

Robert C. Tausworthe, BSEE, MSEE, Ph. D.

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Birth date: September 28, 1934

Dr. Robert C. Tausworthe is a retired Senior Research Engineer of the Jet Propulsion Laboratory, Pasadena, California. He also has served as consultant for 10 years to the Metric Prediction Generator (MPG) Development Team of the Deep Space Network (DSN) Service Preparation Subsystem (SPS) task at JPL.

Dr. Tausworthe received the BSEE degree from New Mexico State University in 1957 and the MSEE and Ph. D. degrees from the California Institute of Technology in 1958 and 1963, respectively.

At JPL he served as Division Technologist of the Information Technologies and Software Systems Division, Software Chief Engineer of Deep Space Network Digital Systems, Manager of Institutional Software Standards development, Deputy Software Manager of the Galileo Project, and Technical Group Supervisors of the Software Standards and Digital Communications Research Groups. He also led the development of the Prediction Services software for the Deep Space Network Planning and Preparation Subsystem Project.

On coming to JPL in 1958, he was engaged in the development of advanced space communications and tracking systems and lunar and planetary radar systems. He served as a co-investigator in the Mariner V Celestial Mechanics experiment, for which he innovated the first planetary ranging system. He was Project Engineer of the Mariners VI—VII high-data-rate telemetry experiment. He was the Telecommunications Systems Engineer for the first Deep Space Network Multi-Mission Command System. He also served as a member of the JPL Telecommunications System Design Board during the 1970-1973 era.

He was also engaged in the research of computer programming methodologies and software life-cycle models and in the promotion, development, and application of software engineering standard practices and development tools. He is the author of a two-volume set, Standardized Development of Computer Software (Prentice-Hall, Inc.), and has published over one hundred papers and reports on software methodology, information and communications systems, and mathematics. He is the originator of the Tausworthe Random Number Generator used widely in simulation and Monte Carlo studies of complex statistical systems.

He assisted the European Space Agency in development of their software standards, which were modeled on his works. He also consulted for the Joint Logistics Commanders Policy Coordinating Group on Computer Resource Management, helping to formulate recommendations for tri-service standardization in key areas of software management that eventually led to the first joint service software standards for the Department of Defense.

He taught electrical engineering at New Mexico State University and the University of Southern California, and Computer Science at West Coast University in Los Angeles, on a part-time basis. He has conducted industry seminars in software economics throughout the United States, Europe, and the Middle East.

He was awarded the NASA Exceptional Engineering Achievement Medal for innovation in software engineering, the NASA Exceptional Service Medal for contributions to deep space communications and tracking technology, two Outstanding Performance Awards from Mariner missions, and a group achievement award for his work in the Deep Space Network Mark III Data System Project. He is a Life Fellow member of the Institute of Electrical and Electronic Engineers, a charter member of the New Mexico Electrical and Computer Engineering Academy, a member of the Sigma Xi national honor society, a retired member of the Association of Computing Machines, and a retired member of the American Institute of Astronautics and Aeronautics, for which he served as a member of their Software Systems Technical Committee. He holds two patents.

Education

BSEE 1957 New Mexico State University, with High Honors
Las Cruces, New Mexico

MSEE 1958 California Institute of Technology
Pasadena, California

PhD 1963 California Institute of Technology
Pasadena, California

- ❑ Dual Major: Electrical Engineering (Communications Theory) and Mathematics
- ❑ Thesis: “Correlation Properties of Cyclic Sequences”

Work Experience

2007—2010 SGT, Inc.
SGT, Inc.
7701 Greenbelt Road, Suite 400
Greenbelt, MD 20770

- ❑ Consultant to Jet Propulsion Laboratory in Deep Space Network Metric Prediction Generation

2001—2007 L-3 Communications, Inc., Titan Group
Pasadena, CA

Titan Systems Corporation, Averstar Group
Pasadena, CA

- ❑ Consultant to Jet Propulsion Laboratory in Deep Space Network Metric Prediction Generation

1958—1999 Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

- ❑ Senior Research Engineer (1980—1999)
- ❑ Division Technologist, Information Systems Division (1986—1999)
- ❑ Chief Analyst, Prediction Services Development, Deep Space Network Planning and Preparation System, Network Control Project (1995—1999).
- ❑ Manager, Institutional Software Standards Development (1983—1986)
- ❑ Software Chief Engineer, Deep Space Network Data Systems Section (1978—1986)
- ❑ Deputy Software System Manager, Project Galileo (1979—1980)
- ❑ Manager, Deep Space Network Software Standards and Programming System Projects (1973—1978)
- ❑ Technical Staff, Telecommunications Science and Engineering Division (1969—1972)
- ❑ Technical Staff, Communications Research Section (1967—1968)
- ❑ Technical Group Supervisor, Digital Communications Research Group (1963—1967)
- ❑ Research Engineer (1958—1962)

