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HANDBOOK OF SYSTEMS EFFECTIVENESS MODELS

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Prepared by Research Triangle Institute
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13. ABSTRACT

Identifies and summarizes computer programs for modeling techniques currently used in effectiveness engineering. The programs employ a wide range of systems effectiveness techniques and convey the current variety in approaches used. They are summarized to assist engineers and analysts in the search for techniques to adapt for solution of their own application problems. The document will also serve as a basis for planning and future developments in effectiveness synthesis.

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FOREWORD

The purpose of this document is to identify and summarize for the reader computer programs for modeling techniques currently used in effectiveness engineering. Those computer programs employ a wide range of systems effectiveness techniques and convey the current variety in approaches used. They are summarized herein to assist engineers and analysts in their search for techniques to adapt for solution of their own application problems. It will also serve as a basis for planning and future developments in effectiveness synthesis.

Program categories were selected to be self-descriptive as to the effectiveness measure, attribute, technique or activity addressed. Most of the programs were not unique to a single category and Appendix A, Cross Index, lists other pertinent categories and additional key words. Some Integrated Logistic Support (ILS) programs, for instance, include modules which concern most of the remaining categories. In some instances these modules are summarized individually and in others, collectively. Coverage was determined by the information available and the integrity of the complex of programs.

The computer programs summarized herein are representative of the kinds or types available and are not intended to be comprehensive or all-inclusive. Contractural data, addresses, phone numbers, and names of cognizant individuals are included whenever available. An attempt was made to include only documented programs. Ownership and terms of purchase for non-government programs were not generally available. Previous work on surveys and evaluations of programs is described in the following documents:

a) "Survey of Studies and Computer Programming Efforts for Reliability, Maintainability, and System Effectiveness," Report OEM 1, Office of the Director of Defense, Research and Engineering, September 1965 (AD-522 676).

b) "Evaluation of Computer Programs for Systems Performance Effectiveness," Volumes I and II, prepared by Research Triangle Institute for Naval Applied Science Laboratory, Contract N00140 66 C 0499, August 1967 (AD-829 353L and AD-829 354L).

Each computer program is identified by the serial number in the lower right-hand corner of each page. Bibliographic citations are listed by serial number and are included as Appendix B.

ADMINISTRATIVE INFORMATION

This handbook was prepared for the Naval Electronics Laboratory Center by Research Triangle Institute under contract N00123-71-D-0168, under the technical direction of H. Greenstein, Systems Effectiveness Engineering Division. Work was performed under SF0999002, Task 1622 (NELC R124).

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SECTION 1

COST ESTIMATING PROGRAMS

TITLE: Generalized Life Cycle Cost Model

LANGUAGE: FORTRAN IV

COMPUTER: B5500 (Time Share)

DATE OPERATIONAL: 1970

DESCRIPTION: This program aggregates costs per unit of equipment in three life cycle phases: Research and Development (R&D), Investment, and Operations and Maintenance (O&M). The Investment and O&M phases are analyzed in more detail than the R&D phase. The program provides the option of calculating a number of cost elements as functions of other specific cost elements within the life cycle, rather than aggregation from a lower level of estimation. The output lists life-cycle costs by year and by phase, and cost relationships by level of detail analyzed.

COMMENTS: A series of data collection sheets to assist in identifying data requirements and a descriptive handbook are included in the source referenced below. In large measure, this model represents an enlargement and updating of a Computerized Cost Model for Electronic Communications Equipment previously used by the developing agency, the Army Electronics Command, Systems/Cost Analysis Office, Ft. Monmouth, New Jersey.

SOURCE: A Generalized Life Cycle Cost Model for Electronic Equipment, Booz-Allen Applied Research, Inc., Bethesda, Maryland, March 10, 1970 (AD-719 709).

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TITLE: A Probabilistic Cost Estimating System Simulator (PROCESS)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 3300 with MSOS System, IBM 360/30, IBM 1620 II-D

DATE OPERATIONAL: Latest update - May 1970

DESCRIPTION: This computer simulation program provides flexible, iterative statistical modeling of cost and requirements uncertainties as a system analysis aid. An analytical system model is first constructed of independent and dependent uncertainty factors. This model provides the basic framework evaluation. A library of cost estimating relationships is provided in the program to evaluate the dependent factors based on input constant and independent factor data. A library of data distributions which are selectable as an approximation of the expected uncertainty of a cost or requirement is provided. The selected distribution is then bounded by high and low value estimates. This type of analysis is performed for each variable in the system model. A Monte Carlo iterative simulation routine is then performed on the data, the independent variable distributions are approximated and merged to obtain a total system uncertainty distribution. Dependent on data input modes, a single system may be estimated, competitive system design processes evaluated and analogous evaluations performed. The outputs are in the form of a tabular listing of the system distribution, a statistical summary of the data, and a line printer histogram plot of the output data.

COMMENTS:

SOURCE: Singer-Librascope, 808 Western Avenue, Glendale, California 91201, telephone (213) 245-8711. Contact G. F. Swygard and P. E. Roy, Jr.

TITLE: System Parametric Allocation of Resources and Costs (SPARC)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65, FORTRAN G compiler

DATE OPERATIONAL: 1969

DESCRIPTION: The SPARC computer program was developed to aid in estimating the costs of proposed ICBM weapon systems. The SPARC cost model can be used for a variety of costing exercises. The primary use is intended to be as an aid to the preparation of preliminary technical development plans and contract formulation plans. A trained user of the program can reduce from months to days, the time required for a major cost analysis of a proposed weapon system. Other benefits provided by the use of the proposed basic system; reduction of the opportunity for human calculational error; reduction of clerical effort; and standardization of computations and presentation of results. Output is printed in formats conforming to the requirements of Air Force Systems Command Manual 173-1.

COMMENTS: The obvious disadvantages to the use of the SPARC program are the necessity of learning to use the program and the inflexibility inherent in conforming to the specific requirements of any computer program. The task of learning to use the program is intended to be facilitated by the source report below and a companion user's manual. The limitations imposed by the need to conform to data requirements, built-in costing factors, and input formats has been provided which provides nominal values of many of the required input parameters. Provisions have been made for the input override of the calculations of various components of the total cost model. This capability will allow the trained user to do much in tailoring the SPARC program to his individual needs.

SOURCE: J. W. Bond III: SPARC Computer Program, Aerospace Corporation, San Bernardino, California, TR-0059 (S6529)-1, March 1970, Air Force Report No. SAMSO-TR-70-234, prepared for Space and Missile Systems Organization, Air Force Systems Command, Los Angeles, California 90045 (AD-872 655).

TITLE: Computerized Cost Model (COCOM)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6400, IBM 360-65, IBM 370 series

DATE OPERATIONAL: 1968

DESCRIPTION: This is a large scale cost model for parametric estimating. It is capable of handling up to 500 or 1,000 Work Breakdown Structure (WBS) items depending upon model configuration. WBS items are estimated using internally stored equations with input formula coefficients. This model has seen extensive use on military and space contracts. Output includes cost by year for each WBS item or for any level of WBS desired. That is, cost may be computed at the fifth level with a printout showing cost only to the third level or fourth level, as designated by option. A summary output is also available. It provides total cost by WBS as well as the percentage that each cost item represents with respect to program phase (RDT&E, Investment, O&M, etc.) and to the total program, i.e., two percentages for each item. The program will also summarize a series of projects or weapon systems and provide the same by year output and percentage sensitivity information for the summary.

COMMENTS: This same source has a number of related programs which span all levels of system/mission detail and also provide integrated measures of cost effectiveness. This program (COCOM) is used in conjunction with the Integrated Logistic Support program MILSIM and the Availability program MILSAM for overall optimization of logistic decisions.

SOURCE: This program was developed by the Martin-Marietta Corporation Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE: SHIP

LANGUAGE: Time Share FORTRAN (Essentially FORTRAN IV)

COMPUTER: GE 635

DATE OPERATIONAL: April 1971

DESCRIPTION: The program accepts detailed annual operating costs and capital costs for ships of different degrees of automation. It sums capital and annual costs for the life cycle period, properly allocating them according to constant subsidies, then calculates total present worth of the costs. The data are then normalized for squal ship productivity, and present worth is calculated. The program will accomodate any number of ship concepts and prints out the detailed life cycle data for each ship with both detailed annual and life cycle costs displayed.

COMMENTS:

SOURCE: General Electric Company, P.O. Box 2500, Daytona Beach, Florida 32014, telephone (904) 258-3933. Contact Mrs. M. L. Currin or F. J. Mayer.

TITLE: Subsystem Operations Cost Model (SOCM III)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360

DATE OPERATIONAL: May 1969

DESCRIPTION: This is an accounting type model that uses F-111 generated definitional equations to find recurring and non-recurring costs at the LRU/SRU level. It generates detailed cost estimates as input to overall life-cycle cost models. SOCM III consists of a cost model supported by a data file which may be the contractors automated support requirements and general logistics information file. The model has been designed to do a large amount of internal data manipulation after costs are computed. As a result, output is very flexible. The level of output detail can range from any individual LRU/SRU, combination thereof, to total force, ten-year input/cost ratios for any subsystem or system. The model can be used with maintainability parameters defined by design engineers or by operational experience. Advanced systems lacking this level of detail can be costed using CER's derived by SOCM III from analogous systems.

COMMENTS: Refer to comments for Integrated Logistics Support program ORLA utilized by this same source.

SOURCE: This Air Force sponsored program was developed by General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4871. Contact Sam Abraham or Charles Hatfield, Operations Research and Support Requirements.

SECTION 2

INTEGRATED LOGISTIC SUPPORT PROGRAMS

TITLE: TRANSIM IV

LANGUAGE: FORTRAN

COMPUTER: IBM 360/50 and up; GE 635; UNIVAC 1108; Control Data 6400 and up

DATE OPERATIONAL: August 1971

DESCRIPTION: TRANSIM IV is a user-oriented management problem-solving tool for modeling and analyzing real-life problem situations by means of computer simulation. Because all aspects of the computer model and its simulated operation can be described in everyday terms on standard data forms, users of TRANSIM IV are not required to be familiar with computer operations or computer programming. Because TRANSIM IV is a general-purpose technique, its standard computer program is not modified from one problem to another. The entire description of the problem is set forth on the standard input data forms.

TRANSIM IV is suitable for modeling and problem situations which can be described in terms of the flow of "traffic" through a network of "operating elements." The traffic units might be trucks, ships, pallets, messages, invoices, men, fork trucks, dollars, documents, or tools; the operating elements would be the various system functions which process or utilize the traffic units. In the computer, the model operates just as does the aspect of system operation: number of items processed, queue lengths, service time distributions, man hours expended, etc. Alternative systems, procedures, policies, etc., are evaluated by making the appropriate changes to the basic model, "running" the model again in the computer, and comparing the results. Any input data may be specified in terms of probabilistic as well as deterministic times, quantities, etc. The output results will accurately reflect the effects of such variability.

