon L. Nickel, M.D., Rancho Los Amigos Hospital, Downey, California

Ian Scott, Micro Telemetry Systems Company, Anaheim, California

228

Telemetry Tracking of Summer Transplanted Elk in South Central Wyoming

Richard W. Weeks, Associate Professor, and Jerry Cupal, University of
Wyoming, Laramie, Wyoming

A. Lorin Ward, U. S. Forest Service, Laramie, Wyoming

238

Session X—Digital Communication Systems

Dr. Marvin K. Simon, Jet Propulsion Laboratory, Pasadena, California, *Chairman*

On Synchronization Techniques for Digital Communication Systems

R.W. Chang, Bell Telephone Labs., Inc., Holmdel, New Jersey

245

Bandwidth Efficiency for Digital Communication via a Hard Limiting Channel

C.R. Cahn, Magnavox Research Laboratories, Torrance, California

C.R. Moore, North American Rockwell

256

L-Orthogonal Signal Transmission and Detection

M.K. Simon, Jet Propulsion Laboratory, Pasadena, California

W.C. Lindsey, University of Southern California, Los Angeles, California

266

How Do You Define Bandwidth?

R.A. Scholtz, University of Southern California, Los Angeles

281

Amplitude-Phase-Keying with M-ary Alphabets; A Technique for Bandwidth Reduction	
C.M. Thomas, TRW Systems, Redondo Beach, California	289

Session XI—Digital Image Transmission

Lawrence W. Gardenhire, Radiation, Inc., Melbourne, Florida, *Chairman*

Comparison of Bit Plane Encoding and First Order Encoding Techniques	*
Dick Shaphorst, Philco-Ford	

Redundant Area Coding System (REARCS)

J.J. Maier, Rome Air Development Center, Rome, New York

L. Gardenhire, Radiation Systems Division, Melbourne, Florida 301

Simulation of Digital Imagery System

Jack Rudnick, RCA

Experimental Comparisons of Television Transmission Techniques

F.A. Perkins and J.A. Proctor, Radiation Systems Division, Melbourne, Florida 315

Self-Correcting Differential PCM

T.A. Hawkes, J.J. Durand, Thomson-CSF, Paris, France

P. Anglade, Service des Equipements de Champ de Tir, Arcueil, France 324

Session XII—Image Coding

Professor William K. Pratt, University of Southern California, Los Angeles, California, *Chairman*

Delta Modulation and DPCM Coding of Color Signals

A. Habibi, University of Southern California, Los Angeles, California 333

Image Processing Over the ARPA Computer Network

W.K. Pratt and R.P. Kruger, University of Southern California, Los Angeles, California 344

Data Compression for Earth Resources Satellites

C.L. May and D.J. Spencer, TRW Systems, Redondo Beach, California 352

Adaptive Line by Line Encoder for Image Transmission

V.R. Algazi, University of California, Davis, California 363

Session XIII—Space and Terrestrial Communication at Optical Frequencies

Dr. Henry H. Plotkin, NASA Goddard Space Flight Center, Greenbelt, Maryland, *Chairman*

*Invited Paper

10 Micrometer Band Communication Terminals in Space	372
Nelson McAvoy, NASA Goddard Space Flight Center, Greenbelt, Maryland	
A 10.6 Micrometer Laser Communication System for Terrestrial Use	384
Frank Goodwin, Hughes Research Laboratories, Malibu, California	
Airborne Visible Laser Optical Communication Experiment	395
Joseph L. Randall, NASA George C. Marshall Space Flight Center, Alabama	
Fiber Optics Communications	407
Sasson Somekh and Amnon Yariv, California Institute of Technology, Pasadena, California	
Session XIV—Data Collection and Information Networks	
Col. Philip Enslow, Jr., Office of Telecommunication Policy, Washington, D.C., <i>Chairman</i>	
Information Networks	419
Donald Silverman, NASA Office of Applications, Washington, D.C.	
Biomedical Networks	*
Al Feiner, National Library of Medicine, Bethesda, Maryland	
Satellite Networks for Education	*
J.P. Singh, R.P. Morgan and F.J. Rosenbaum, Center for Development Technology, Washington University, St. Louis, Missouri	
Computer Network Design Principles Derived from Experience and Measurements on the ARPA Network	440
Leonard Kleinrock, University of California, Los Angeles, California	
Data Networks and Policy: An Introduction	442
Col. Philip H. Enslow, Jr., Office of Telecommunication Policy, Washington, D.C.	
Session XV—Implant Telemetry	
R.D. Rader, University of Southern California, Los Angeles, California, <i>Chairman</i>	
Implantable Ultrasonic Blood Flowmeters	450
Dr. James D. Meindl, Stanford University, Stanford, California	

