

# An Additional Catalog of Programs and Data for 100 MHz - 100 GHz Radio System Predictions

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**U.S. DEPARTMENT OF COMMERCE**  
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## PREFACE

The sole purpose of this publication is to provide the public with a list of existing computer aids for the evaluation of radio systems which operate in any part of the radio spectrum. Consequently, neither the Department of Commerce (DoC), nor the National Telecommunications and Information Administration (NTIA) approves of, recommends, or endorses any particular proprietary product or service mentioned in this publication. Accordingly, no reference should be made to NTIA, DoC, or this publication that (1) implies or states the contrary, or (2) has as its purpose the recommendation, directly or indirectly, for the purchase of any particular proprietary product or service listed in this publication.



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An Additional Catalog of Programs and Data  
for 100 MHz - 100 GHz Radio System Predictions

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Analysis aids and data bases for predicting the performance of 100 MHz - 100 GHz communication systems are presented and briefly described. They are loosely grouped into the following functional categories:

- 1) Computations of transmission loss and radar returned power.
- 2) Computations of desired-to-undesired signal ratios.
- 3) Computations of atmospheric and precipitation parameters.
- 4) Data bases and associated programs.
- 5) Performance of digital communication systems.
- 6) Miscellaneous programs.

Sources are given for the analysis aids, data bases, and additional information.

Key Words: atmosphere; computer programs; data bases; desired signal; digital communications; precipitation; propagation prediction; radar power; transmission loss; undesired signal.

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## 1. INTRODUCTION

This catalog is the second publication in a continuing effort to compile a comprehensive set of computer programs and data bases to predict the performance of radio systems. The first catalog, published in March 1978 as OT Report 78-141, concentrated on the 10 - 100 GHz portion of the spectrum. Additional catalogs are planned, so that eventually the entire radio spectrum will be covered.

Most of the programs in OT Report 78-141 were developed at the National Telecommunications and Information Administration, Institute for Telecommunication Sciences. For this report, programs have been solicited from universities and private industry as well as various government agencies. These reports should be viewed as complementing each other since many of the programs in the previous publication cover the frequency range of this report, but have not been listed in this catalog.

## 2. COMPUTER PROGRAMS AND DATA BASES

Each catalog entry contains brief information about the program's function or content, user inputs, limitations, current status, references, and information contacts for that program. This information is supplied so that searchers can rapidly identify analysis aids or data bases of interest which they can pursue through the given information contact.

The entries have been arranged alphabetically within the following categories:

- 1) Computations of transmission loss and radar returned power.
- 2) Computations of desired-to-undesired signal ratio.



3) Computations of atmospheric and precipitation parameters.

4) Data bases and associated programs.

5) Performance of digital communication systems.

6) Miscellaneous programs.

Category 1  
Computations of Transmission Loss  
and Radar Returned Power

Item: 1-1

Title: COSPEM, Communication System Performance Model

Computes: This is a communication system performance model that computes the probability of successful communications, ( $p_s$ ), versus range or other variables (e.g., transmitter power, antenna gain or height, etc.). The model also computes operational range of a radio system for a specified required probability of success,  $p_{sr}$ . It will compute for up to three systems simultaneously, with graphics and line printer output.

Input: The required input consists of system parameters (transmitter power, antenna gains, transmission line losses, receiver noise figure, and modulation information); propagation parameters (Longley-Rice input plus vegetation and urbanization information); noise environment category; and operational parameters (required channel quality and reliability, fixed or mobile).

Limitations: This program has the basic limitations of the 1977 version of the Longley-Rice model. (Frequency  $\geq$  20 MHz). CCIR Reports 258 and 322 noise models limit the frequency to  $\leq$  300 MHz, although the noise model can be extended to 20 GHz. Antenna heights are permitted from 1 m to 3 km.

Current Status: The program is operational and available to the public by contract with SRI International. It is written in FORTRAN for the CDC 6400, but can be converted for use on other computers. Its output agrees well with measured data for FM voice systems from Fort Hood, TX, and Fulda, FRG (30-76 MHz).

References:

Tupper, B. C., and G. H. Hagn (1978), Nap-of-the-earth communication program for U.S. Army helicopters, final report, SRI Project 4979, Contract DAAB07-76-C-0868, SRI International, Menlo Park, CA,

For more information contact: G. H. Hagn, SRI International, 1611 N. Kent Street, Arlington, VA 22209, (703) 524-2053; B. C. Tupper, SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025, (415) 326-6200, ext. 3821.

Item: 1-2

Title: ION, The Bent Ionospheric Model.