COMMENTS: TRANSIM IV is an updated version of TRANSIM I, whose development was originally sponsored (1963-1966) by the Navy, U.S. Dept. of Commerce, and the Maritime Administration.

SOURCE: Project TRANSIM, School of Engineering and Applied Science, University of California, Los Angeles, California 90024. Telephone 213-825-1806.

TITLE: Systems Effectiveness Submodel (SES)

LANGUAGE: SIMSCRIPT 1.6

COMPUTER: IBM 360/91; CDS 3200

DATE OPERATIONAL: 1970

DESCRIPTION: SES simulates the operational environment in which an inventory is to function by generating removals of specific parts from aircraft, creating demands for replacements, sending parts to repair facilities, simulating the return of repaired parts to the base supply for re-issue, etc., over a specified period of time. By maintaining a real-time history of each part of the inventory, SES can measure the effectiveness of the total inventory to support the squadron as it responds to a given operational flight schedule requirement. It therefore provides the means for determining, for any specified support and operational concept, the following features: a. The probabilities and distributions of delays for parts by aircraft system. b. An approximation to the expected NORS rate. c. Periodic status summaries of the repair/resupply pipeline, including number of component removals, repair actions, shortages experienced, etc. Output data are summaries by class of the parts. For example, if the procurement cost of the parts is used as the differentiating factor, a specific class of parts may consist of all those parts costing over $5,000.00. On the other hand, parts may be classified with reference to the particular aircraft systems with which they are associated.

COMMENTS: This program is identified in WSAO Report R-70-3, dated 1 May 1970.

SOURCE: Naval Weapon Systems Analysis Office (WSAO), Marine Corps Air Station, Quantico, Virginia 22134.

TITLE: General Operations and Logistics Simulation (GOALS)

LANGUAGE: GPSS

COMPUTER: IBM 360/65, 67, 75

DATE OPERATIONAL: November 1969

DESCRIPTION: This large scale simulation model is designed to evaluate and measure the impact of various operational plans, logistics concepts, costs, and resource levels (spares, personnel and facilities) in the operation and support of a wing of aircraft for periods up to 2 months duration. All of these elements can be selectively altered to determine the effects on operational effectiveness and life cycle costs of the weapon system. Both organizational and field level maintenance tasks are simulated to many levels of detail. Personnel are assigned to a shift by special type and quantity based on selectable weekly schedules. Base supply stock is replenished and all major details, such as shipping costs are considered. The primary source of maintenance data used for the B-52G baseline model development and validation was the Air Force AFM 66-1 data collection system. GOALS outputs a variety of reports. These include operational statistics such as sortie/abort rates and operational ready rate; maintenance reports of manhours per flight hour, downtimes, NORM and NORS; supply reports of demands, cannibalizations, base repair times; reliability reports; personnel availability reports; AGE, facility, cost categories and life cycle costs.

COMMENTS: Documentation of GOALS has been transmitted to several Navy agencies. The source below has an extensive collection of related programs.

SOURCE: The Boeing Company. Contact Jack H. Kenny, Aerospace Group, Kent, Washington, telephone (206) 655-8312. Also contact C. S. Bartholomew, Boeing Computer Services Inc., P.O. Box 24346, Seattle, Washington 98124.

TITLE: Reliability and Maintainability Effectiveness Models

LANGUAGE: FORTRAN

COMPUTER: 360/65, 67, 75

DATE OPERATIONAL: June 1970

DESCRIPTION: This is a program complex of multi-purpose models capable of being used individually or integrated, depending on the nature of the problem. The programs are designed to manage multiples of variables, constraints, and parameters to provide realistic design guidelines weighted against economics, logistics, and operational factors. It can be used at any level of design from system through piece part. Outputs can take on many forms depending upon level of analysis and problem being evaluated. In general, the outputs will provide decision criteria for: (a) level of repair analyses, (b) level of maintenance analyses, (c) spares optimizations, (d) redundancy effectiveness for design (all forms), (e) economics trade analyses, (f) mission effectiveness, and (g) reliability and maintainability allocations for design.

COMMENTS: Some of the individual modular programs comprising this collection are: Multi-state analysis (Markov Model) (MARKAP), Level of Maintenance Analysis Program (LOMAP), Dynamic Programming Optimization (DYNPR), Apportionment Program Model (APPRO), Mission Analysis Simulation Model (MAFTS).

SOURCE: Grumman Aerospace Corporation, Bethpage, Long Island, New York, telephone (615) 575-7911. Contact V. H. Pellicione or G. Friendenreich (Head), Systems Reliability and Maintainability.

TITLE: A Computer Programmed Mathematical Model for Maintainability Prediction and System Support Requirements

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL:

DESCRIPTION: This program does all arithmetic computations involved in making maintainability predictions and computes logistics support requirements for a complex weapon system. Outputs from this model are based on the input and manipulation of the three prime determinants of weapon system support requirements: reliability, maintainability, and operational information. The model permits variation of these parameters for trade-off analysis of various design configurations. Some specific outputs are:

a. Quantitative M_{ct} predictions at organizational and field maintenance levels.
b. Percent repairable by maintenance echelon.
c. Failure distributions/deployed unit/unit time.
d. Probable spares demend on maintenance and supply systems.
e. Stock level requirements/deployed unit.
f. Depot repairables quantities.
g. Workload data and active maintenance manpower requirements.
h. A_i and A_o on an operational time and calendar time basis.

COMMENTS: The same source has a number of related programs which span all levels of system detail and also provide integrated measures of cost effectiveness. This program, when coupled with costs (see Cost Estimating program COCOM), may be used to justify the selection of a maintenance concept and the resulting support requirements.

SOURCE: This program was developed by the Martin-Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE: Optimum Repair Level Analysis (ORLA)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360

DATE OPERATIONAL: September 1969

DESCRIPTION: ORLA provides a systematic method for determining whether unserviceable equipment should be discarded, repaired locally, repaired in a mobile van, returned to a specialized depot repair activity or a combination of these alternatives used. The model will simultaneously analyze all specified items. The repair and discard costs are calculated at all repair levels for each item. A level of repair decision is selected for each item which results in the lowest possible cost for the entire equipment set. The model will accept up to three indentures in a set (example: top assembly, subassembly, module) for both mechanical and avionics items. The outputs are: (a) optimum repair level decisions, (b) costs associated with optimum and alternate repair level decisions, and (c) sensitivity of optimum repair level decisions to input parameters.

COMMENTS:

1. This is an Air Force program. Input data include: fleet size, basing concept, flying program, item weight, failure types and frequencies, man-hours to repair; labor costs, parking and shipping costs, pipeline times; administrative, base and depot AGE, training and tech data costs. ORLA approaches the data uncertainty problem by considering several levels (i.e., a parametric analysis approach) of variable factors such as flying program and item cost.

2. Source (1), below, has a complex of related programs such as SOCM III, SPAREM (both in this catalog) and others which utilize a large set of inputs in common. These inputs are obtained directly from the weapon systems automated support inventory and requirements data base in some instances.

SOURCE: The program has been implemented by at least two prime contractors; (1) Advanced Logistics Dept. 501, Support Technology, McDonnell Douglas Corp., St. Louis, Missouri. Contact Howard L. Swain; (2) General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4811. Contact Sam Abraham or George Cude.

TITLE: ILS

LANGUAGE: Extended Basic

COMPUTER: IBM 360

DATE OPERATIONAL: 1972

DESCRIPTION: This program prepares spares lists for electronic equipment. The inputs are: parts MTBF's, parts counts (population density), parts lists, and equipment designators. The output is a tabulated spares requirements list by part numbers, for particular systems, subsystems and equipments.

COMMENTS: The source given below has a number of related programs

SOURCE: Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact E. W. Umlauf or V. D. Tomasule.

TITLE: Military Essentiality Through Readiness Indices (METRI)

LANGUAGE: FORTRAN

COMPUTER: IBM 7090

DATE OPERATIONAL: June 1965

DESCRIPTION: The model was developed to permit calculation of a shipboard allowance list of repair parts. Its objective was to maximize the material readiness of the ship within a budget constraint. The approach was to structure in an engineering model the hierarchy from the ship's mission down through the system, subsystems, equipments, components, to the parts level in a successive dependency tree structure. The output of the calculation was a designation of the allowance list parts and quantities and a determination of the material readiness one could expect to achieve. The model was formulated using a single DD as the prototype structure.

COMMENTS:

SOURCE: Naval Supply Systems Command, Research and Development Division, (Code 0631B), Washington, D.C. 20390, telephone (202) 697-4561.

TITLE: Martin Integrated Logistics Support Model (MILSIM)

LANGUAGE: GPSS

COMPUTER: IBM 360

DATE OPERATIONAL:

DESCRIPTION: The purposes of this program are to simulate system support from the field through the depot level. The model consists of maintenance, supply and support services logic loops. The maintenance loop simulates corrective and scheduled maintenance at all levels above the organization. The supply loop takes spares requirements from all levels, provides and requisitions spares, and records spares statistics. The support services loop simulates the provision of peripheral services such as transportation, facilities maintenance and personnel support functions.

COMMENTS: The same source has a number of related programs which span all levels of system detail and also provide integrated measures of cost effectiveness. This program (MILSIM) used in conjunction with a Cost Estimating program (see COCOM) and a mission oriented Availability program (see MILSAM) simulates operation and support from the organization through the depot and produces life cycle costs.

SOURCE: This program was developed by the Martin-Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

TITLE: Spares Provisioning and Requirement Evaluation Model (SPAREM)

LANGUAGE: SIMSCRIPT

COMPUTER: CDC 6600, IBM 360

DATE OPERATIONAL: 1970 (CDC), 1968 (IBM)

DESCRIPTION: This program provides an evaluation of inventory effectiveness in terms of such measures as flights missed, Not Operationally Ready Supply (NORS) rate, and backorder days. It can be used to establish the relative merits of various logistics policies (e.g., spares management procedures and repair policies) and to evaluate their concommitant impact on aircraft availability. Cannibalization, expedited maintenance, and priority resupply are simulated over several months operation in order to depict realistic wing activation problems. Input data for each LRU and module include removal rate, NRTS rate, shop repair time, order and shipping times from depot, and initial inventory levels. The cycle times for repair and resupply are determined by sampling input distributions. Outputs are NORS rate, OR rate, shortages, backorder days, LRU and module cannibalization, flights on-schedule/cancelled/rescheduled.

COMMENTS: Refer to comments for Integrated Logistics Support program ORLA, utilized by this same source.