- 1973—1989 West Coast University
Los Angeles, California
- ❑ Senior Instructor, Department of Computer Science
 - ❑ Instructor, Department of Computer Science
- 1982—1985 Consultant
- ❑ Industrial Seminars in Software Economics
- 1963—1971 University of Southern California
1980—1981 Los Angeles, California
- ❑ Instructor, Electrical Engineering
- 1957 New Mexico State University
Las Cruces, New Mexico
- ❑ Instructor, Electrical Engineering
- 1952—1954 Flight Determination Laboratory
White Sands Proving Ground
New Mexico
- ❑ Co-op Student Trainee

Awards

- ❑ Charter Member, New Mexico State University Electrical and Computer Engineering Academy, 1991.
- ❑ NASA Exceptional Engineering Achievement Medal, 1983.
- ❑ Fellow, Institute of Electrical and Electronics Engineers, 1980.
- ❑ NASA Exceptional Service Medal, 1975
- ❑ NASA Outstanding Performance/Group Achievement Awards
 - ❑ 1967—Mariner-Venus Planetary Ranging System
 - ❑ 1969—Mariner-Mars High-Rate Telemetry System
 - ❑ 1978—Mark III Deep Space Network Data Subsystem Project
- ❑ NASA Certificates of Recognition
 - ❑ Simplified Correlator for Ranging Codes
 - ❑ Third-Order Phase-Locked Loop Filter
 - ❑ Active Retrodirective Antenna Array
 - ❑ Phase Conjugation Method for Retrodirective Antenna Array
 - ❑ MBASIC Language for Univac 1108
 - ❑ Deep Space Network Software Cost Estimation Model Program
 - ❑ Algorithms for Software Development Version Control and Change Detection
- ❑ NASA Software Advisory Council Certificate of Appreciation

Patents

- ❑ “Filter for Third-Order Phase-Locked Loops,” (with R. B. Crow), patent No. 3,740,761; 1973.
- ❑ “Phase Conjugation Method and Apparatus for an Active Retrodirective Antenna Array,” (with R.C. Chernoff), patent No. 4,148,031; April 3, 1979.

Service Positions

- ❑ AIAA Technical Committee on Software Systems, member 1983—1986.
- ❑ NASA Intercenter Autonomous Systems Working Group, 1981—1982.
- ❑ NASA Software Management and Assurance Program Steering Committee, 1989--1991.
- ❑ NASA Software Advisory Council, 1996—1998.

Publications

Books

Standardized Development of Computer Software, Prentice-Hall, Inc., Englewood Cliffs, NJ.

- Volume I: Methods (1977)
- Volume II: Standards (1979)

Phase-Locked Loops and Their Applications, (Ed. by W. C. Lindsey and M. K. Simon) IEEE Press, N. Y., 1977.

Advances In the Astronautical Sciences, Vol.15: Exploration of Mars, (Ed. by G. W. Morgenthaler); American Astronautical Society, N.Y., N.Y., 1963.

“The Work Breakdown Structure in Software Project Management,” in

- *Software Cost Estimating and Life Cycle Control*, (Ed. by L. Putnam) IEEE Computer Society Press, N. Y., October, 1980.
- *Tutorial: Software Management*, (Ed. by D. J. Reifer, 1979, 1981, 1986) IEEE Computer Society Press, N. Y., 1981.
- *Tutorial: Software Engineering Project Management*, (Ed. by R. H. Thayer) IEEE Computer Society Press, N. Y., 1987.
- *Data Processing Project Management*, (Ed. by A. O. Awani) Petrocelli Books, Inc., Princeton, NJ.

“Software Reliability Simulation,” Chapter 17 of *Handbook of Software Reliability Engineering*, (Ed. by M. Y. Lyu) McGraw-Hill, Inc., 1995.

“Model-Based Software Quality Management,” in *Annals of Software Engineering*, (Ed. by J. D. Arthur and S. M. Henry) Baltzer Science Publishers, Amsterdam, Holland, 1995.

Technical Journal Articles

1. “Properties of Root-locus Asymptotes,” (with C. S. Lorens) *Trans. of PG-AC*, Vol. 5, No. 1, January, 1960; pp. 71—72.
2. “Coherent Detection by Quasi-Orthogonal Square-Wave Pulse Functions,” *Trans. of PG-IT*, Vol. 6, No. 4, June, 1960; pp. 410--411.
3. “A Boolean Function Multiplexed Telemetry System,” *Trans. of PTG-SET*, Vol. 9, No. 2, June, 1963; pp. 42—45.
4. “Optimal Ranging Codes,” *Trans. of PTG-SET*, Vol.10, No. 1, March, 1964; pp. 19—30.
5. “Equivalence Classes of Sequences,” *Ill. Jour. Math.*, Vol. 8, No. 2, June, 1964; pp. 266—270.
6. “Random Numbers Generated by Linear Recurrence modulo Two,” *Math. of Comp.*, Vol. XIX No. 90, April, 1965; pp. 201—208.
7. “A Practical Planetary Range-Tracking Radar,” *IEEE Trans. on Space Elec. and Telem.*, June, 1965; pp. 78—85.
8. “Cycle Slipping in Phase-Locked Loops,” *IEEE Trans. on Comm. Tech.*, Vol. COM-15, July, 1967; pp. 417—420.
9. “A Method for Calculating Phase-Locked Loop Performance Near Threshold,” *IEEE Trans. on Comm. Tech.*, Vol. COM-15, August, 1967; pp. 502—506.