Computes: For a given condition consisting of station, satellite, date, and time information, the electron density versus height profile is computed from which range, range-rate, and angular refraction correction, as well as vertical and total angular electron content, are obtained. The model has the additional capability of improving its predictions by updating with actual ionospheric observations.

Input: The required input parameters are transmission frequency, station latitude and longitude, elevation angle to satellite, azimuth angle, satellite height, elevation rate, altitude rate, year, month, day, time, daily solar flux for month, 12-month running average of sunspot number and of solar flux. Optional input consists of the same information for updating with actual ionospheric observations.

Limitations: The program removes only between 75% and 90% of the ionospheric effects under solar maximum conditions.

Current Status: The program is well documented and has been used extensively on a Sigma 7 computer. Slight modifications may be necessary for other machines. The program is written in FORTRAN.

References:

Llewellyn, S. K., and R. B. Bent (1973), Documentation and description of the Bent ionospheric model, Atlantic Science Corporation.

For more information contact: Judy Lipofsky, Atlantic Science Corp., P.O. Box 3201, Indialantic, FL 32903, (305) 773-1300.

Item: 1-3

Title: AMAP, Atmospheric Microwave Analysis Program.

Computes: The program computes attenuation, refraction, and dispersion for ground-to-aircraft or ground-to-satellite paths. It includes the effects of water vapor (both uncondensed and condensed), molecular oxygen, clouds, and rain. The MSFC 4-D Atmospheric Model is used for temperature, humidity, and density profiling from the ground to 25 km height. Above 25 km, exponential atmosphere is assumed. The user may choose any of nine standard cloud models or may specify his own model. Precipitation rates may be specified, or the program will default to values typical of the cloud model. The location of the cloud with respect to the ground terminal must be specified.

Attenuations due to uncondensed water vapor, molecular oxygen, condensed water, and rain are printed separately and summed, so that an evaluation of contributions can be made. The path length is computed both along the line of sight and along the ray path for listing of both range errors and apparent refraction. Delay excess is printed.

Input: The required input parameters are latitude and longitude of ground station; month of year; frequency; cloud type; distance to storm center and storm radius; height of rain cell and precipitation rate; satellite or aircraft height; thickness of atmospheric slices; starting value and number of increments of ray takeoff elevation; and choice of mean or best/worst case analysis.

Limitations: The frequency range is 0.5 - 100 GHz, although the accuracy above 30 GHz has not been evaluated. The graphic output requires CDC DD280 plot routines and hardware.

Current Status: The program is operational on the CDC 6500 at Martin Marietta Company/Denver Division. The program source listing is proprietary.

For more information contact: D. Lund, Martin Marietta Aerospace, P.O. Box 179, Denver, CO 80201, (303) 973-3326.

Item: 1-4

Title: SPHERE

Computes: The program computes the basic transmission loss over the earth for microwaves.

Input: The required input parameters are station separation, station heights, and wavelength.

Limitations: The program accounts for reflection, refraction, diffraction, but not tropospheric scatter or ionosphere refraction. It also assumes perfect conductivity.

Current Status: The published version assumes a "4/3 earth;" other earth factors can be obtained by scaling the distances and the wavelength. The in-house version has an input for earth factor.

References:

1976 Microwave Engineers Handbook, Microwave Journal, 1976. The program evaluates the solution given by V. Fock, Electromagnetic diffraction and propagation problems, 1965, Chap. 12.

For more information contact: Dr. Ira Gilbert or Dr. J. J. G. McCue, Lincoln Laboratory, MIT, Lexington, MA 02173.

Item: 1-5

Title: CSPM, Communication System Performance Model.

Computes: This automated model uses the point-to-point version of the Longley-Rice propagation loss model to estimate communication system performance throughout a defined geographical area. The model calculates radio path terrain profiles and statistically characterized basic transmission loss, power density, received signal level, and ultimately, communication reliability for a large number of specific paths within the geographical area. All computed data are available in either tabulated or plotted forms, at the option of the user.

Input: The required input are the coordinates of a fixed antenna and the coordinates of the bounds of a geographical area. Opportunity is provided for specifying a large number of other parameters which characterize the technical aspects of the problem and define the desired mode for running the model and the desired form of the output data. The technical data which may be specified as input include frequency, antenna heights and gains, polarization, transmitter output power, threshold received signal level, ground dielectric constant and conductivity, surface refractivity, climate code, and coordinates defining the geographical area bounds. When not specified, nominal or computed values are assigned to these parameters.

Limitations: Radio frequencies must be between 20 MHz and 20 GHz. Antenna heights are restricted to 0.5 to 3000 m and only vertical or horizontal polarizations may be specified.