SOURCE: This program was developed by General Dynamics, Convair Aerospace Division, P.O. Box 748, Fort Worth, Texas 76101, telephone (817) 732-4811. Contact W. M. Faucett or R. D. Gilbert, Operations Research & Support Requirements.

TITLE: Pipeline Spares Cost Model (NORSPARE)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1969

DESCRIPTION: The NORSPARE model utilizes a minimum-cost method of allocating the total number of each weapon system's components required to satisfy the pipeline requirement subject to the constraints of a specified Not Operationally Ready-Supply (NORS) rate. Allocation is made with a simultaneous consideration of the following input data: the specified NORS rate, number of aircraft, sorties per aircraft per day, flight hours per sortie, spares demand rates (units per flight hour); pipeline times, and unit costs. The output is composed of the federal stock number and/or part number of the Line Replaceable Unit (LRU), the LRU nomenclature, and the pipeline spares cost by each of the major pipeline spare categories. These categories, condemned, NRTS, and repair are shown along with a total cost for the LRU. A summary is also compiled which illustrates pipeline spares costs as a function of federal stock class.

COMMENTS: This same source has other, related programs which are modularized toward various needs for infomration such as: Source Model (operational capability analysis), Maintenance Break Rate Program, Maintenance Regeneration Program, Direct and Indirect Maintenance Manpower Program, Maintenance and Support Manning Program, Replenishment Spares Cost Model, and Computerized AGE Requirements Program.

SOURCE: Northrop Corporation, Aircraft Division, 3901 West Broadway, Hawthorne, California 90250, telephone (213) 675-4611. Contact D. D. Gregor.

TITLE: Inventory Planning Model

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: October 1970

DESCRIPTION: This program optimizes a spare parts inventory at two levels of assembly (weapons replaceable assembly and shop replaceable assembly). Inventory selection can be constrained by either cost or backorder days. The simple Poisson or compound Poisson distribution can be used. If the compound Poisson is used, a variance to mean ratio input for each candidate part is required.

COMMENTS:

SOURCE: Contact G. C. Henry, Operations, Naval Air Systems Command, (Code 4013), Columbia Pike Office Building, Arlington, Virginia 20309

TITLE:	An Economic Equipment Replacement Model (ERM)
LANGUAGE:	SIMSCRIPT 1.5
COMPUTER:	IBM 7094
DATE OPERATIONAL:	September 1968
DESCRIPTION:	This equipment replacement model is based on economic life theory. Consideration is given to repair cost in order to develop an operational decision rule. The decision rule is based on a maximum one-time repair cost limit. Application of this decision rule takes advantage of repair cost information in order to improve on a policy of automatic replacement at the end of economic life calculated on the basis of historical data.
COMMENTS:	
SOURCE:	Naval Seabee Systems Engineering Office (Code 15B), Port Hueneme, California 93043, telephone: Commercial (805) 982-4942, Autovon 898-3300 X4942. Documentation exists for this program.

TITLE: Carrier Aircraft Squadron Effectiveness Evaluation (CASEE)

LANGUAGE: GPSS-360/Norden

COMPUTER: IBM 360/370

DATE OPERATIONAL: July 1970

DESCRIPTION: The CASEE simulation model has been developed as a systems analysis tool for relating the operational effectiveness of carrier-based aircraft to aircraft reliability and maintainability design characteristics as well as to carrier support resources in terms of personnel, procedures, support equipment, spares and space. By examining the model with different assumptions in respect to these system parameters, quantitative trade-off data can be obtained for systems analysis and as backup in decision making. The present version of CASEE is structured around the A-6A Intruder; however, it has been designed to be adaptable to all other carrier-based aircraft types, and also to be expandable to include an entire carrier air wing. The simulation procedures standard GPSS output statistics and also a summary report tailored to suit the user's needs. Typical outputs are: aircraft readiness data, flight data, maintenance summaries, manpower utilization and spares activity.

COMMENTS: This work was sponsored by the Naval Air Systems Command under Contract No. N00019-69-C-0040.

SOURCE: Seidler, S. W.: The CASEE (Carrier Aircraft Squadron Effectiveness Evaluation) Simulation Model. Prepared by Norden Division, United Aircraft Corporation for the Naval Air Systems Command, Washington, D.C., July 1970, 126pp. (AD-875 131).

TITLE: Budget Allocation Procedures for Naval Aircraft Ground Support Equipment

LANGUAGE: Inventory; Allocation

COMPUTER: CDC 6600; UNIVAC 494

DATE OPERATIONAL: June 1971

DESCRIPTION: The method is intended to be used in determining replenishment quantities for a specified segment of aviation ground support equipment managed at the Navy Aviation Supply Office. The model incorporates a budget constraint and has as its objective function the minimization of the total of time-weighted shortages supply system-wide. The method includes a Bayesian forecasting procedure as well as considering the elements of procurement leadtime, repair cycle time and attrition, in the replenishment quantity determination.

COMMENTS:

SOURCE: Naval Supply Systems Command, Research and Development Division (Code 0631B), Washington, D.C. 20390, telephone (202) 697-4561.

SECTION 3

EFFECTIVENESS PROGRAMS

TITLE: System Effectiveness Simulation Model

LANGUAGE: FORTRAN IV

COMPUTER: IBM 7094

DATE OPERATIONAL: June 1967

DESCRIPTION: A straightforward extension of the basic WSEIAC model permits a partition of the capability of the system into that which is contributed by the hardware system and that which is attributable to the human factor. When the functional relationships of the various subsystems have been ascertained, the computer program will accept at subsystem level the quantitatively specified (or demonstrated) MTBF, MTTR, MDT, individual estimates of probability of use for specified system states, and the parameters of the associated capability distributions for both the personnel and hardware subsystems. The computer program will accept information regarding the uncertainty and it will automatically generate sampling distributions of the systems effectiveness for each subsystem and for the overall system.

A potential user may wish to obtain some of the following types of information as output provided that he can furnish the appropriate inputs: (a) A point estimate for each subsystem effectiveness and for the overall system effectiveness for each mission interval and/or for the whole mission. (b) The relative impact on these effectivenesses when uncertainty (variability) in specified combinations of the system attributes. (c) The effect of introducing repairability. (d) Trade-off analysis among system attributes.

COMMENTS: This appears to be a quite flexible and potentially useful program. N. A. Engler, University of Dayton Research Institute, telephone 229-3921 is also familiar with the Air Force Aeronautical Systems Division (ASD) under contract AF33(615)2707. A report has been published (AD-863 449).

SOURCE: Balachandean, V. and Gephart, L. S. (University of Dayton): A Computerized Approach to Simulating System Effectiveness. Proceedings 1971 Annual Symposium on Reliability, Washington, D.C., January 12, 13, 14, 1971, pp. 245-253.

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TITLE: System Effectivity Calculation and Analysis (SECAN)

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL:

DESCRIPTION: This consists of two program modules, RETURN AND EFFCTV. RETURN uses Monte-Carlo simulation to determine the value return distribution function. Input consists of the mission times at which the system state is reviewed and pay allocated accordingly, the pay matrix, and component failure rates. Various performance constraints or success-path criteria are also accepted to be used for pay allocation in special situations. The output of RETURN is a curve which gives the probability of achieving at least a specified value return, e.g., hours of data or incentive fee dollars. The expected return and standard deviation are calculated to show whether system performance can be expected to be satisfactory, and how much margin exists above minimum requirements. EFFCTV performs a system level Markovian value return analysis. The values of given combinations of failed and non-failed system functions are inputs together with failure-rates for the system components. The program evaluates the system state probabilities and performance loss functions, and then determines the expected fraction of full system capability and the cumulative value return as functions of mission time. Questions answered by EFFCTV are: What fraction of full system capability will be available at mission time t? How much returns (hours of data, incentive fee, etc.) have been cumulated from the mission at time t?

COMMENTS: This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis using Computerized Techniques (REACT) developed by the reference source.

SOURCE: Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350, contact T. Turner and J. M. Legg.

TITLE: ASW Ship Effectiveness

LANGUAGE: FORTRAN IV, STRAP

COMPUTER: IBM 7030 (STRETCH)

DATE OPERATIONAL: February 1968

DESCRIPTION: The ASW Ship Effectiveness Program is a computer simulation designed for studying the relative effectiveness of existing or proposed ASW surface ship systems, subsystems, weapons and tactics under likely environmental and tactical conditions. Program input flexibility is sufficient to describe the salient performance characteristics of both surface and subsurface systems, and wide latitude exists for specifying operational concepts and tactical doctrine.

COMMENTS:

SOURCE: Current Mathematical Models (For Digital Computers). Naval Weapons Laboratory (NWL), Dahlgren, Virginia, NWL TR-2390, August 1970, p. 42 (AD-872 919L).

Contact R. L. Kulp, D. R. Snyder, L. E. Perkins, or R. T. Bevan at NWL.

TITLE:	Squadron Performance Effectiveness Analytic Representation (Flight Model), (SPEAR (FLITE))
LANGUAGE:	FORTRAN
COMPUTER:	CDC 3200
DATE OPERATIONAL:	June 1967
DESCRIPTION:	The FLITE model analyzes the mission effectiveness of an aircraft. Several phases of a mission can be studied in terms of degraded mode probability states of required equipments. It is a self-contained segment of SPEAR.
COMMENTS:	
SOURCE:	Naval Air Development Center, (Code SAED/SR), Johnsville, Warminster, Pennsylvania 18974.

SECTION 4

AVAILABILITY PROGRAMS

TITLE: Generalized Effectiveness Methodology (GEM)

LANGUAGE: GEM Language

COMPUTER: CDC 6600

DATE OPERATIONAL: August 1966

DESCRIPTION: The Generalized Effectiveness Methodology (GEM) is a user-oriented computer program for computing one or more of a set of system statistics such as reliability, availability, mean up time, mean down time, effective failure and repair rates, restore time distributions and repairmen utilization. The inputs required are the system model and data in the form of parameters of distributions of times to failure and times to repair for the elementary components of the system. The system model essentially includes the reliability configuration of the system, a set of system failure definitions, and logistic information in terms of repair crews, spares pools and priorities. The system model may include any reliability structure. For systems without repair, the elementary components can be characterized by any one of five distributions of times to failure: exponential, Weibull, gamma, log normal, and truncated normal distributions. For systems with repair, distributions of times to failure, repair, or replacement for the elementary components are assumed to be exponential only. A user-oriented high level source language is used. Inputs written in the GEM Language are used by the GEM Compiler to generate a FORTRAN program. Depending on the problem, solutions by GEM are obtained either by combinatorial methods or by solving a set of linear differential equations describing the system state probabilities, or both. Answers are given in the forms of tables and plots.