10. "Celestial Mechanics Experiment," *Science*, Vol.15B, No.3809, December 19, 1967; pp. 1689--1690. (With J. D. Anderson, G. E. Pease and L. Efron).
11. "The Gravity Field of Venus and the Mariner V Radio Tracking Data," Presented to Am. Geophys. Union, Washington D. C., April8-11, 1968. (with J. D. Anderson, G. E. Pease, L. Efron).
12. "The Radius of Venus as Determined by Planetary Radar and Mariner 5 Radio Tracking Data," (with J. D. Anderson, D. L. Cain, L. Efron, R. M. Goldstein, W. G. Melbourne, D. A. O'Handley, and G. E. Pease) *Journal of Atmospheric Sciences*, Vol. 25, No. 6. November, 1968, pp. 1171—1173.
13. "Data Compression Rates as Technique with Greatest Potential for Deep Space," *Communications Designers Digest*, March, 1969, p. 20.
14. "Space Communications Depends on Technology," *Electro-Technology*, March, 1969, p. 26.
15. "Frequency-Counted Measurements and Phase-Locking to Noisy Oscillators " (with R. M. Gray), *IEEE Trans. Comm. Tech.*, Vol. COM-19, No. 1, February 1971; pp. 21—30.
16. "Convergence of Oscillator Spectral Estimators for Counted-Frequency Measurement," *IEEE Trans. on Comm. Tech.*, Vol. COM-20, No. 2, April, 1972; pp. 214—218.
17. "Simplified Mean-Slip Time of Phase-Locked Loops with Steady-State Phase Error," *IEEE Trans. on Com. Tech.*, Vol. COM-20, No. 3, June 1972; pp. 331--337.
18. "The Work Breakdown Structure in Software Project Management," *Jour. of Systems and Software*, Vol. 1, pp. 181—186, Elsevier North Holland, Inc., 1980. Also reprinted in the *ISPA Journal of Parametrics*, Vol. VI No. 2, June 1986.
19. "Concepts and Tools for the Software Life Cycle," *Computer Physics Communications*, No. 38, 1985, pp. 135—148.
20. "Information Models of Software Productivity, Limits on Productivity Growth," *Journal of Systems and Software*, Vol. 19, 1992, pp. 185-201.
21. "Reliability Measurement: From Theory to Practice," (with F. T. Shelton, K. M. Kavi, J. T. Yu, R. Brettschneider, and W. W. Everett) *IEEE Software*, July 1992, pp. 13—20.
22. "Software Reliability Modeling: An Oversimplified Art," in open forum "Software Reliability: To Use Or Not To Use? " *Proc. of the Journal of Defense Software Engineering*, Vol. 8, No. 2, February 1995, pp. 20—26.
23. "A Generalized Technique for Simulating Software Reliability," *IEEE Software*, Vol. 13, No. 2, March 1996, pp. 77—88.

Conference Papers and Proceedings

1. "Communications for Deep-Space Probes," 6th IEEE Reg. Conf., San Diego, California, April 26, 1963.
2. "Instrumentation and Communications Aspects of Mars Mission," (with W. K. Victor and E. Rehtin), Symposium on the Exploration of Mars, Denver, June 6-7, 1963; pp. 373—388.
3. "Optimal and Minimax Sequences," Proc. of the First International Telemetry Conference, London, September, 1963; pp. 381—389.
4. "The Role of Pseudorandom Codes in Communications," Sixth International Symposium on Global Communications, Philadelphia, PA, June 2:5; 1964; p. 34.
5. "A Precision Planetary Range-Tracking Radar," Joint Meeting of IEEE-URSI, Urbana, Illinois, October 31, 1964.
6. "Optimum Design of Turn-Around Ranging Systems," Proc. of the National Telemetry Conference, 1965; pp. 36—38.
7. "The Role of Planetary Radar in the Development of Space Communications Systems," Record of the 1965 International Space Electronics Symposium, IEEE-PTG-SET, November, 1965; pp. 7A1--7A11.
8. "A Method for Calculating Phase-Locked Loop Performance Near Threshold," Proc. of the National Telemetry Conference, Boston, Mass., May 10-12, 1966; pp. 249—251.
9. "Ranging the 1967 Mariner to Venus," Proc. of the IEEE National Convention, March, 1967, New York, pp. 294—295.
10. "The Radius of Venus as Determined by Planetary Radar and Mariner V Radio Tracking Data," Presented to the One-Hundred-Twenty-Seventh Meeting of the American Astronomical Society, Dominion Astrophysical Observatory, and University of Victoria, Victoria, British Columbia, August 20-23, 1968 (with J. D. Anderson, L. Efron, R. M. Goldstein, W. G. Melbourne, D. A. O'Handley, and G. E. Pease.)
11. "A High-Rate Telemetry System for the Mariner 1969 Mission," Proc. of the International Telemetry Conference, October 8-11, 1968, Vol. IV, International Foundation for Telemetry, Tarzana, California, pp. 465-480. (With M. F. Easterling and A. J. Spear).
12. "The Evolution of Planetary Communications Technology," IEEE National Convention Record, Session 59, March 24--27, 1969, New York Hilton, New York.
13. "Projected Requirements for Deep Space Communications," IEEE International Conference on Communications, Conference Record, Boulder, Colorado, June 9-11, 1969.
14. "Improvements in Deep-Space Tracking by Use of Third-Order Loops," (with R. B. Crow), Proc. of the International Telemetry Conference, Vol. VIII, pp. 577—583, Los Angeles, California, 1972.
15. "Structured Programming and Software Engineering of Hard Real-Time Minicomputer Systems," Eleventh Asilomar Conference, Pacific Grove, California, November, 1977.
16. "Software Engineering Models, Measures, and Metrics," Proc. of the Second Software Engineering Workshop, Goddard Space Flight Center, Greenbelt, MD, pp. 22—34.
17. "Deep Space Network Software Implementation Standards," Proc. of the SHARE50 Conference, Denver, CO, March 10--11, 1978.