Current Status: The program is operational on CDC 6000 series computer systems. Documentation is complete and available from the NTIS. The program can be provided on magnetic tape.



References:

Jennings, R. D., and S. J. Paulson (1977),  
Communication system performance model for VHF and higher  
frequencies, OT Report 77-128, (NTIS PB274-458/AS).

For more information contact: R. D. Jennings, NTIA/ITS,  
U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000,  
ext. 3233 or FTS 323-4303 or 323-3233; S. J. Paulson,  
NTIA/ITS, U.S. Dept. of Commerce, Boulder, CO 80303, (303)  
499-1000, ext. 3874 or FTS 323-3874.

Item: 1-6

Title: SLAM, Slant-Path Absorption Model.

Computes: The program computes the molecular attenuation of microwave and submillimeter waves in earth's atmosphere. For a fixed frequency ( $\text{cm}^{-1}$ ) and a given atmospheric model, it computes horizontal (dB/km) and upward- and downward-looking vertical (dB) attenuations vs altitude. The complete exponential term for induced emission is employed.

Input: Required are a modified binary tape version of AFCRL (AFGL) line parameter compilation; constituent molecule(s); atmospheric model (from 1966 supplement to 1962 U.S. Standard); line profile (Van Vleck-Weisskopf, Gross, Lorentz, Voigt-type); frequency range; and "bound." This determines furthest lines used.

Limitations: The program computes molecular attenuation only (no aerosol or clouds). It computes fixed-frequency calculations at intervals of  $0.001 \text{ cm}^{-1}$  ( $\pm 30 \text{ MHz}$ ). There is no continuum correction included, and "interference" is neglected. The Voigt-type approximation is only approximately valid above 40 km. The AFCRL data out to  $550 \text{ cm}^{-1}$  (= 16.5 THz) is employed.

Current Status: The FORTRAN program and associated binary data is stored on magnetic tape. It is immediately usable on disc-oriented XDS Sigma-series computers, but is straightforwardly convertible for other computers with FORTRAN IV compilers.

References:

Greenebaum, M., and D. Koppel (1975), A study of millimeter and submillimeter wave attenuation and dispersion in the earth's atmosphere, final report F-1/306-3-14, Riverside Research Institute, New York, NY 10023 (AD-A015544).

Koppel, D. (1976), Present status of the RRI slant-path absorption model (SLAM) computer program, Tech. Rept. T-2/306-3-14, Riverside Research Institute, New York, NY 10023.

For more information contact: Dr. Michael Greenebaum, RRI, 80 West End Avenue, New York, NY 10012, (212) 873-4000, ext. 347.

Item: 1-7

Title: MRRPR, Microwave Radio Relay Path Propagation Reliability Models for Overland Multipath Fading.

Computes: The program computes median fade duration and time distribution; overland earth and atmospheric multipath fading outage in accordance with the Bell and CCIR criteria 4, 5-ms-mean distributions; and CCIR criteria 3, 1-min-mean distributions; and fade margin difference for a given outage. In addition, the program computes space and frequency diversity improvement factors, path roughness factors, and minimum path lengths at which multipath fading can be expected.

Input: The required input parameters are frequency, fade margin, path distance and roughness, geographic factors, and annual mean temperature.

Limitations: The applicable frequency range is from 4 to 18 GHz.

Current Status: The program is operational on the HP 67 calculator.

References: No published references.

For more information contact: H. J. Sartori, Collins Commercial Telecommunications Group, P.O. Box 10462, Dallas, TX 75201, (214) 690-5000.

Item: 1-8

Title: RMRRPP, Reliability of Microwave Radio Relay Paths with Precipitation.

Computes: The program computes the annual rainfall outage time and cumulative rainfall time distribution as a function of path distance and surface point rainfall rate.

Input: The required input parameters are frequency, fade depth, path distance, annual rainfall, and thunderstorm ratio.

Limitations: The applicable frequency range is from 4 to 18 GHz.

Current Status: The program is operational on the HP 67/97 calculator.

References: No published references.

For more information contact: H. J. Sartori, Collins Commercial Telecommunications Group, P.O. Box 10462, Dallas, TX 75201, (214) 690-5000.

Item: 1-9

Title: PCTDCP, Partially Correlated Tropo Diversity Calculation Program.

Computes: This program computes the probability that the output of a maximal ratio combiner will be above some threshold value as a function of the signal power in a given channel.