Implantable Telemetry in the Chimpanzee	
Dr. H.L. Stone, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, Texas	
Dr. Harold Sandler, NASA Ames Research Center, Moffett Field, California	
Thomas B. Fryer, NASA Ames Research Center, Moffett Field, California	464
Physiological Considerations in Implantable Underwater Telemetry	
Dr. W.R. Adey and J.R. Zweizig, Brain Research Institute, Space Biology Laboratory, Medical Center, University of California, Los Angeles, California	474
Use of Implanted Telemetry in Vascular Research	
Roland D. Rader, Dr. Christopher M. Stevens, James P. Henry, M.D., John P. Meehan, M.D., University of Southern California, Los Angeles, California	
Session XVI—Practical Applications of Coding Techniques	
Professor A.J. Viterbi, University of California, Los Angeles, California, <i>Chairman</i>	
A Very High Speed Hard-Decision Sequential Decoder	
K.S. Gilhousen, Linkabit Corporation, San Diego, California	
D.R. Lumb, NASA Ames Research Center, Moffett Field, California	499
Convolutional Coding for Multiple-Access Satellite Communication	
I.M. Jacobs, Linkabit Corporation, San Diego, California	507
Feedback Decoders for Naval Applications	
J.A. Heller, Linkabit Corporation, San Diego, California	
R.D. Peterson, Naval Electronics Laboratory Center, San Diego, California	510
Survey of Block Coding Applications in Computer Systems	
J.J. Stiffler, Raytheon Company, Sudbury, Massachusetts	517
Hybrid and Concatenated Coding Applications	
L.B. Hofman, NASA Ames Research Center, Moffett Field, California	
J.P. Odenwalder, Linkabit Corporation, San Diego, California	522
Session XVII—Synchronization	
Dr. R.E. Totty, Radiation, Inc., Melbourne, Florida, <i>Chairman</i>	
The Use of Matched Filters for Synchronization	
Peter Halpern, General Dynamics Corporation, Orlando, Florida	532
Bit Synchronization	
D.D. McRae and E.F. Smith, Radiation, Inc., Melbourne, Florida	539
Statistical Dynamics of a First-Order Phase-Locked Loop	
U. Mengali, University of Pisa, Pisa, Italy	553

Digitally Implemented Clock Acquisition Loops for Low SNR Data Signals
R.W. Schoolcraft, Magnavox Research Laboratories, Torrance, California 563

Improvements in Deep Space Tracking by Use of Third-Order Loops
R.C. Tausworthe and R.B. Crow, Jet Propulsion Laboratory, Pasadena, California 577

Session XVIII—Progress Report on Range Telemetry Data Quality Improvement

Major General Jessup D. Lowe, Commander, SAMTEC, Vandenberg AFB, California, *Chairman*

Impact of Solar Calibration on Telemetry System Testing and Checkout
W.S. Crane and R.B. Pickett, ITT-Federal Electric Corporation, Vandenberg AFB, California 584

Management of a Magnetic Tape Dubbing and Evaluation Station
G.R. McKelvey, ITT-Federal Electric Corporation, Vandenberg AFB, California and K.O. Schoeck, Space and Missile Test Center, Vandenberg AFB, California 591

Application of Range Commanders Council Document 118-71 Test Methods to Range Management
S.R. Radom, Technical Director, Space and Missile Test Center (SAMTEC) Air Force Systems Command, Vandenberg AFB, California 597

Application of IRIG 118-71 Test Methods to Management of Range-User Interface
J.J. Grant, Aerospace Corporation, Redondo Beach, California *

Automatic System Calibration
P.S. Quinlan, WSMR, New Mexico *

Session XIX—Telemetry Processing and Tracking Systems
Dr. Walter Hedeman, Member Technical Staff, Aerospace Corporation, Los Angeles, California, *Chairman*

Data Quality Assurance in a Shipboard Computer-Controlled Telemetry System
H.E. Baggot, Interstate Electronics Corporation, Anaheim, California 603

Microprogrammable Processors Applied to Telemetry Processing Systems
Daniel J. Karleskint, Control Data Corporation, Palo Alto, California 614

A Mobile Tone Range/RDF System for Telemetry Tracking of Sounding Rockets
G.K. Mayer, Deutsch Forschungs-und Versuchsanstalt für Luft-und Raumfahrt, Oberpfaffenhofen, Germany 621

Timing Accuracies of Range Instrumentation
F.L. Matthews, Federal Electric Corporation, Vandenberg, California 626

*Invited Paper

Dynamic Requirements for Diversity Combiners

R.G. Streich, D.E. Little, R.B. Pickett, Federal Electric Corporation,
Vandenberg AFB, California 635

A Real Time Multiprogrammed Telemetry System

G.B. Muse, Control Data Corporation, Palo Alto, California 643

Session XX—Deep Space Communications

Dr. Philip Hartl, D.F.V.L.R., Oberpfaffenhofen, Germany, *Chairman*

Recent Development Results on the HELIOS S-Band Command Receiver

B. Heynisch, Aeg-Telefunken, Ulm, Germany 648

A Single Channel Command Detector for Deep Space Missions

S. Knapp, Aeg-Telefunken, Ulm, Germany 662

The German Telecommand Ground Station for HELIOS—A New Concept

H. Ottl and H. Holl, D.F.V.L.R., Oberpfaffenhofen, Germany 668

A Telecommunications Link Model for Deep Space, with Applications to the HELIOS Probe

E. Stolle, D.F.V.L.R., Oberpfaffenhofen, Germany 679

Session XXI—Telemetry Data Real-Time Retransmission

C.G. Thomas, ETR/Pan-American World Airways, *Chairman*

Papers not available for publication.

Session XXII—Digital Telemetry Systems

Professor Larry Rauch, University of Michigan, Ann Arbor, Michigan, *Chairman*

On-Board Registration and Redundancy Reduction Method for Quasi-Stationary Poisson Processes

J. Khodarev, V. Nikolayev, I. Skobkin, J. Shtarkov, and E. Vassiliev, Institute
for Space Research, Academy of Science, Moscow, USSR 693

Reconstruction of Analog Signals and Choice of Sampling Rates in Telemetry

V.P. Evdokimov and L.I. Kolesnikov, Institute for Space Research,
Moscow, USSR 700

Effects of Multipath Fading on Low Data-Rate Space Communications

C.H. Chen, Southeastern Massachusetts University, N. Dartmouth, Massachusetts 710

Comparing Bandwidth Requirements for Digital Baseband Signals

R.C. Houts and T.A. Green, University of Alabama, University, Alabama 716