18. "Management of Software Development Projects," Proc. of the GUIDE-46 Conference, Miami, Florida, May 22—25, 1978.
19. "The Work Breakdown Structure in Software Project Management, Second Software Life Cycle Management Workshop, Atlanta, Georgia, August 21-22, 1978; pp. 156—161.
20. "Implementing a Software Management Discipline," Proc. of the IEEE COMPSAC-79, Chicago, Illinois, November, 1979.
21. "The Deep Space Network Software Cost Estimation Model," Proc. of the Fifth Annual Software Engineering Workshop, Goddard Space Flight Center, Greenbelt, MD, October, 1980.
22. "Progress in DSN Software Cost Estimation Modeling," Proc. of the International Society of Parametric Analysts, San Diego, CA, May 7-9, 1981.
23. "Staffing Implications of Software Productivity Models," Proc. of the Seventh Annual Software Engineering Workshop, Goddard Space Flight Center, Greenbelt, MD, December, 1982.
24. "Software Life Cycle Dynamics Simulation Model," Proc. of the AIAA Computers in Aerospace IV Conference, Hartford, CT, October 24-26, 1983 (with Merle McKinzie and Chi Lin).
25. "A Dynamic-System Simulation Model of the Software Development Process," Proc. of the Summer Computer Simulation Conference, Boston, MA, July 23--25, 1984 (with Merle McKinzie, Chi Lin, and Donald Reifer).
26. "Concepts and Tools for the Software Life Cycle," Europhysics Conference on Software Engineering, Methods, and Tools in Computational Physics, Brussels, Belgium, August, 1984.
27. "Productivity: Perspectives, Prospects, and Prognosis," National Conference on Software Productivity, DPMA Education Foundation and US Professional Development Institute, Washington, DC, April 27—29, 1987.
28. "A Communication Channel Model of the Software Process," Proc. of the Thirteenth Software Engineering Workshop, Goddard Space Flight Center, Greenbelt, MD, November, 1988.
29. "Bounds on Effectiveness of Software Reuse," Proc. of the AIAA Computers in Aerospace VII Conference, Monterey CA, October 3—5, 1989, pp. 361—367.
30. "A General Software Reliability Process Simulation Technique," IEEE Computer Society Technical Committee on Software Engineering, Washington, DC, April, 1990.
31. "Simulating the Software Reliability Process," IEEE International Symposium on Software Reliability Engineering, Austin, TX, May 17-18, 1991.
32. "Encyclopedia of Software Components," Proceedings of Third ACM Conference on Hypertext, San Antonio, TX, pp. 425--426 (with Brian Beckman, Bonny Boyd, Sheldon Shen, W. Van Snyder, and Van Warren).
33. "Software Forecasters' Mental Models," Proc. of the Fifteenth Annual Conference of the International Society of Parametric Analysts, San Francisco, CA, June 2—4, 1993, (with A. Greisel, J. Hihn, K. Bruno, and T. Fouser).
34. "A Software Forecasting Lifecycle Derived from Forecasters' Mental Models," (with A. Greisel, J. Hihn, K. Bruno, and T. Fouser) 18th Annual Software Engineering Workshop, Goddard Space Flight Center, 1-2 December, 1993.
35. "A Generalized Software Reliability Process Simulation Technique and Tool," Proc. of the Fifth International Symposium on Software Reliability Engineering, Monterey CA, November 6--9, 1994, pp. 264—275.
36. "Software Reliability Modeling: An Oversimplified Art," in panel "Software Reliability: To Use Or Not To Use?"

“Proc. of the Fifth International Symposium on Software Reliability Engineering, Monterey CA, November 6--9, 1994, pp. 69—71.