Input: The program requires a complex correlation matrix of the tropo system. This matrix has elements relating the fading on each diversity branch to all other diversity branches. The correlation matrix is square and is, at most, 4 by 4. The elements may be written in the form  $P_{ij}$  where  $P$  is the complex correlation coefficient between the amplitude fluctuations (fading) on the  $i$ th and  $j$ th diversity branch. If the complex correlation coefficient is not available, it may be approximated by the square root of the envelope correlation coefficient, which is the correlation commonly measured experimentally.

Limitations: The program is limited to making calculations for dual or quad diversity systems.

Current Status: The program is in FORTRAN and is operational on an IBM 370.

References:

Pierce, J. N., and S. Stein (1960), Multiple diversity with nonindependent fading, Proc. IRE, 48 No. 1.

For more information contact: Dr. J. Wick, Mail Stop A160, The MITRE Corporation, Bedford, MA 01730, (617) 271-4590 or AUTOVON 478-1001, ext. 75-4590.

Item: 1-10

Title: SELSP, Satellite to Earth Location Signal Power.

Computes: The program computes the following data for satellites in earth orbit, for any given ground point:

Slant range in kilometers.

Satellite cone angle in degrees.

Satellite clock angle in degrees.

Ground point location elevation to satellite.

Ground point location azimuth to satellite.

Power flux density at ground point location in dBW/m<sup>2</sup>.

Path loss in dB.

Elapsed time in seconds.

The program was primarily intended for the analysis of potential interference between satellites and earth stations of different services, but it can be used in a generalized manner without modification. The program performs an orbit inclination test and informs the user if the orbit inclination and ground point location preclude any view periods. The program also retains information used in the computations, which can easily be accessed by a trained operator. Once initialized, the program runs until commanded to stop by the user. Typical run times vary from a few minutes upward depending on the quantity of output required. Data is output at time increments determined by the user.

Input: An interactive segment of the program leads the user through the necessary input steps.

Required input parameters are:

Orbit altitude at perigee.

Orbit inclination.

Longitude of ascending node.

Angle between ascending node and perigee.

Orbit ellipticity.

GMT at ascending node.

Time increment for data during track.

Ground station longitude and latitude.

Ground station minimum elevation angle.

Transmitter frequency.

E.I.R.P.

Initial elliptical angle.

Limitations: Atmospheric effects are not included.

Earth radius is assumed constant (6378.16 km). Calculates data only for one satellite and one ground point per run.

Current Status: The program is operational and available. It is written for HP 9815A desk top computer, but could be converted for use on other machines.

For more information contact: Dennis Nightingale, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91103, (213) 354-6326 or FTS 792-6326.



Item: 1-11

Title: LCP, Link Calculator Program.

Computes: This program computes the path loss, modulation losses, threshold parameters, Doppler, as well as link margins for FM, AM, and PM systems.

Input: The required input parameters are antenna gains, system temperature, losses, modulation-type, modulation parameters, range, frequency, and accuracy required.

Limitations: The program uses only a simplified model for atmospheric effects that is custom designed for NASA STDN links for VHF and S-band frequencies.

Current Status: The program is currently operational.

References:

STDN Link Analysis Handbook, Volumes I, II, and III,  
June 1977, November 1977.

For more information contact: Frank Stocklin, Goddard Space  
Flight Center, Code 861.3, Greenbelt, MD 20071, (301) 982-  
5712.

Item: 1-12

Title: RADREF, Radar Refraction.

Computes: The program computes radar angular deviation and range inaccuracies which occur when electromagnetic waves traverse the earth's atmosphere. Both the troposphere and the ionosphere are considered in the program. The outputs are primarily the errors in elevation angle and range as functions of apparent elevation and apparent range, but various types of associated data can be broken down into the various components resulting from retardation and bending, from both the troposphere and the ionosphere. The program is available in both a double-precision version and a single-precision version.

Input: Program input consist primarily of data parameters which define the refractive profile of the earth's atmosphere (troposphere and ionosphere), plus radar frequency, and various computational control and output selection parameters. The indices of refraction in the troposphere can be either input directly or computed as a function of surface temperature, pressure, and water vapor pressure, as well as height. The indices of refraction in the ionosphere are computed as a function of the latitude and either the electron density or the plasma frequency.

Limitations: Primary limitations of the program are that the program assumes a spherically symmetric atmosphere. Computations are also currently accomplished using a "stratified layer method," in which the vertical profile of the atmosphere is approximated by a series of thin layers each of constant refractivity. The program currently assumes that the radar site is on the ground; there is no provision for air- or space-borne sensors. Studies have indicated that the single-precision version of the program provides good computational results (i.e., truncation errors

are not the dominant accuracy limitation) when the program is run on a computer with 48 or more bits per word; however, the double-precision version of the program is recommended for machines with 36 or fewer bits per word. Usable frequency is from 30 MHz thru 3 GHz.