COMMENTS: The original GEM program was updated aperiodically. Documents published in 1971 include the Capability Summary (TD 131), User's Manual (TD 114), Reference Manual (TD 115), and Mathematics Library Manual (TD 116).

SOURCE: For documents or further information, contact Naval Electronics Laboratory Center (Code 4100), San Diego, California; or Naval Ships Engineering Center (Code 6102C), Hyattsville, Maryland.

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TITLE: Reliability and Availability Program (RAP)

LANGUAGE: PL/I And Assembly Language

COMPUTER: IBM 360

DATE OPERATIONAL: 1971

DESCRIPTION: RAP is for modeling and evaluating systems with respect to a selection of three statistics: reliability, availability, and transition rates between system states. The program is applicable to systems with repair, active and standby redundancies, multiple operational modes, and multiphase missions. The elementary items of the system are assumed to have times to failure and repair which are described by exponential distributions with constant parameters. Essentially, the inputs to RAP include reliability/maintainability/availability model of the system, item failure and repair rates, and system failure criteria or mission requirements. The model is described in terms of blocks and repair facilities, where a block is a group of identical elementary items or equipments required to perform a system function, while a repair facility is a unit of repair capability to which equipments from one or more blocks may be assigned for repair according to ordered priorities. For the elementary items within each block, RAP offers a choice of two item models which effectively allows one to consider either one or two levels of failure for a given equipment.

COMMENTS: RAP is an updated version of a program called MINI-GEM which was created by extracting a subset of the capabilities from the Generalized Effectiveness Methodology (GEM) program and introducing some simplifications and flexibility. Although both RAP and GEM perform basically the same functions, they do differ in a number of reatures. These include the input/output formats, program size and machine requirements, as well as the types of systems modeled and the statistics evaluated. (See availability program GEM.) A RAP User's Manual, dated September 1971, is available.

SOURCE: RAP was originated by the System Analysis Branch (Code 6112), Ship Concept Design Division, Naval Ships Engineering Center, Hyattsville, Maryland 20782.

TITLE: MAXISIM/TIGER

LANGUAGE: FORTRAN EXTENDED

COMPUTER: CDC 6600, FTN V3.0

DATE OPERATIONAL: 1971

DESCRIPTION: MAXISIM/TIGER is a monte carlo simulation program for estimating reliability and availability of systems with multiphase missions and allowable downtimes. It is generally applicable for systems with series-parallel or m-out-of-n reliability configurations. Elementary items, of the system are assumed to have times to failure and repair described by exponential distributions with constant parameters. The inputs required by the program are essentially the system reliability configuration; mean times to failure and repair, and utilization factors of the equipments; and mission abort criteria. The mission abort criteria are given in terms of the set of allowable downtimes: T_1 is the negligible downtime, T_2 the allowable sustained downtime, and T_3 the cumulative downtime. With this set of criteria, a mission is aborted if either T_2 or T_3 is exceeded by the system downtime. The program offers a number of features or options, including consideration of standby redundancy (at equipment level), choice of repair or no repair during a mission phase, alternate phase schemes, and alternate computer output print-outs.

COMMENTS: The program is basically similar to the MAXISIM/TIGER (See SIM-3). A MAXISIM/TIGER User's Manual, dated December 1971, is available.

SOURCE: MAXISIM/TIGER was generated by the System Analysis Branch (Code 6112), Ship Concept Division, Naval Ships Engineering Center, Hyattsville, Maryland 20782.

TITLE: Precedence List Reliability - Version 3 (PLR-3)

LANGUAGE: FORTRAN

COMPUTER: CDC 3200, IBM 360

DATE OPERATIONAL: 1966

DESCRIPTION: The PLR-3 program was designed to calculate reliability and availability for systems the reliability configurations of which may include series, parallel, and bridge type structures. The program accepts as input a reliability network of the system described by a precedence list, data in the form of equipment failure and repair rates, and time points for which the system reliability and/or availability functions are to be evaluated. It is assumed that all equipment times to failure and repair are exponentially distributed with constant parameters. The system availability is calculated under the assumption of no repair limitations or constraints, while reliability is calculated for systems without repair only. In addition, PLR-3 also performs reliability and availability allocations for serial systems using an equal apportionment method.

COMMENTS: The PLR program was developed for the Navy by the Fundamental Methods Associates, Inc. The original version of the program was called PLR-1, which was updated and became known as PLR-2. The PLR-3 program is the result of the last update. Both PLR-1 and PLR-2 are described in a document entitled "Precedence List Reliability Calculations," October, 1966. PLR-3 was described in another document entitled "Calculation of System Reliability and Availability as a Function of Time by Precedence List Methods," December 1966.

SOURCE: Naval Electronics Laboratory Center (Code 4100), San Diego, California.

TITLE: Mean Up and Down Time Program

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: 1971

DESCRIPTION: Two important measures of system effectiveness are Mean Up-Time (MUT) and Mean Down-Time (MDT). MUT is defined as the average time (in the steady state) the system spends in system up-states after it returns from a system down-state due to completion of a repair. MDT is defined as the average time (in the steady state) the system spends in the system down-states after it enters into one of them due to occurrence of some failure. The concept of viewing the Markov process of a Markovian system as an imbedded Markov chain together with exponential holding time at each system state is employed to simplify the computation. The output is the MUT and MDT, with the input being a partition of the transition rate matrix.

COMMENTS: The listing is in the reference noted below, along with the theoretical development of the method.

SOURCE: Lee, C. T. H. and Duhman, A. (Dynamics Research Corporation, Wilmington, Massachusetts 01887): New Results in Effectiveness Prediction for Markovian Systems. Proceedings 1970 Annual Symposium on Reliability, Washington, D.C., February 3, 4, 5, 1970, pp 410-419.

TITLE: Ship Propulsion Concept Formulation Reliability and Availability Program

LANGUAGE: FORTRAN

COMPUTER: IBM 360/40

DATE OPERATIONAL: 1968

DESCRIPTION: This program was designed to evaluate ships propulsion plants at the concept formulation stage of development. It generates data for computing reliability, reliability with repair, and availability numerics. The program is Monte-Carlo simulation wherein times-to-failure and times-to-repair are exponentially distributed. Input failure and repair data can be in the form of a table, actual distribution or just a mean value for each equipment. Each phase of the mission may be assigned specific constraints, such as minimum downtime, maximum accumulated downtime, configuration and required equipments to be operational. For each phase, the system is described in the usual reliability block diagram. This consists of a series of blocks, each of which contains parallel branches with equipments in series (or single equipments). The program handles active redundancy only - not standby.

COMMENTS: Program listings are in the source reference below.

SOURCE: Langley, Harvey L.: Ship Propulsion Concept Formulation: Reliability and Availability Simulation, Naval Ship Research and Development Laboratory, Annapolis, Maryland, May 1969, 82 pp. (AD 853-075).

TITLE: General Availability Program (GAP)

LANGUAGE: FORTRAN V

COMPUTER: UNIVAC 1108, EXEC 8

DATE OPERATIONAL: 1970

DESCRIPTION: This program performs an availability analysis of a system. Availability of a system is the proportion of time that the system is in acceptable states. This system measure is a function of the mission to be accomplished and is also a function of such mission elements as the system replenishment method, system supply, system production schedules, and system reliability. The system involved in the analysis can be defined at any level of complexity for a component or module all the way up to a large system. The method of analysis used in the program is Monte Carlo. The simulation approach is used because of the inadequacy of closed form methods in considering complexities such as introduced by non-exponential survival functions, non-homogeneous system populations, production constraints, and complex replenishment methods.

COMMENTS: Source below has in its scientific computational library a series of computer programs to perform system effectiveness and related engineering analysis.

SOURCE: Lockheed Missiles and Space Company, Sunnyvale, California, telephone (408) 743-2486. Contact R. L. Ramsey or W. L. Finch.

TITLE: Reliability and Availability Analysis Program

LANGUAGE: Basic

COMPUTER: GE 635, CDC 6400, POP-10

DATE OPERATIONAL: June 1970

DESCRIPTION: A computer program was developed for the time sharing which enables one to compute the reliability of a system composed of up to 100 elements and up to 50 strings of elements. Data input consists of failure rates or MTBF's or probability of successful operation, times of operation, and K factors for each of the elements, and a description of how the elements are configured in the reliability model. At present, active partial redundancy, standby redundancy, and series and series-parallel configurations can be handled by the program in any combination. It is assumed that all elements have exponential failure-time densities. The first step in performing the reliability analysis of a system is to generate the reliability block diagram to identify the various string configurations used in the system. Next, obtain failure rates and operate times for each of the elements. The failure rates may be modified by a single K factor or by separate K factors. These data are then entered via the terminal for the program computation. Outputs are reliability and availability values for each unit, each string configuration and system.

COMMENTS: Source below has a number of related programs.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 268-4100. Contact H. Dagen.

TITLE: Mechanized Assessment of System Reliability (MASER)

LANGUAGE: FORTRAN IV

COMPUTER: GE 615 (time share)

DATE OPERATIONAL:

DESCRIPTION: This consists of two program modules. One module, named FT5, computes reliability for series, parallel and standby with or without command switching. Input consists of mission phase, environmental K-factors, duty cycles and system indenture structure. A printer plot routine is included to graphically display reliability vs. time. The program automatically adjusts to provide the most meaningful output should some inputs be missing. This is extensively used to update reliability estimates. A second module, named SAKA, computes availability, reliability and aggregates costs for three levels of indenture. Both the initial and recurring costs of implementing and maintaining the sub-systems under study are displayed. Since at times certain hardware groupings, called segments, appear in many areas, the output results may be stored for retrieval and use in subsequent calculations.

COMMENTS: This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis Using Computerized Techniques (REACT) developed by the source below.

SOURCE: Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350. Contact T. Turner or J. M. Legg.

TITLE: Reliability and Maintainability Calculations for System Availability

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/30

DATE OPERATIONAL: September 1969

DESCRIPTION: This is a three program system. Program One calculates failure rates and repair rates for each functional block in the system. The rates are determined using actual data values. Program Two calculates subsystem availability for various groups of functional blocks. The SEIAC approach is used to calculate subsystem availability at the end of each mission phase. Program Three summarizes the output from Program Two to calculate system availability at the beginning and end of each mission phase.

Program One produces only punched data for use in Program Two. Program Two prints the subsystem availability for the subsystem states and punched data for use in Program Three. Program Three prints system availability at the beginning and end of each mission phase.

COMMENTS: Source below has a number of related programs.

SOURCE: This program was developed by the ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 268-4100, for the Naval Weapons Quality Assurance Office under contract N00600-69-C-0317. Contact H. J. Kennedy.