NASA Tech Briefs

1. “Third-Order Phase Locked Loop Receiver,” with R. B. Crow, NPO-11941, 1974.
2. “Active Retrodirective Antenna,” with R. C. Chernoff, NPO-13641, 1977.
3. “Processor for the UNIVAC 1100 Series,” with Bracher, F. H. and Holzman, R. E., NPO-13469, 1979.
4. “Software Design Analyzer System,” NPO-16234, 1985.
5. “Software Cost Estimation Model,” NPO-15862, 1985.
6. “Algorithms for Software Development,” NPO-16079, 1985.
7. “Simplified Correlator for Ranging Codes,” with J. R. Smith, NPO-17415, 1990.
8. “Tau Ranging Revisited,” NPO-1717413, 1989.
9. “Software Design Analyzer System,” NPO-18212, 1991.
10. “Estimating the Cost of Developing Software,” NPO-17936., 1991.
11. “Finding Every Root of a Broad Class of Real Continuous Functions in a Given Interval,” NPO-46901, 2009

NASA COSMIC Programs

1. CRISP80, a software design and documentation tool suite.
2. SoftCost, a prototype software cost estimation model.
3. SoftRel, a software reliability process model.

Jet Propulsion Laboratory Publications

1. “Properties of Root-Locus Asymptotes,” (with C. S. Lorens) JPL-EP No. 581, December, 1958.
2. “Semi-Orthogonality of Square-Wave Pulses,” JPL Section Report No. 8-580, March, 1959.
3. “Modulation by Random and Pseudo-Random Sequences,” (with L. R. Welch), JPL Report No. PR-20-387, June, 1959.
4. “Coherent Detection by Semi-Orthogonal Square-Wave Pulse Functions,” JPL Report No. M-20-193, September, 1959.
5. “Correlation Properties of Random-like Periodic Sequences,” JPL Report No. PR-29-391, October, 1959.
6. “Equivalence of Cyclic Sequences Under Transformations of the Affine Group,” JPL Research Summary No. 36-10, September, 1960; pp. 17—21.
7. “Calculations Involving Matrix Functions,” JPL Research Summary No. 36-7, March, 1961; pp. 47—48.
8. “Non-Existence of Certain Perfect Sequences,” JPL Research Summary No. 36-9, July, 1961; pp. 30—31.
9. “Power Spectra of Signals Modulated by Random and Pseudo-random Sequences,” (with L. R. Welch), JPL Report No. 32-140, October, 1961.

10. "Maximality of Majority Logic," JPL Research Summary No. 36-11, November, 1961; pp. 31—33.
11. "Finding Sequences with Favorable Autocorrelation Functions," JPL Research Summary No. 36-14, May, 1962; pp. 51—53.
12. "Sequence-Correlation Estimates by Partial Summation," JPL Space Programs Summary No. 37-15, Vol. IV, June, 1962; pp. 39--40.
13. "On Optimizing Clock-Component Ranging Codes," JPL Space Programs Summary No. 37-17, October, 1962; pp. 91--96.
14. "Symmetry Classes of Periodic Sequences," JPL Space Programs Summary No. 37-18, Vol.IV, December, 1962; pp. 154--155.
15. "The Algebra of Periodic Sequences," JPL Report No. 32-381, January, 1963.
16. "Symmetry Classes of Periodic Sequences," JPL Space Programs Summary No. 37-19, Vol.IV, February, 1963; p. 143.
17. "A Boolean-Function Multiplexed Telemetry System," JPL Space Programs Summary No. 37-19, Vol. IV, February, 1963; pp. 157--159.
18. "Optimum Ranging Codes," JPL Report No. 32-411, April, 1963.
19. "Periodic Sequences with Specified Autocorrelation," JPL Space Programs Summary No. 37-20, Vol. IV, April, 1963; pp. 91--93.
20. "Bounds on the Number of Equivalence Classes of Sequences," JPL Space Programs Summary No. 37-20, Vol. IV, April 1963; p. 93.
21. "An Upper-bound on the Number of Solutions to the Correlation Equation," JPL Space Programs Summary No. 37-21, Vol. IV, June, 1963, pp. 133--136.
22. "Correlation Properties of Cyclic Sequences," JPL Report No. TR-32-388, July, 1963.
23. "The Symmetry of Difference Sets," JPL Space Programs Summary No. 37-22, Vol. IV, August, 1963; pp. 135--137.
24. "Binary Cyclic Constant-Distance Codes," JPL Space Programs Summary No. 37-22, Vol.IV, August, 1963; pp. 147--153.
25. "Instrumentation and Communications Aspects of Mars Mission," (with W. K. Victor and E. Rehtin), JPL Report No. TR-32-501, August, 1963.
26. "Optimum Transmitter Power for Klystron Drive-Keyed Radar," JPL Space Programs Summary No. 37-23, Vol.III, September, 1963; pp. 52--55.
27. "The Autocorrelation Function of the Product of Markov Signals," JPL Space Programs Summary No. 37-21, Vol. IV, June, 1963; pp. 136--138.
28. "Asymptotic Signal-to-Noise Behavior of a Snap-Action Limiter," JPL Space Programs Summary No. 37-23, Vol. IV, October, 1963; pp. 161--164.
29. "Optimal Threshold and Level Selection for Quantizing Data," JPL Space Programs Summary No. 37-24, Vol.IV, October, 1963; pp. 196--200.