Current Status: The current version of the program (RADREF IV) is in the final stages of debugging and testing. The program is written in standard FORTRAN IV. It has been used on the Honeywell 6080 and 6060 and the Philco 212 computers, but is easily convertible for use on other computers which have a FORTRAN IV compiler.

References:

Technical Memorandum, 78-1, RADREF IV Documentation by St Clair Hultsman, Directorate of Analysis DCS/Plans and Programs Headquarters NORAD/ADCOM.

For more information contact: St Clair Hultsman or Preston M. Landry, HQ ADCOM, Peterson AFB CO 80914, (303) 635-8911, ext. 3535.

Category 2  
Computations on Desired-to-Undesired  
Signal Ratios

Item: 2-1

Title: TSPD, Terrestrial Surface Power Flux Density Limits for Services Using Satellites.

Computes: The program computes the probable impact of various levels of power flux density at the earth's surface upon terrestrial systems as a function of percentage of terrestrial systems affected.

Input: The Government Master File provides terminal locations and required equipment parameters.

Limitations: The program is limited to the information available on the Government Master File.

Current Status: The program is currently running on the DOC CDC 6600 computer.

References:

Haydon, G. W., and R. K. Rosich (1973), Technical considerations in the efficient use of the spectrum: Part 1 - terrestrial surface power flux density limits for services using satellites, OT Report 73-19 (NTIS, COM75-10863/AS).

For more information contact: George W. Haydon, NTIA/ITS, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3583 or FTS 323-3583; Dr. Rayner K. Rosich, NTIA/ITS, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3109 or FTS 323-3109.

Item: 2-2

Title: IMP, Interference Modeling Program.

Computes: The program computes the following data for interference at DSN ground stations tracking real-time mission spacecraft from either satellites or from other active spacecraft not being tracked:

Elapsed time in seconds.

Satellite azimuth and elevation.

Angle off boresight between sun and mission spacecraft.

Angle off boresight between satellite and mission spacecraft.

Satellite power flux density at ground station.

Power from satellite in dBW.

Signal to interference ratio in dB.

The output is tabularized by ground station - a maximum of three can be used - and by satellite and mission spacecraft. Output is directly to the user terminal in demand mode or to a line printer in batch mode. Future plans call for selected output to go to data files, which may be used for plotting.

Input: The program requires responses to prompting for some input and accesses other parameter files for additional data. Some of this additional data is stored on tape, principally that concerning future potential space missions for deep space research. The required input parameters are:

Operating frequency band.

Satellite name(s).

Mission spacecraft ID and operating parameters.

Names of ground stations (three maximum).

Start time of run.

Time increment for data (for mission to mission interference only, otherwise fixed by program).

Limitations: Not all known satellites are currently filed. The output data format is presently limited to 80 characters per line to allow direct extraction into 8-1/2 x 11 pages. Thus, not all available computed data are printed. Also, the effect of weather, sun, planets, etc., on system noise temperatures is ignored.

Current Status: Program is still under development for use on Univac 1108 computer. (Note that "canned" data available at JPL's 1108 computers are essential). It is written in FORTRAN IV.

References:

Newton, R. R. (1960), Astronomy for the non-astronomer, IRE TRANS. on Space Electronics and Telemetry, 1-16.

For more information contact: Dennis Nightingale, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91103, (213) 354-6326 or FTS 792-6326.

Category 3  
Computations of Atmospheric and  
Precipitation Parameters

Item: 3-1

Title: FAP, Frequency Analysis Program.

Computes: The program computes and tabulates the frequency of occurrence of 10 weather classes with clear and dry at one extreme and heavy rain at the other.

Input: The program is designed to operate on the Rand collection of weather data called RAWDAB. There are approximately 90 stations in the collection covering the Northern Hemisphere. Data is most dense in Central Europe.

Limitations: The chief limitation is data input. Some stations have poor observations and a limited length of record.

Current Status: Operating.

References:

Deirmendjian, D. (1969), Electromagnetic Scattering on Spherical Polydispersions, American Elsevier Publishing Co., Inc., New York.

Deirmendjian, D. (1975), Far-infrared and submillimeter wave attenuation by clouds and rain, J. Appl. Meteor., Vol. 14, No. 8, 1584-1593.

For more information contact: Charles Schutz or Jeanine Lamar, Rand Corp., 1700 Main Street, Santa Monica, CA 90406, (213) 393-0411.