SECTION 5

RELIABILITY PROGRAMS

TITLE: Scenario Simulation Program, Version 3 (SIM-3)

LANGUAGE: FORTRAN

COMPUTER: CDC 3200, 3300, IBM 360

DATE OPERATIONAL: 1969

DESCRIPTION: This program was designed for computing mission reliability of a system with allowable downtimes. The mission reliability being computed is the probability that the mission's equipment requirements, which may be different for different phases of a mission, will be met by the system throughout the mission. This program is applicable for systems with reliability configurations which contain series-parallel or m-out-of-n structures; i.e., the system consists of a number of subsystems connected in series, with each subsystem being described by a parallel or m-out-of-n structure. The elementary items of the system are called equipments, for which the times to failure and repair are assumed to have exponential distributions with constant parameters. All equipments of the system are assumed independent, and the system is assumed to have no repair limitations or constraints. The inputs are a reliability configuration of the system for each phase of the mission; equipment mean times to failure and repair: mission abort criteria; and a utilization factor for each equipment. For each computer run, mission success or abort is determined using a monte carlo sampling procedure. The mission reliability is then given by the ratio x/N, where N is the total number of computer runs, and x is the number of runs for which the simulated mission is successful. The outputs may also include all simulated events (equipment failures and mission abort) and the time of their occurrence. The ratio x/N is an estimate of the true mission reliability. The confidence level associated with this estimate is a function of N, the number of computer runs.

COMMENTS: The first and second versions of the Scenario Simulation Program were called SIM-1 and SIM-2, both of which were superceded by SIM-3. All three versions were generated by Naval Applied Science Laboratory (NASL). SIM-3 has been described in Appendix J of the NASL final report on Lab Project 920-72-16.

SOURCE: Naval Electronics Laboratory Center (Code 4100), San Diego, California.

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TITLE: Programmed Analysis and Calculation of Equipment Reliability (PACER)

LANGUAGE: FORTRAN IV

COMPUTER: Most machines 32K (bit) or larger

DATE OPERATIONAL:

DESCRIPTION: PACER calculates the failure-rate of electronic parts and equipment as a function of applied electrical and temperature stress. Input to PACER can range from the detailed failure-modes-and-effects data to the bare minimum of a simple parts list. This program will read a company standard, MIL-HDBK-217A, or a job-oriented parts reliability data library card deck, which consists of the part identity, base failure-rate, and failures mode distribution. In addition, electrical/temperature stress coefficients, minimum failure rate, number of leads, observed average stress, electrical rating, MIL Spec number, part class code, application K-factors, and the limits of failure-rate model applicability are usually supplied. The program automatically recognizes the detail of the input and adjusts the output accordingly. All input information, regardless of detail, is supplied in the same format, using the same coding sheets. This removes the need for special data arrangement for the various analyses and keeps the process simple. Major outputs are: (a) part failure-rates displayed in report format, (b) assembly/circuit total and FMEA failure-rate summaries, (c) inventory count by part type used, (d) total count of weldable/solderable connections per circuit, (e) average electrical stress by part type, (f) library data summary, and (g) logistics spare parts requirements.

COMMENTS: This is part of a collection of related program modules collectively termed Reliability Engineering and Analysis using Computerized Techniques (REACT) developed by the referenced source. Copies of the PACER program are sent to all requestors.

SOURCE: Western Development Laboratories Division of Philco-Ford Corporation, 3939 Fabian Way, Palo Alto, California 94303, telephone (415) 326-4350. Contact T. Turner or J. M. Legg.

TITLE: Bounds for Reliability Analysis of Paths and Cuts

LANGUAGE: Dialect of FORTRAN II

COMPUTER: IBM 360

DATE OPERATIONAL: 1969

DESCRIPTION: This program provides bounds for system reliability. The algorithms are based on the concepts of success paths and cut sets. A listing of the elements in the system, their predecessors, and the probability of successful operation of each element are the inputs. The outputs are the success paths, the cut sets, and a series of upper and lower reliability bounds; these bounds converge to the reliability which would be calculated if all the terms in the model were evaluated. The algorithm for determining the cuts from the success paths is based on Boolean logic and is relatively simple to understand.

COMMENTS: The program listing is contained in the Short Notes section of the May 1971 issue of the journal noted below. Source below also has a number of related programs.

SOURCE: Nelson, Jr., A. C.; et al. (Research Triangle Institute, P.O. Box 12194, Research Triangle Park, North Carolina 27709),: A Computer Program for Approximating System Reliability, IEEE Transactions on Reliability, Vol. R-19, No. 2, May 1970, pp. 61-65.

Contact J. R. Batts of the Research Triangle Institute, telephone (919) 549-8311.

TITLE: System for Computing Operational Probability Equations (SCOPE)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360

DATE OPERATIONAL: July 1969

DESCRIPTION: This program generates a mathematical expression which equates the reliability of a system as a function of the individual reliabilities of its components. The input to SCOPE describes a system network for various mission-oriented phases of operation. This description must be limited to series-parallel expressions and standby situations are not accepted. Three to four hierarchal levels of complexity are accepted (such as component, stage, system, vehicle). SCOPE generates a complete set of minimal paths from which the system reliability equation is obtained. Output is in the form of punched cards.

COMMENTS: This program module prepares input to another program, named APRDCT which is also summarized in this catalog. These, and other related programs were developed by the source below.

SOURCE: These non-proprietary programs were developed under contract by North American Rockwell Space Division, 12214 Lakewood Boulevard, Downey, California 90241, telephone (213) 922-2111. Contact Mike Mezzacapa or C. O. Baker (Director) Design Quality, Reliability and Safety Research, Engineering, and Test.

TITLE: Computer Program for System Reliability

LANGUAGE: FORTRAN IV

COMPUTER: B-5500

DATE OPERATIONAL: 1969

DESCRIPTION: This computer program can be used to analyze the reliability of the following redundant configurations: parallel, partially redundant (non-identical elements) and standby redundant (non-identical elements). In the first two models (i.e., parallel and partially redundant) it is assumed all the elements have been operating continuously. In the standby redundant configurations, elements may be standing by to take over if the primary element fails. The output is such that each block reliability is given in order and system reliability is the last output.

COMMENTS: The method used to calculate system reliability is to consider the system made up of blocks in a series configuration. There is no restriction on the number of blocks in the system. However, at present there is a restriction of six elements in a block. Two input/output formats are available; a freefield data input from a previously prepared disk file, and an on-line interrogation routine.

SOURCE: Niemela, R. J., et al: Computer Program for System Reliability. U. S. Army Electronics Command, Fort Monmouth, New Jersey, March 1970, (AD-706 827).

Contact R. J. Niemela, telephone (201) 535-2264.

TITLE: Reliability Analysis Program

LANGUAGE: FORTRAN

COMPUTER: IBM 1130

DATE OPERATIONAL: August 1968

DESCRIPTION: The program uses electrical and thermal piece part stress levels to calculate equipment reliability in terms of failure rate and MTBF. Constant individual part data including part reliability grade are stored in the program library file and are coded by part number. A data card is required for each part used in the equipment. This data card lists the indentured item number, part number, operational duty cycle and the applied stress levels. The operational use environment is provided on a single header card. The program has the capability of accepting nodal thermal analysis data from an independent thermal analysis program, or of using measured thermal stress levels for the individual parts, or of using an estimated average thermal stress for all parts within a common assembly. The general equations used for calculating the individual part failure rates are those given in the RADC Reliability Notebook.

Output alternates are: (a) Indentured print out by assembly, module, equipment. A failure rate and MTBF is given for each assembly cumulated for each module and for each equipment. (b) All data in accordance with part number. (c) Grand totals only. (d) Module totals only. (e) Part group totals only.

COMMENTS: Electronic Communications, Inc., P.O. Box 12248, St. Petersburg, Florida 33733.

SOURCE: Contact H. Z. Snyder, R. Newbern, or M. Bogart, telephone (813) 347-1121.

TITLE: Weibull Mission Reliability

LANGUAGE: FORTRAN

COMPUTER: IBM 360, GE TIME SHARE MARK II

DATE OPERATIONAL: June 1969

DESCRIPTION: Mission reliability is computed for a system of independent renewal processes where times - between - renewals are identically Weibull distributed. The program is primarily designed to compute reliability versus system age for a system whose parts exhibit either increasing or decreasing hazard rates. It provides system reliability estimates which reflect the effects of non-Markovian behavior through transient and steady state system ages. The input are simply the Weibull shape and scale parameters for each renewal process in the system. The output is a tabulation of system reliabilities for an array of selected system ages at mission start and selected mission durations.

COMMENTS: Source below has a similar program for Erlangian mission reliability and related programs for fitting data. The government sponsor of these programs was the Army Weapons Command under Contract DAAF03-70-C-0040.

SOURCE: Igor Bazovsky and Associates, Inc., 4419 Van Nuys Blvd., Suite 400, Sherman Oaks, California 91403, telephone (213) 986-3550. Contact Evelyne M. Mutchall, E. Sax, or L. Gran.

TITLE: Mission Reliability Model

LANGUAGE: Basic

COMPUTER: GE 625/635

DATE OPERATIONAL: April 1971

DESCRIPTION: A mission reliability model was developed which permits the criticality of specific subsystems to be identified as related to their impact on the mission performance. The developed model utilizes a simple matrix analysis approach to determine the reliability of the system for any specific mission and operating state. The model determines the product of three matrixes which reflect the unit failure rates, percentage of each unit that is required for its operation in a given state during each phase of a specific mission, and the times associated with each phase of the designated mission. The outputs are: failure rate matrix, time matrix, mission reliability at the completion of each phase, series reliability at the completion of each phase, mission related system MTBF, and series MTBF.

COMMENTS: Source below has a number of computer programs in reliability and in related areas.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland, telephone (301) 296-4626. Contact J. Garafola, D. Githens, or J. Witt.

TITLE: Reliability/MTBF

LANGUAGE: FORTRAN IV/COMPASS

COMPUTER: CDC 3300 with MASTER System and CDC 3300 with MSOS System

DATE OPERATIONAL: March 1971

DESCRIPTION: The Reliability/MTBF computer program is a multifaceted system reliability program. It calculates upper and lower MTBF estimates at a specified confidence level on a single equipment and also on a sum of observed equipments based on a Chi-square approximation of the assumed exponential failure distribution of the equipment. Point estimate MTBF values are also calculated. Operational data for these calculations may be entered based on a fixed time observation period or on a fixed number of failure observations. These calculations are performed on a multi-system configuration basis. The program also performs an iterative approximation to system reliability at discrete stepped confidence levels (from .00 to .99). This iterative approximation is derived through cumulative sums of Gamma-distributed random numbers which, when summed, produce a random variable that is Chi-square distributed. The system reliability is produced by evaluating the reliabilities of individual equipments in various redundancy orders. The sequence of equipment evaluations continues until the entire reliability structure of the system is evaluated. The program also considers mean repair time which evaluates the system reliability with varying active mission time requirements (for individual equipments).