30. "Correlation of Clock Component Codes," (with Paul Schottler), JPL Space Programs Summary No. 37-24, Vol. IV, December, 1963; pp. 189--192.
31. "Quantizing for Maximal Signal-to-Noise Ratios," JPL Space Programs Summary No. 37-24, Vol. IV, December 31, 1963; pp. 209--211.
32. "A Range-Gated Lunar Radar Experiment," JPL Space Programs Summary No. 37-25, Vol. III, January, 1964; pp. 38--44.
33. "Spectral Density of Markov Pulse-Duration Processes," JPL Space Programs Summary No. 37-25, Vol. IV, Feb., 1964; pp. 160--162.
34. "Bounds on Barker-type Codes," JPL Space Programs Summary No. 37-25, Vol. IV, February, 1964; pp. 157--158.
35. "A Theorem on Low-Pass Filtering," JPL Space Programs Summary No. 37-26, Vol. IV, April, 1964; pp. 238--240.
36. "Predetection Filters in Radiometric Receivers," JPL Space Programs Summary No. 37-26, Vol. IV, April, 1964; pp. 249--252.
37. "X-Band Lunar/Planetary Radar System," JPL Space Programs Summary No. 37-27, Vol. III, May, 1964; pp. 79--81.
38. "Optimization of Radar-Radiometric Cycle," JPL Space Programs Summary No. 37-27, Vol. IV, July, 1964; pp. 212--215.
39. "Random Numbers Generated by Linear Recurrence modulo Two," JPL Space Programs Summary No. 37-27, Vol. IV, July, 1964; pp. 185--189.
40. "A Precision Long-Range Tracking Radar System for Planetary Ranging," JPL Space Programs Summary No. 37-28, Vol. III, August, 1964; pp. 55--61.
41. "Filtering to Optimize Signal-to-Noise Ratios," JPL Space Programs Summary No. 37-28, Vol. IV, August, 1964; pp. 222--223.
42. "The Role of Pseudorandom Codes in Communications," JPL Report No. TR-33-185, August, 1964.
43. "Asymptotic Results for Optimum Equally-Spaced Quantization of Gaussian Data," JPL Space Programs Summary No. 37-29, Vol. IV, October, 1964; pp. 242--244.
44. "Higher-Order Distributions of Pseudo-Random Numbers," JPL Space Programs Summary No. 37-29, Vol. IV, October, 1964; pp. 211--213.
45. "Optimum Design of Turn-Around Ranging Systems," JPL Space Programs Summary No. 37-30, Vol. IV, December, 1964; pp. 253--259.
46. "Determination of Planetary Sub-Earth-Point Distances," JPL Space Programs Summary No. 37-30, Vol. IV, December, 1964; pp. 248--251.
47. "A New Calculation of Phase-Locked Loop Performance," JPL Space Programs Summary No. 37-31, Vol. IV, February, 1965; pp. 292--300.
48. "Another Look at the Optimum Design of Tracking Loops," JPL Space Programs Summary No. 37-32, Vol. IV, April, 1965; pp. 281--283.