Item: 3-2

Title: MWPE, Millimeter Wave Propagation Experiment Central Data Reduction Program.

Computes: The program computes rain attenuation and related statistics (rain rate, radar backscatter, radiometric temperature, etc.) from measurements on an earth-space propagation path using satellite beacons.

Input: The required input parameters are received signal levels (calibrated), rain gauge tips, ambient temperature and pressure, radar reflectivity, etc. - all from ground station equipment.

Limitations: The program is designed for the specific requirements of the NASA terminals at Rosman, N. C., and GSFC, Greenbelt, MD. Approximately 36 inputs are used to develop 24 plots and printouts.

Current Status: The program has been operational since 1969 at GSFC. It has been used (with modifications) on the ATS-5, ATS-6, CTC, and COMSTAR satellite programs.

References:

Numerous reports and references in open literature - available on request.

For more information contact: Louis J. Ippolito, NASA Goddard Space Flight Center, Code 953, Greenbelt, MD, (301) 982-6716.



Item: 3-3

Title: RPP, Rain Propagation Prediction.

Computes: The program computes the attenuation, isolation, and phase shift of millimeter wave signals passing through a rain/ice medium.

Input: The required input parameters are frequency, elevation angle, transmit/receive antenna polarization states, and rain/ice parameters. The rain medium can be divided into 10 segments with different characteristics.

Limitations: The program has been designed for use at 11, 19, 30 GHz with rain rate from 1 to 300 mm/hr.

Current Status: The program is operational on an IBM 370 and is written in FORTRAN IV.

For more information contact: Dr. W. L. Stutzman, Virginia Tech, Electrical Engineering Dept., Blacksburg, VA. 24061, (703) 951-6834.

## Category 4

### Data Bases and Associated Programs

Item: 4-1

Title: ZPRARS, Z Profile and Rain Attenuation from Rain Scatter.

Computes: This program computes the following parameters over each adjacent radar range bin:

The height of the pulse volume (km),.

The range of the pulse volume (km).

The received power (dBm).

The number of tape units.

The reflectivity factor of rain ( $\text{mm}^6/\text{m}^3$  and dBZ).

The attenuation coefficient (dB/km) at a frequency, f.

The cumulative attenuation (dB) at a frequency, f.

The Marshall-Palmer rain rate (mm/hr).

Input: The input parameters are radar constant, calibration slope and intercept, number of range bins to be processed, drop size distribution parameters, file number to be processed, and time.

Limitations: This program is written for a PDP-8-IBM compatible format. The PDP-8 minicomputer controls the radar and injects the output on line onto an IBM tape.

Current Status: This program is operational.

References:

Goldhirsh, J. (1977), Analysis of single and multiple wavelength radar systems for estimating slant path attenuation through rain at frequencies greater than 10 GHz, APL/JHU internal memo S1R77U-036.

For more information contact: J. Goldhirsh, Applied Physics Laboratory, The Johns Hopkins University, Johns Hopkins Road, Laurel, MD 20810, (301) 953-7100, ext. 2779.

Item: 4-2

Title: RAT, Rain Attenuation vs Time.

Computes: This program computes the estimated attenuation due to rain for three arbitrary frequencies depending upon the drop size distributions assumed. These attenuations correspond to the path along the radar beam where the attenuation contribution due to each adjacent range bin is considered.

Input: The input parameters are radar constant, calibration slope and intercept, number of range bins to be processed, drop size distribution parameters, file numbers, time interval to be processed, and sampling interval.

Limitations: This program is written for a PDP-8-IBM compatible format. The PDP-8 minicomputer controls the radar and injects the output on line onto an IBM tape.

Current Status: This program is operational.

References:

Goldhirsh, J. (1978), Prediction of attenuation of the 28 GHz COMSTAR beacon signal using radar and measured rain drop spectra, APL/JHU internal memo SlR78U-009.

For more information contact: J. Goldhirsh, Applied Physics Laboratory, The Johns Hopkins University, Johns Hopkins Road, Laurel, MD 20810, (301) 953-7100, ext. 2779.

Category 5

Performance of Digital Communication Systems

Item: 5-1

Title: DTCM, Digital Telecommunication Conversion Model.

Computes: The program computes the mean, standard deviation, and probability functions of the number of bits/message for message mixtures which arrive at a digital telecommunication network station for conversion to electronic messages.

Input: The required input parameters are the percentages of digital data on magnetic tape or cards, the percentage of alphanumeric messages on paper, the percentage of graphic messages on paper, data compression ratios, and lines per inch facsimile scanning ratios.