COMMENTS: Singer-Librascope, 808 Western Avenue, Glendale, California 91201, telephone (213) 245-8711. This program was developed under NUSC contract N00017-71-C-1204.

SOURCE: Contact Gene F. Swygard, or contact Asa Davis, Naval Underwater Systems Center (NUSC), Newport, Rhode Island.

TITLE: A Program for Estimating Overall System Reliability Based on Component, System and Flight Data (RELY)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6500

DATE OPERATIONAL: January 1969

DESCRIPTION: RELY is a program for estimating overall system reliability based upon test and performance data collected at different levels of assembly and at different periods of time. This program requires as input six sets of attribute-type data consisting of three types of data gathered at two distinct time periods. The three types are as follows: (a) component test results, (b) sub-assembly or circuit test results and (c) flight data from test firings of the missile. These data are weighted by sample-size, time, and complexity level and the resulting factors are assumed to be parameters of a beta-distributed reliability function. A Monte-Carlo simulation of the failure events is used to estimate overall system reliability. Output consists of a histogram and a "best" estimate of mean and variance.

COMMENTS:

SOURCE: T. A. Neef: RELY, A Program for Estimating Overall Systems Reliability Based on Component, System and Flight Data. Picatinny Arsenal, Dover, New Jersey, T. M. 1891, March 1969, 48 pp (AD-684-927).

This program was developed by the Mathematical Analysis Division of the Data Processing Systems Office at Picatinny Arsenal, Dover, New Jersey, telephone (201) 328-3908. Contact B. D. Barnett or T. A. Neef.

TITLE: Network Reliability Analysis Model

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1966

DESCRIPTION: The model accepts component failure rates and a description of the system to compute system reliability. The method of computation is based on Bayes theorem for conditional probabilities. Outputs are: (a) system reliability, and (b) the partial derivative of system reliability with respect to the reliability of each component (these numbers are used to identify weak points in the system).

COMMENTS:

SOURCE: McDonnell Douglas Corporation, 3855 Lakewood Boulevard, Long Beach, California 90801. Contact H. A. Reesing.

TITLE:	Bayesian Confidence Limits for the Reliability of Mixed Exponential and Distribution-Free Cascade Subsystems
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360, UNIVAC 1108
DATE OPERATIONAL:	September 1970
DESCRIPTION:	The posterior cumulative distribution function is derived for the reliability of a system consisting of independent cascade subsystems whose failure density are unknown. A computer program using multiprecision (to any desired level) is operational. Utilizing subsystem test data, it obtains the reliability posterior density in both functional and tabular form, and tabulates the reliability cumulative posterior distribution function for any desired increments, from which Bayesian confidence intervals for system reliability may be obtained. Outputs are: (a) Coefficients and exponents which specify the posterior probability density function of system reliability. (b) Tabulation of h(R) in arbitrary R increments. (c) Tabulation of cumulative posterior distribution function H(R) of system reliability R in arbitrary R increments.
COMMENTS:	
SOURCE:	Industrial Engineering Department, University of Arkansas, Fayetteville, Arkansas 72701, telephone (501) 575-3156. Contact M. D. Springer.

SECTION 6

MAINTAINABILITY PROGRAMS

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TITLE: Maintainability Predictions

LANGUAGE: FORTRAN

COMPUTER: IBM 360

DATE OPERATIONAL: November 1970

DESCRIPTION: This program predicts the maintainability (MTTR) characteristics of electronic equipment. It uses procedure 2 of MIL-HDBK 472. Inputs are: line replaceable units, quantity failure rates, individual task times, an assembly level code, a distribution (normal, lognormal or exponential) code and a percentile for max M. The output is per MIL-HDBK 472, procedure 2 worksheet format.

COMMENTS: Source below has a number of computer programs in related areas.

SOURCE: Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact A. E. Saari or E. W. Umlauf.

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TITLE:	M Demonstration Task Selection
LANGUAGE:	FORTRAN IV
COMPUTER:	IBM 360
DATE OPERATIONAL:	April 1971
DESCRIPTION:	This program selects maintenance tasks to be applied during the M. demonstration test in accordance with the procedure in Appendix A, MIL-STD 471. The inputs are: line replaceable unit name, quantity, and failure rates; and the number of maintenance tasks. The output is a tabular listing of line replaceable units to be submitted for selection of candidates for the M demonstration test, and the percentage of contribution of each candidate to the total system maintenance load.
COMMENTS:	Source below has a number of computer programs in related areas.
SOURCE:	Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact A. E. Saair or E. W. Umlauf.

TITLE: Systems Simulation Submodel (SSS)

LANGUAGE: SIMSCRIPT 1.5

COMPUTER: IBM 360/91

DATE OPERATIONAL: 1970

DESCRIPTION: SSS aggregates information pertaining to the reliability and maintainability of aircraft systems and subsystems, and generates distributions of maintenance action rates, times to repair, and numbers and types of maintenance personnel required. After the system personnel and equipment maintenance requirements are established, SSS moves to a simulation phase, using a Monte Carlo technique. This phase generates demands for personnel and equipment to perform maintenance, after a flight, on a given aircraft system, based on the parameter previously developed using statistical techniques. The utilization of personnel and equipment resources in response to the generated demands can be used to develop probability distributions of the span times that reflect the length of time each type of personnel or equipment is employed.

COMMENTS:

SOURCE: Naval Weapon Systems Analysis Office, Marine Corps Air Station, Quantico, Virginia 22134, telephone (202) OX3-2010. Documentation exists for this program.

SECTION 7

SAFETY PROGRAMS

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TITLE: Fault Tree Analysis

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/75

DATE OPERATIONAL: 1970

DESCRIPTION: This program provides the means by which a fault tree, already constructed, can be evaluated. The fault tree may be of general complexity, may consist of up to 2000 components and 2000 gates, and may include any number of inhibit conditions. The gate structure of the fault tree is limited to "AND" gates and "OR" gates, and the unique components on the tree are assumed to be independent. The program consists of two distinct sets of computer codes: the PREP codes which obtain the minimal cut sets (failure modes) or the minimal path sets (success modes) of the fault tree and the KITT codes which obtain the numerical probabilities associated with the tree. The input data, besides the fault tree itself, are the component failure rates and repair times. The failure rates may be constant or may vary with respect to phasing. The component failures may have constant repair times, exponential repair distributions, or may be nonrepairable. The repair data may be constant or may vary with respect to phases. Any mixture of various types of component failures can be handled, and further, any inhibit conditions may also be incorporated. The probability characteristics which are obtained include unavailability, reliability, expected number of failures, failure rate, and failure intensity. These characteristics are obtained for the system failure, for each component on the fault tree and for each minimal cut set or path set. The characteristics are obtained at arbitrary time points specified by the user.

COMMENTS:

SOURCE: W. E. Vesely and R. E. Narum: PREP and KITT: Computer Codes for the Automatic Evaluation of a Fault Tree, U.S. Atomic Energy Commission Scientific and Technical Report issued under contract AT (10-1)-1230, Idaho Nuclear Corporation report IN-1349 (TID-4500).

This program has also been adapted for use by the Martin-Marietta Corporation, Orlando Division, P.O. Box 5837, Orlando, Florida 32805, telephone (305) 855-6100. Contact F. J. Denny.

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TITLE: Flight Safety

LANGUAGE: COBOL

COMPUTER: UNIVAC 1108, adapted to IBM 360

DATE OPERATIONAL: 1970

DESCRIPTION: Thirteen programs are combined in three evaluation techniques to produce a quantified safety index of malfunction-problem severity. The first of these techniques yields a mathematical model that accepts inputs taken from pilot post-flight debriefings. The second permits systematic identification of the functional relationships of aircraft equipment to flight safety. The third provides functional safety sensitivity indices corresponding to malfunction information from the post-flight debriefings.

Taken together, the three techniques yield a methodology sensitive to the probability of occurrence of an in-flight malfunction and the probability that it will result in accident exposure. Each of the techniques will yield safety criticality indices. That is, three independent sets of indices -- two applicable to pilot-reported symptoms during flight, and one applicable to equipment malfunctions -- can be compiled. The responsiveness to current operations makes this method unique in its ability to currently and continuously rank malfunction problems with respect to their accident potential. This ranking, based on criticality assessment, can provide the basic parameters necessary for analysis of safety versus cost for proposed aircraft modifications, changes in maintenance or flight operations, or even alternative aircraft designs.

COMMENTS:

SOURCE: ARINC Research Corporation, 1222 East Normandy Place, Santa Ana, California 92702, telephone (714) 547-7594. Contact J. G. Fountain or Douglas Kelly.

TITLE: Fault Tree Analysis

LANGUAGE:

COMPUTER:

DATE OPERATIONAL:

DESCRIPTION: This program is directed at the requirements of MIL-S-38130A for quantitative system safety analyses. It calculates fault tree critical path and system probability statistics using Monte Carlo simulation with importance sampling.

COMMENTS: Source below has several different but related programs concerned with fault tree analysis. These include programs which produce plotter tape to automatically produce fault tree diagrams for routine customer documentation.

SOURCE: Boeing Computer Services, Inc., P.O. Box 24346, Seattle, Washington 98124. Contact C. S. Bartholomew.

TITLE: Simulated Analysis of Shipboard Electronics

LANGUAGE: FORTRAN IV

COMPUTER: IBM 7094 or compatible computer

DATE OPERATIONAL:

DESCRIPTION: The simulation model determines safety, readiness, reliability, maintainability and availability parameters of the shipboard electronic system based on Monte Carlo techniques. Each mission is composed of several phases with each phase composed of events (general quarters, etc.). All events of the mission are simulated. When the mission is complete, the result from the simulation in terms of major item, subsystems, systems and functional reliability, maintainability, availability, and safety parameters are determined. In addition, the total number of failures encountered and the maintenance man-hours are available. The simulation uses an "event slicing" approach similar to the General Purpose System Simulator and Simscript Programming Languages. The mission simulation synthesizes the occurrence of scheduled and unscheduled events. The scheduled events are those events which compose the entire mission.

COMMENTS: The inclusion of operational type along with safety parameters broadens the scope of this program.

SOURCE: Eliot, C. C. and Briggs, R. (Raytheon Company, Missile Systems Division, Bedford, Massachusetts): Analysis of Shipboard Electronics Using Simulation Techniques. Proceedings Eighth Reliability and Maintainability Conference, Denver, Colorado, July 7, 8, 9, 1969, pp. 403-416.