49. "Minimizing the VCO Noise Effects in Phase-Locked Loops," JPL Space Programs Summary No. 37-33, Vol.IV, April, 1965; pp. 287--290.
50. "Further Investigation of Random Numbers," JPL Space Programs Summary No. 37-33, Vol. IV, April, 1965; pp. 269--271.
51. "An Integral Formula for Limiter Suppression Factor," JPL Space Programs Summary No. 37-35, Vol.IV, August, 1965; pp. 307--309.
52. "A Phase-Locked Receiver Analysis Program," JPL Space Programs Summary No. 37-38, Vol.III, January, 1966; pp. 29--34.
53. "Maximum Sweep and Doppler Rates in Phase-Locked Loops," JPL Space Programs Summary No. 37-38, Vol.IV, February, 1966; pp. 261--264.
54. "Correlation of Shortened PN Sequences," JPL Space Programs Summary No. 37-38, Vol.IV, February, 1966; pp. 264--265.
55. "Theory and Practical Design of Phase-Locked Receivers," Vol.1, JPL Technical Report No. TR-32-819, February, 1966.
56. "Calculation of Range-Clock Jitter," JPL Space Programs Summary No. 37-40, Vol. IV, August, 1966; pp. 219--225.
57. "Limit Cycles in Passive-Filter Phase Locked Loops," JPL Space Programs Summary No. 37-41, Vol.IV, October, 1966; pp. 268--270.
58. "An Experimental Study of the First-Slip Statistics of the Second-Order Phase-Locked Loop," (with D. Sanger) JPL Space Programs Summary No. 37-42, Vol. III, November, 1966; pp. 76--80.
59. "A Phase-Locked Receiver Analysis Program," JPL Space Programs Summary No. 37-42, Vol. III, November, 1966.
60. "Ranging the 1967 Mariner to Venus," JPL Space Programs Summary No. 37-42, Vol. III, November, 1966.
61. "Minimizing Range Code Acquisition Time," JPL Space Programs Summary No. 37-42, Vol.IV, December, 1966; pp. 198--200.
62. "Cycle Slipping in Phase-Locked Loops," JPL Space Programs Summary No. 37-42, Vol.IV, December, 1966; pp. 200--205.
63. "The Design of Lock Detectors," JPL Space Programs Summary No. 37-43, Vol. III, January, 1967; pp. 71--75.
64. "Specifications of Parameters of Phase-Locked Receivers at an Arbitrary Design Point," JPL Space Programs Summary No. 37-46, Vol. III, July, 1967; pp. 49--53.
65. "Acquisition and False Lock Behavior of Phase-Locked Loops with Noisy Inputs," JPL Space Programs Summary No. 37-46, Vol. IV, August, 1967; pp. 226--234.
66. "Phased-Locked Loops with Externally Aided Track," JPL Space Programs Summary No. 37-46, Vol.IV, August, 1967; pp. 234--238.
67. "Phase-Locking to Noisy Oscillators," JPL Space Programs Summary No. 37-48, Vol. III, December, 1967; pp. 198--203.
68. "Analysis of the Effect of Input Noise on a VCO," (with Robert Gray), JPL Space Programs Summary No. 37-

- 48, Vol. III, December, 1967; pp. 37--48.
69. "Analysis of Narrow-Band Signals through the Band-Pass Soft Limiter," JPL Space Programs Summary No. 37-53, Vol. III, October, 1968; pp. 209--214.
 70. "High Rate Telemetry Project," JPL Space Programs Summary No. 37-54, Vol. II, November, 1968; p. 71.
 71. "Considerations for Low Bit-Rate Communications," JPL Space Programs Summary No. 37-54, Vol. III, December, 1968.
 72. "Efficiency of Noisy Reference Detection," JPL Space Programs Summary No. 37-54, Vol. III, December, 1968.
 73. "Limiters in Phase-Locked Loops: A Correction to Previous Theory," JPL Space Programs Summary No. 37-54, Vol. III, December, 1968; pp. 201--204.
 74. "Cycle Slipping in Second-Order Phase-Locked Loops with Limiting," JPL Space Programs Summary No. 37-56, Vol. II, March, 1969; pp. 94--97.
 75. "A High-Rate Telemetry System for the Mariner 1969 Mission," JPL Technical Report No. TR-32-1354, April, 1969.
 76. "Accurate Analysis of AGC Performance," (with R. Burt), JPL Space Programs Summary No. 37-58, Vol. II, July, 1969; pp. 122--126.
 77. "DSS Subsystem Implementation by Time-Shared Computer," JPL Technical Memorandum, No. TM-33-420, October, 1969.
 78. "A Second/Third-Order Hybrid Phase-Locked Receiver for Tracking Doppler Rates," Deep Space Network Progress Report, JPL Technical Report 32-1526, Vol. I, February, 1971; pp. 42--45.
 79. "Practical Design of Third-Order Phase-Locked Loops," JPL Document 900-450, Jet Propulsion Laboratory, Pasadena, California, April 27, 1971.
 80. "Improvements in Deep Space Tracking by Use of Third-Order Loops," JPL Quarterly Review, Vol. I, No. 2, July, 1971; pp. 91--106.
 81. "Block IV Subcarrier Demodulator Assembly Acquisition Problem," (with J. K. Holmes and R. B. Crow), JPL Technical Report 32-1526, Deep Space Network Progress Report, Vol. XIII, February, 1973; pp. 42--47.
 82. "A Bibliography of the Theory and Application of the Phase-Lock Principle," (with W. C. Lindsey), JPL Technical Report No. TR-32-1581, April, 1973.
 83. "Program Structures for Non-Proper Programs," JPL Deep Space Network Progress Report No. 42-21, March-April, 1974; pp. 69--81.
 84. "Control Restrictive Instructions for Structured Programming (CRISP)," JPL Deep Space Network Progress Report No. 42-22, May-June, 1974; pp. 134--151.
 85. "Data Structure Design Guidelines," JPL Deep Space Network Progress Report No. 42-23, July-August, 1974.
 86. "Simple Intuitive Models of Programming," JPL Deep Space Network Progress Report No. 42-33, March-April, 1976; pp. 85--95.
 87. "Standard Classifications of Software Documentation," JPL Technical Memorandum TM-33-756, Jet Propulsion Laboratory, Pasadena, CA, January 15, 1976.