Current Status: The program is operational. The program is documented and described in the two references given below. The program is written in FORTRAN IV for a CDC 6600.

References:

McManamon, P. (1975), A digital telecommunication conversion model for electronic message mixtures, U.S. Postal Service Report, (NTIS PB252-183).

Miles, M. (1975), Analysis of a digital telecommunications message model, U.S. Postal Service Report, (NTIS PB252-184).

For more information contact: Dr. P. McManamon, NTIA/ITS, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3570 or FTS 323-3570; R. Marcotte, USPSR&D Center, 11711 Parklawn Drive, Rockville, MD 20853, (301) 443-6100 or FTS 443-6100.

Item: 5-2

Title: DTGTAP, Digital Tropo Generalized Time Availability Program.

Computes: This program computes the generalized time availability of a digital troposcatter system at a given service probability.

Input: The program requires the following input data:

A. The mean and variance of the energy-per-bit to noise ratio ( $E_b/N_o$ ) supplied to the modem.

B. The mean and variance of the distribution of multipath spread characterized by its two sigma width.

C. Fifteen samples from the modem performance curve. This is the plot of required mean  $E_b/N_o$  vs mean multipath spread for which the digital troposcatter modem will produce a given average bit error rate.

Limitations: The accuracy of the program degrades when the modem is operated under multipath conditions where its performance is significantly degraded by intersymbol interference. The computational problem is a consequence of the steep slope of typical modem performance curves in this region.

Current Status: The program is operational. Running time could be significantly reduced by refinement of the two dimensional integration algorithm used.

References:

Sherwood, A., S. Wenglin, and J. Wick, An experimental program leading to development of a tactical digital troposcatter system, to be published in the proceedings of the AGARD EPP symposium on "Aspects of Electromagnetic Scattering in Radio Communication," 3-7 October, Cambridge, MA.

For more information contact: Dr. J. Wick, Mail Stop A160,  
The MITRE Corporation, Bedford, MA 01730, (617) 271-4590, or  
AUTOVON 478-1001, ext. 75-4590.

Category 6  
Miscellaneous Programs

Item: 6-1

Title: MAIM, Multipath Analysis of ILS and MLS.

Computes: This program computes the position error of ILS and MLS due to multipath from the environment. The environment is modeled as a number of flat triangles with a given roughness. Specular and diffuse components are computed.

Input: Required input parameters are the geometrical and electrical properties of each triangle, coordinates of the ground system and the aircraft, antenna radiation pattern, and frequency band, as well as type of ILS or MLS.

Limitations: The program is limited to systems for which computer models exist, such as Scanning Beam MLS, Doppler Scan MLS, Interferometry MLS and ILS.

Current Status: The program is operational.

References:

Breien, T. (1976), Computer analysis of MLS in multipath environment, IEE Conf. Publ. No. 147.

For more information contact: T. Breien, ELAB, N-7034  
TRONDHEIM - NTH, NORWAY.

Item: 6-2

Title: Y, Earth Coverage Footprints from Geostationary Satellite Antennas.

Computes: The program contains an algorithm for generating on microfilm output, earth coverage footprints from geostationary satellite antennas. Also, a separate algorithm is included for determining whether given coordinates or ground points are included in or excluded from a particular footprint. The antenna beam can be elliptic in cross-section with an arbitrary orientation of semi-minor and semi-major axes.

Input: The required inputs are data giving latitude and longitudes of continental U.S. plus state boundaries or latitude and longitude of political boundaries on world map, longitude of satellite and distance from earth center, latitude and longitude of antenna aim point, semi-minor and semi-major axes, and rotation angle of elliptic pattern.

Current Status: The program is operating and available on request.

References:

Ott, R. H. (1975), A numerical method for generating earth coverage footprints from geostationary antennas, report prepared for Advanced Mail Systems Directorate, U.S. Postal Service, Rockville, MD 20852.

For more information contact: Dr. R. H. Ott, NTIA/ITS, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3353.



Item: 6-3

Title: JRW001, Transionospheric Ray Tracing with Iterative Homing.

Computes: This program is designed to perform ray tracing of radio waves through a spherically-stratified model ionosphere, using Snell's Law iterated at each layer. A homing capability is included so that the actual path which will connect transmitter and receiver will be determined to whatever accuracy is specified. O and X waves are traced separately and Faraday Rotation obtained from their phase path length difference. Various model ionospheres can be used, including profiles derived from ionosondes. Different models of the geomagnetic field can be specified.