SECTION 8

HUMAN FACTORS PROGRAMS

TITLE: System Response Time Simulator (SRTS)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65, CDC 6600

DATE OPERATIONAL: June 1969

DESCRIPTION: This is a user-oriented program specifically designed for simulation of complex multi-station man-machine systems, such as Combat Information Centers. The major design goal of the SRTS is to predict system response time to threat situations under varying load or saturation conditions. The required inputs include the threat scenario in Operational Sequence Diagram (OSD) format; time curves for each man and machine action; the physical arrangement of men and equipment; and the system communication matrix. Overall system response time is determined by summation of Monte Carlo sampling of the time curves. The user can also time any specific subsequence of the system. Each threat can be simulated singularly or in conjunction with other on-going threats, testing system performance under varying load conditions. Each simulation can be replicated as many times as desired, giving estimates of minimum, maximum and average response times.

For each system replication the user receives an event by event listing time of occurrence, performing station and action performed. This simulation log also flags all system delays and communication failures. All clock times are printed out and at the end of the simulation summary statistics are given for each clock. An optional output of each simulation is a CalComp plot of the time line events depicted in the OSD.

COMMENTS: The SRTS has been used in the DLGN-38, CVAN-71, and DLG/DLGN programs. It is scheduled for use in Naval Ships Engineering Center's command control standardization program.

SOURCE: Naval Electronics Laboratory Center, San Diego, California 92152. Contact Dr. R. A. Fleming, Human Factors Technology Division (Code 3400), telephone (714) 225-7372, Autovon 952-7372.

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TITLE: Maintenance Index Computing Program

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1970

DESCRIPTION: This is a computer program that calculates aircraft maintenance manhour requirements. It facilitates the rapid, consistent and valid calculation of mature direct maintenance manhour requirements for any aircraft for which basic description and performance parameters are available, while the aircraft is operated at selected but varied mission requirements. The program prints maintenance manhours required for the specified condition categorized for each system's work unit code at the five levels of organizational and intermediate maintenance.

COMMENTS: This same source has other, related programs which are modularized toward various needs for information such as: Source Model (operational capability analysis), Maintenance Break Rate Program, Maintenance Regeneration Program, Direct and Indirect Maintenance Manpower Program, Maintenance and Support Manning Program, Replenishment Spares Cost Model, and Computerized AGE Requirements Program.

SOURCE: Northrop Corporation, Aircraft Division, 3901 West Broadway, Hawthorne, California 90250, telephone (213) 675-4611. Contact D. D. Gregor.

TITLE: SHIP II

LANGUAGE: FORTRAN IV

COMPUTER: CDC 3800

DATE OPERATIONAL: 1968

DESCRIPTION: SHIP II simulates the operations of an entire destroyer class ship, or part of a ship. Emphasis is placed on those aspects of operations affecting and affected by manpower considerations. Model output statistics include: (a) manhours spent on watch, maintenance, ships work, training, etc. (by man, division, total ship), (b) amount of work and maintenance left undone, (c) equipment status, (d) training and combat readiness evaluation, and (e) many other data categories related to personnel and equipment utilization. All functions involving manpower are simulated. Statistics can be generated for any time interval. A scenario which includes evolution and training requirements drives the model. The model is viewed as a useful tool for manpower planners concerned with both new and existing ships and systems.

COMMENTS: This program appears to be useful for equipment studies as well as for personnel studies.

SOURCE: Naval Personnel Research and Development Laboratory (Code 200), Washington Navy Yard, Washington, D.C. 20390, telephone OX 3-2664.

SECTION 9

OPTIMIZATION PROGRAMS

TITLE: Optimization of Redundancy Subject to Constraints (SYEFF)

LANGUAGE: FORTRAN V

COMPUTER: UNIVAC-1108

DATE OPERATIONAL: 1965

DESCRIPTION: This system is designed to perform system reliability optimization and tradeoff subject to constraints of weight, volume, and cost. The optimization is accomplished by an iterative process in which the program selects which functional element of the system, if made redundant, would result in the largest reliability increase for least penalty in weight, volume, and cost. This element is added to the basic configuration and the process is repeated until either a maximum constraint is reached or the system cost goes through a minimum inflection point. Various outputs are provided for each state solution which includes cumulative weight and volume, total cost, total R&D cost, total opearational cost, expected number of systems required to meet a mission requirement reliability, and system mean life. Additionally, the program takes the UNIVAC 1108 data and provides a plot to a SC4020 microfilm recorder, which produces a plot ouptut in terms of reliability versus time, reliability sensitivity to incremental weight, and, if cost data are included, expected cost versus weight, and cost versus design life.

COMMENTS: Source below has in its scientific computational library a series of computer programs to perform system effectiveness and related engineering analysis.

SOURCE: Lockheed Missiles and Space Company. Sunnyvale, California, telephone (408) 743-2486. Contact R. L [illegible]ay or W. L. Finch.

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TITLE: Provisioning Model for General-Purpose Use by the Aviation Supply Office

LANGUAGE: FORTRAN, COBOL, SPURT

COMPUTER: UNIVAC-490, 494

DATE OPERATIONAL: April 1970

DESCRIPTION: The spares-optimization model provides a method of obtaining an optimum inventory of spare parts at minimum cost. There are two program-cutoff constraints: (a) cost, i.e., the program will stop purchasing spares when a particular cost constraint is reached, and (b) the probability of spares adequacy obtained by minimizing expected stock back orders. Optimization is accomplished by applying an iterative process, which uses the Poisson distribution. The output of the probability-constrained optimization program is an Initial Outfitting List (IOL) and quantities of system stocks (backup stocks). The IOL indicates the quantities of items to be made available at the time of initial outfitting and to be maintained at a specified activity. These items keep the activity in a material-readiness condition. The system-stocks quantity calculated for each item is the quantity of the item to be maintained at a backup spares location, called the "systems stockage point." This location supports all bases, providing spares for items lost because of wearout and for certain types of items that are being repaired. The output is the gross spare parts requirement for a specified distribution of support points as determined by operating plans. The actual level of spares adequacy versus that desired for each base selected is summarized, as is cost.

COMMENTS: This program was developed under Naval Air Systems Command contract N000 19-70-C-0027. Source below has a number of related programs.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 268-4100. Contact Fred Jacoby.

TITLE: A Method for Automatically Selecting Optimum Redundancy

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6500

DATE OPERATIONAL: November 1969

DESCRIPTION: A recently developed computer program, H744, aids in selecting redundant parts and their redundancy type. The program determines the impact of active, standby, and storage redundancy for each component on various system characteristics such as: (a) probability of no system loss, (b) total number of system failures, (c) maintenance time, (d) weight, (e) volume, and (f) recurring cost. The program is unique by assessing the reliability penalties associated with each type of redundancy. With active redundancy, the failure probability of some failure modes (e.g. external valve leakage) is increased. Standby redundancy requires additional switching equipment and storage redundancy necessitates various isolation equipment to effect a replacement.

The program input utilizes component characteristics such as failure rates, failure modes, environmental stress factors, maintenance times, weights, volumes, and cost. Certain system or mission charatteristics are also used as input and include operating times, non-operating times, and number of initial components. The program output is a preferential ranking of redundant components and their redundancy types based on a predetermined selection criterion.

COMMENTS:

SOURCE: McDonnel Douglas Astronautics Company, Huntington Beach, California, telephone (714) 896-4648. Contact W. H. Widawsky.

TITLE: Dynamic Programming for Equipment Replacement (DPER)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/50

DATE OPERATIONAL: January 1971

DESCRIPTION: This model determines the optimum cycle time for equipment replacement when the replacement equipment is identical to the original. The replacement period is dependent upon acquisition cost and the cost or return per unit of use.

COMMENTS:

SOURCE: Naval Seabee Systems Engineering Office (Code 15B), Port Hueneme, California 93043, telephone (805) 982-4942, Autovon 898-3300 X4942.

TITLE: Reliability Versus Cost Model

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360/65

DATE OPERATIONAL: 1969

DESCRIPTION: This program uses dynamic programming techniques to determine the maximum system reliability attainable as a function of a specific cost investment for improved parts. It has been used as a design guide to develop the optimum mix of standard and high-reliability parts in critical electronic systems. The outputs are: (a) Curve of reliability versus dollars available for improved parts. (b) A list of the parts that should be improved (and the required level of improvement) to achieve a given reliability. (c) A list of the parts that should be improved to maximize system reliability under specific cost constraints.

COMMENTS:

SOURCE: McDonnell Douglas Corporation, 3855 Lakewood Boulevard, Long Beach, California 90801. Contact H. A. Reesing.

SECTION 10

ALLOCATION PROGRAMS

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TITLE: S-II Prediction-Apportionment Program (APRDCT)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 360

DATE OPERATIONAL: July 1969

DESCRIPTION: This is a general reliability prediction and approtionment program which allocates contractural reliability goals to lower levels based upon indices developed for each mission phase. These indices are also used to predict reliability from lower to higher levels of system organization. The weighting indices are based upon a combination of the input parameters, which are failure-rates, mission durations and system contractural stage goals, and the input functions which are the system reliability equation and the mission-phase ranking matrix. Output is a tabular listing of components along with the predicted or apportioned reliability by mission-phase and by subsystem, etc.

COMMENTS: This program module accepts inputs from two other programs developed by the same source. The system reliability equation is generated by SCOPE and the mission-phase ranking matrix is developed by a Thurstone-Mosteller program. SCOPE is summarized in this catalog. The Thurstone-Mosteller program is a rating system which computes weighted reliability ranking from paired comparison ranking surveys.

SOURCE: These non-proprietary programs were developed under contract by North American Rockwell, Space Division, 12214 Lakewood Boulevard, Downey, California 90241, telephone (213) 922-2111. Contact Mike Mezzacapa or C. O. Baker (Director), Design Quality, Reliability and Safety Research, Engineering and Test.

TITLE: Generalized Electronic Maintenance Model (GEMM)

LANGUAGE: FORTRAN IV

COMPUTER: B 5500, IBM 360, CDC 6600

DATE OPERATIONAL: July 1971

DESCRIPTION: GEMM is a life-cycle, cost-effectiveness model for logistics trade-offs and maintainability-reliability trade-offs. It is capable of determining the optimum maintenance allocation for a given system based on life-cycle costs. It is also capable of examining one maintenance policy in terms of life-cycle costs and operational availability, maintenance allocation, test equipment and manpower requirements and initial provisioning data. Also, graphical and tabular results of sensitivity analysis are obtained.

COMMENTS:

SOURCE: Systems Analysis Division, Plans and Analysis Directorate, Army Electronics Command, Fort Monmouth, New Jersey 07703, telephone (201) 535-2113, Autovon 99-52113. Contact D. A. Tyburski.