88. "Software Production Methodology Testbed Project," JPL Deep Space Network Progress Report No. 42-33, March-April, 1976; pp. 96--106.
89. *Standardized Development of Computer Software, Part 1: Methods*, Jet Propulsion Laboratory book, SP-43-29, July 1976. *Part 2: Standards*, Jet Propulsion Laboratory book, SP-43-29-2, August, 1978.
90. "Standard Random Number Generation for MBASIC," JPL Deep Space Network Progress Report No. 42-36, September--October, 1976; pp. 58--62.
91. "Stochastic Models for Software Project Management," JPL Deep Space Network Progress Report No. 42-37, November--December, 1976; pp. 118--126.
92. "Discovery and Repair of Software Anomalies," JPL Deep Space Network Progress Report No. 42-39, March-April, 1977; pp. 49--59.
93. "CRISPFLOW, A Program Design Tool," JPL Deep Space Network Progress Report No. 42-41, July-August, 1977; pp. 112--126.
94. "The DSN Standard Real-Time Language," (with R. L. Schwartz and G. L. Fisher), DSN Progress Report 42-44, Jet Propulsion Laboratory, Pasadena, CA, April, 1978, pp.131--138.
95. "Preparation Guide for Class B Software Specification Documents," Report 79-56, Jet Propulsion Laboratory, Pasadena, CA, October, 1979.
96. "Deep Space Network Software Cost Estimation Model," DSN Progress Report 42-61, Jet Propulsion Laboratory, Pasadena, CA, Feb., 1981, pp. 39--57.
97. "Deep Space Network Software Cost Estimation Model," Report 81-7, Jet Propulsion Laboratory, Pasadena, CA, April 15, 1981.
98. "Implications of the Putnam Software Equation on Confidence Levels for Project Success," Telecommunications and Data Acquisition Progress Report 42-66, Jet Propulsion Laboratory, Pasadena, CA, Dec. 1981, pp.172--185.
99. "Algorithms for Software Development Version Control and Change Detection," Telecommunications and Data Acquisition Progress Report 42-69, Jet Propulsion Laboratory, Pasadena, CA, June, 1982, pp. 20--35.
100. "Staffing Implications of Software Productivity Models," TDA Progress Report 42-72, Jet Propulsion Laboratory, Pasadena, CA, February 15, 1983.
101. "Software Task Statistics Derived from DSN Mark IV-A WBS System Data," (with D. J. Synott) JPL Report D-1882, Jet Propulsion Laboratory, Pasadena, CA, October, 1984.
102. "Concepts and Tools for the Software Life Cycle," TDA Progress Report 42-80, Jet Propulsion Laboratory, Pasadena, CA, February 15, 1985.
103. "JPL Software Management Standard," (with P. M. Molko, R. Horttor, S. Jeane, D. Royer, P. Poon, and S. McMahan), JPL Document 500-152 (later D-4000, Version 1), Jet Propulsion Laboratory, Pasadena, CA, March 1986.
104. "CISO Database System Management and Development Standards," Documents 170-1 through 170-5, Office of Computing and Information Services, Documents D-5038 through D-5042, Jet Propulsion Laboratory, Pasadena, CA, March, 1988.
105. "Software Acquisition and Development Cost Forecasting Guidebook," written for Office of the Chief Engineer, National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, CA, November, 1985.

106. "Tau Ranging Revisited," Telecommunications and Data Acquisition Progress Report 42-91, Jet Propulsion Laboratory, Pasadena, CA, November 15, 1987.
107. "A Simplified, General Purpose Deep-Space Ranging Correlator Design," (with John R. Smith), Telecommunications and Data Acquisition Progress Report 42-92, Jet Propulsion Laboratory, Pasadena, CA, February 15, 1988.
108. "A Communication Channel Model of the Software Process," Report D88-25, Jet Propulsion Laboratory, Pasadena, CA, October, 1988.
109. "Information Systems Division Technology Plan," Document D-8094, Jet Propulsion Laboratory, Pasadena, CA, December 20, 1990.
110. "A General Software Reliability Process Simulation Technique," Publication 91-7, Jet Propulsion Laboratory, Pasadena, CA, April 1, 1991.
111. "Conjunctive Programming: An Interactive Approach to Software System Synthesis," Publication 92-12, Jet Propulsion Laboratory, Pasadena, CA, August 1, 1992.
112. "Computing the Apparent Elevation of a Near-Earth Spacecraft at Low Elevation Angles for an Arbitrary Refraction Function," Interplanetary Network Progress Report 42-162, Jet Propulsion Laboratory, Pasadena, CA, August 15, 2005.
113. "Finding Every Root of a Broad Class of Real Continuous Functions in a Given Interval," Interplanetary Network Progress Report 42-176, Jet Propulsion Laboratory, Pasadena, CA., February 15, 2009.

Online Mathematica Publications

A large number of Mathematica studies (over 300) are contained in the archives of the Deep Space Network Metric Prediction Generator (MPG) task. These are available to JPL Service Preparation System personnel online. They contain analyses, algorithms, and validations developed for MPG applications, along with an Explanatory Supplement containing all domain knowledge required for understanding the mathematical theory of the prediction algorithms.