Input: The required input parameters are frequency, transmitter location, receiver location, parameters to define ionosphere profile (N(h)), and parameters to define geomagnetic field model.

Limitations: The program uses a spherically stratified ionosphere. There are no frequency limits; although, of course, it is assumed that the rays do penetrate the ionosphere.

Current Status: Program was converted to run on the NOAA/ERL CDC 6600 in November 1976. Due to the number of subroutines used, this would be a very difficult program to convert to run on other computers.

References:

Lawrence, R. S., and D. J. Posakony (1961), A digital ray-tracing program for ionospheric research, SPACE RESEARCH II, Proc. Second International Space Science Symposium.

For more information contact: Judy Stephenson, NOAA/SEL, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3997; R. B. Fritz, NOAA/SEL, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 6523.

Item: 6-4

Title: RAYTRA, A versatile three-dimensional ray tracing computer program for radio waves in the ionosphere.

Computes: This program will trace rays through an anisotropic medium whose index of refraction varies continuously in three dimensions. The program can represent the refractive index by either the Appleton-Hartree or the Sen-Wyller formula, and has several ionospheric models for electron density, perturbations to the electron density, the earth's magnetic field, and electron collision frequency. For each path, the program can calculate group path length, phase path length, absorption, Doppler shift due to a time-varying ionosphere, and geometrical path length. In addition to printing these parameters and the direction of the wave normal at various points along the ray path, the program can plot the projection of the ray path on any vertical plane or on the ground and punch the main characteristics of each ray path on cards.

Input: The input parameters are transmitter location (longitude, latitude, and height above the ground), the frequency of the wave, the direction of transmission (both elevation and azimuth), the receiver height, and the maximum number of hops desired.

Limitations: The program has no homing capability.

Current Status: The program is written in FORTRAN, is on cards, and is operational on a CDC 6600.

Reference: Jones, R. M., and J. J. Stephenson (1975), A versatile three-dimensional ray tracing computer program for radio waves in the ionosphere, OT Report 75-76.

For more information contact: R. M. Jones, NOAA/SEL, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 6494 or J. J. Stephenson, NOAA/SEL, U.S. Dept. of Commerce, Boulder, CO 80303, (303) 499-1000, ext. 3997.

Item: 6-5

Title: WTC-MBA/LASL.

Computes: The program computes the transient response of thin-wire antennas or scatterers connected to circuits. The solution is obtained by timestepping. The circuit may contain nonlinear elements. The program was designed to analyze the transient response of wire objects. Wideband frequency domain results are also available through a Fourier transform. Structures modeled by grids of wires can also be handled. The current on each wire segment and the voltage of each node of the circuit is available for all timesteps. Far field electric field intensities can be found also.

Input: The required input parameters are antenna geometry, antenna loading, circuit element values, exciting fields or voltages, and the desired timestep increment. The desired far field observation direction and polarization can also be input.

Limitations: Approximately 12 wire segments per wavelength are required to model the wire structure. This limits the structure complexity to approximately 300 segments for a CDC 7600. The ratio of the wire segment length to diameter must be greater than one. The time-step increment must be approximately equal to the length of the longest wire segment divided by the velocity of light.

Current Status: This program is operational and will be available when documentation is complete. It is written in FORTRAN for a CDC 7600.

References:

Landt, J. A., E. K. Miller, and M. Van Blavicum (1974), WT-MBA/LLLIB: A computer program for the time-domain electromagnetic response of thin-wire structures,

UCRL-51585, Lawrence Livermore Laboratory, Livermore, CA  
(Same as WTC-MBA/LASL except for circuit loading).

Miller, E. K., and J. A. Landt (1976), Direct time-  
domain techniques for transient radiation and scattering,  
UCRL-52315, Lawrence Livermore Laboratory, Livermore, CA.

For more information contact: J. A. Landt, MS-429, Los  
Alamos Scientific Laboratory, Los Alamos, NM 87545, (505)  
667-7558 or FTS 843-7558.

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15. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography of literature survey, mention it here.) Analysis aids and data bases for predicting the performance of 100 MHz - 100 GHz communication systems are presented and briefly described. They are loosely grouped into the following functional categories:  <ol style="list-style-type: none"> <li>1) Computations of transmission loss and radar returned power.</li> <li>2) Computations of desired-to-undesired signal ratios.</li> <li>3) Computations of atmospheric and precipitation parameters.</li> <li>4) Data bases and associated programs.</li> <li>5) Performance of digital communication systems.</li> <li>6) Miscellaneous programs.</li> </ol> <p>Sources are given for the analysis aids, data bases, and additional information.</p>				
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