TITLE: Reliability and Maintainability Improvement Priority Assignment Program

LANGUAGE: Basic

COMPUTER: GE 625/635

DATE OPERATIONAL: July 1971

DESCRIPTION: A series of programs have been developed which permit priorities for R and M improvements of alternative systems and subsystems to be assigned on the basis of an optimum strategy. The technique determines the seniority of the total system availability to the R and M improvements to candidate subsystems which may be common to several systems. From the resultant availability improvement to each of the common systems weighted by the number of each type of common system and the system's remaining life a value index is determined. The slope of the value index improvement rate is then identified and used as a basis for identifying the optimum strategy. Improvement goals for each subsystem are defined by improving each to the point where the next system in the ordered list of value indexes has a higher slope. The outputs are: (a) system/subsystem cycle and steady state availabilities under current status, (b) system/subsystem cycle and steady state availability improvement as a function of R or M improvements, (c) subsystem value indexes as a function of R or M improvements, and (d) slope of value indexes as a function of R or M improvements.

COMMENTS: Source below has a number of related programs.

SOURCE: ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401, telephone (301) 295-4626. Contact J. Garafola, D. Githens, or J. Witt.

TITLE:	Maintainability Allocation Techniques
LANGUAGE:	Extended Basic
COMPUTER:	GE 265
DATE OPERATIONAL:	July 1969
DESCRIPTION:	The purpose of this program is to allocate MTTR to individual units or equipments of a system, based on complexity factors. Inputs are unit/group failure rates, complexity factors, and system target MTTR. The output is a tabular listing of unit/group with allocated MTTR's.
COMMENTS:	Source below has a number of related programs.
SOURCE:	Hughes Aircraft Company, P.O. Box 3310, Fullerton, California 92634, telephone (714) 871-3232. Contact E. W. Umlauf or A. E. Saari.

SECTION 11

DATA PROGRAMS

TITLE: Time Series Data Analysis

LANGUAGE: FORTRAN

COMPUTER: IBM 360, GE time share Mark II

DATE OPERATIONAL: June 1969

DESCRIPTION: Times between identical events are computed from time series data for individual items having a given configuration. Weibull and Gamma probability laws are fitted to the times between identical events for the individual items and for the configuration (pooling individual item data). The purposes of the program are: (a) to evaluate age trends of times between events for the individual items, (b) to evaluate differences of times between events from one item to another having the same configuration, (c) to evaluate best-fit Weibull and Gamma shape and scale parameters for use as inputs to an interval reliability program. The Gamma fitting is done using the method of matching moments while the Weibull is fitted by the method of least squares which allows for censored observations.

The output identifies the program title, the configuration and the event effect category (e.g., failure or degradation, etc.). For each effect category the various events within the category are identified. For each event identified, the individual items are identified. For each individual item, a table of item ages and times between events for these ages is printed. For each table, the fitted parameters for Weibull and Gamma laws are printed (mean, standard deviation, shape, scale). If a censored observation exists, its value is printed. After the individual item output, the event effect and event are again identified and best fit parameters are printed for all configuration data and the given event.

COMMENTS: Source below has related programs for fitting data. The government sponsor of these programs is the Army Weapons Command under contract DAAF03-70-C-0040.

SOURCE: Igor Bazovsky and Associates, Inc., 4419 Van Nuys Boulevard, Suite 400, Sherman Oaks, California 91403, telephone (213) 986-3550. Contact E. M. Mitchell, G. Benz, or L. Gran.

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TITLE: Failure Rate Data Program (FARADA)

LANGUAGE: FORTRAN, COBAL and FMSAEG Special

COMPUTER: UNIVAC 1108 with remote terminals

DATE OPERATIONAL: 1968

DESCRIPTION: These programs are for summarizing, integrating and analyzing reliability field experience data. The outputs are statistically presented failure rate and failure mode data prepared from EDP listings and presented in photo-reproduced handbook format.

COMMENTS: Associated publications include FARADA handbooks, instruction book, and special analyzed data reports. Also a quarterly updated computer tapes of handbook data are available on loadn.

SOURCE: FARADA Information Center, Naval Fleet Missile Systems Analysis and Evaluation Group (FMSAEG), (Code 8621), Corona, California 91720, telephone (714) 736-4677. Contact E. T. Richards.

TITLE: Reliability Data Storage/Retrieval Program

LANGUAGE: FORTRAN

COMPUTER: IBM 360/40

DATE OPERATIONAL: September 1970

DESCRIPTION: Solar currently operates an electronic data processing system developed to store reliability/maintainability related data for subsequent rapid and selective retrieval. The program will provide most of the data base for analyses such as life cycle cost, integrated logistics support, reliability/maintainability, etc., but does not perform these tasks automatically. The program can also be used to monitor the failure occurrence/corrective action process on a development project. Selective data retrieval may be by part number, sub-system number, unit serial number, project number, and others. Two output formats are available. The block format contains all the elements of the data base and the other printout is an abstract from the same data base.

COMMENTS:

SOURCE: Solar Division, International Harvester Company, 2200 Pacific Highway, San Diego, California 92112, telephone (714) 233-8241. Contact L. L. Novak or B. M. Gallagher.

SECTION 12

VULNERABILITY PROGRAMS

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TITLE: Assessing Surface Ship Vulnerability (ASSV)

LANGUAGE: FORTRAN IV

COMPUTER: IBM 7090/7094

DATE OPERATIONAL: Believe 1970

DESCRIPTION: A computer program is presented for deriving probabilities of achieving prescribed levels of operational impairment to integrated ship systems as a consequence of possible weapon attacks. The computer solution is based on a Monte Carlo (random draw) technique wherein a high-speed computer generates many random events from which the probability of specific occurrences is then determined. The program essentially takes single-event probabilities of inactivating various possible combinations of system components and derives multiple-event probabilities of inactivating critical combinations associated with prescribed levels of operational impairment. This program can be used to assess vulnerability of any type of ship to any type of weapon attack where the interaction of weapons and ship components can be represented by a single-event probability matrix.

COMMENTS: Program listing is in the reference given below.

SOURCE: R. M. Santamaria: Naval Ship Research and Development Center, Washington, D.C. 20034, A Computer Program for Assessing Surface Ship Vulnerability (ASSV), Report Number NSRDC-2289, December 1970, 63p. (AD-880 285L).

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TITLE: Ship Damage Probability Program

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6400

DATE OPERATIONAL: December 1970

DESCRIPTION: This Monte Carlo program describes single- and multiple-hit internal blast damage to ship targets. Inputs are warhead flight path (azimuth, elevation, velocity, aim point, CEP) and explosive weight in warhead (pounds TNT equivalent). This program can also calculate damage probabilities for uniformly-distributed internal blast rather than aim point-CEP combination. Damage outputs include probabilities of loss of seaworthiness, missile firepower, and mobility and probability of mass detonation, all as a function of number of hits (up to five). A so-called second generation program has been developed, but this has not been converted for use on the CDC. It considers a wider variety of hit conditions, and is not limited to internal blast.

COMMENTS:

SOURCE: Naval Ordnance Laboratory (Code 101), White Oak, Silver Spring, Maryland 20910.

SECTION 13

ELECTROMAGNETIC COMPATIBILITY

TITLE: Shipboard Electromagnetic Compatibility Analysis (SEMCA)

LANGUAGE: FORTRAN IV

COMPUTER: CDC 6700, IBM 360

DATE OPERATIONAL:

DESCRIPTION: SEMCA is an electromagnetic compatibility prediction program designed to calculate and catalog characteristics of all emissions of r-f energy in an isolated environment, and to determine all potential interference sources which can cause interference at each receiver from the total r-f environment. The program is used to process transmitter spectrums through the transmitter channel components, free space, receiver channel components, and the mixer i-f sections of the receiver, and then to predict the spectrum at the output of the last receiver i-f filter.

COMMENTS: There are three versions of this program: SEMCA I, II, and III. The development of these programs has spanned several years.

SOURCE: SEMCA was prepared for the Naval Ship Engineering Center (Code 6179C), Hyattsville, Maryland 20782.

SEMCA III, Volume VIIA, User's Reference Manual, January 1970 (AD-869 295L).

TITLE: General Shielding Effectiveness

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: Believe 1968

DESCRIPTION: This is a computer program for the shielding effectiveness equations for the problem of electromagnetic shielding, applicable within the near field. The principles used in this program have been used historically in the analysis and synthesis of electromagnetic shields. The principal uses of this technique would be: (a) to evaluate theoretical shielding effectiveness for comparison to carefully-obtained test data taken under controlled conditions, (b) to obtain approximate values of shielding effectiveness for some less-controlled set of conditions encountered in practice, and (c) to enable rapid evaluation of the effect of specific parameters upon shielding effectiveness. This program is very simple to use. Material properties data and incident-wave impedance data are placed on data cards, together with the shield thickness and the frequency. The computer printout shows all inputs plus corresponding outputs. Outputs consist of: the absorption loss, both reflection losses, the re-reflection correction term and the total shielding effectiveness, all of which are expressed in db.

COMMENTS: The program listing is in the reference given below. This symposium record (annually) is a source of information about electromagnetic compatibility computer programs.

SOURCE: Adams, W. A. (Martin Marietta Corporation, Denver, Colorado) and Mills, A. H. (General Dynamics Convair, San Diego, California): Electromagnetic Shielding in the Near Field. Electromagnetic Compatibility Symposium Record, Seattle, Washington, July 23, 24, 25, 1968, pp. 317-329.

TITLE: Intra-Vehicle Electromagnetic Compatibility Analysis

LANGUAGE: FORTRAN IV

COMPUTER:

DATE OPERATIONAL: Believe 1971

DESCRIPTION: A computer program was developed to predict and analyze electromagnetic interference between avionics systems on aerospace vehicles. It is an analytic tool to aid the user in establishing intra-vehicle electromagnetic compatibility. The program is used to derive information which is otherwise impractical or difficult to obtain. A study of physical principles, previous work, and practical experience identified four predominant interference coupling paths: antenna-to-antenna, wire-to-wire, electromagnetic field (antenna)-to-wire, and box-to-box. Basic questions and analysis techniques were formulated for each coupling path. These were then assembled into four practical computer analysis programs. The programs are modular and thus can be run separately or combined into one integral program. The report noted below contains a complete description of each program including the mathematical models, basic equations, and analysis procedures used. Examples of the application of the programs together with sample computer outputs are presented.

COMMENTS: This program was sponsored by the Air Force under contract F33615-70-C-1333.

SOURCE: J. L. Bogdanor, et al.: Intra-Vehicle Electromagnetic Compatibility Analysis, Part I., TR-71-155-PT-1, July 1971, 89p. (AD-886 470).

APPENDIX A

CROSS-INDEX

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Acronyms (Program Titles):

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