NASA/SP—2000–6111

Fault Tree Analysis

A Bibliography

National Aeronautics and Space Administration

July 2000

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Introduction

Fault tree analysis is a top–down approach to the identification of process hazards. It is touted as one of the best methods for systematically identifying and graphically displaying the many ways something can go wrong. This bibliography contains references to documents in the NASA Scientific and Technical Information (STI) Database. The selections are based on the major concepts and other NASA Thesaurus terms, including 'reliability analysis.' An abstract is included with most citations.

Items are first categorized by 10 major subject divisions, then further divided into 76 specific subject categories, based on the NASA Scope and Subject Category Guide. The subject divisions and categories are listed in the Table of Contents together with a note for each that defines its scope and provides any cross-references.

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Subject Divisions

Document citations are grouped first by the following divisions. Select a division title to view the category-level Table of Contents.

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Subject Categories of the Division A. Aeronautics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

01   Aeronautics (General)   1

Includes general research topics related to manned and unmanned aircraft and the problems of flight within the Earth's atmosphere. Also includes manufacturing, maintenance, and repair of aircraft. For specific topics in aeronautics see *categories 02 through 09*. For information related to space vehicles see *12 Astronautics*.

02   Aerodynamics   N.A.

Includes aerodynamics of flight vehicles, test bodies, airframe components and combinations, wings, and control surfaces. Also includes aerodynamics of rotors, stators, fans and other elements of turbomachinery. For related information, see also *34 Fluid Mechanics and Heat Transfer.*

03   Air Transportation and Safety   2

Includes passenger and cargo air transport operations; aircraft ground operations; flight safety and hazards; and aircraft accidents. Systems and hardware specific to ground operations of aircraft and to airport construction are covered in *09 Research and Support Facilities (Air)*. Air traffic control is covered in *04 Aircraft Communications and Navigation*. For related information see also *16 Space Transportation and Safety*; and *85 Technology Utilization and Surface Transportation.*

04   Aircraft Communications and Navigation   N.A.

Includes all modes of communication with and between aircraft; air navigation systems (satellite and ground based); and air traffic control. For related information see also *06 Avionics and Aircraft Instrumentation*; *17 Space Communications; Spacecraft Communications, Command and Tracking*, and *32 Communications and Radar.*

05   Aircraft Design, Testing and Performance   3

Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics*. For land transportation vehicles, see *85 Technology Utilization and Surface Transportation.*

06   Avionics and Aircraft Instrumentation   5

Includes all avionics systems, cockpit and cabin display devices; and flight instruments intended for use in aircraft. For related information, see also *04 Aircraft Communications and Navigation; 08 Aircraft Stability and Control; 19 Spacecraft Instrumentation and Astrionics;* and *35 Instrumentation and Photography.*

07 Aircraft Propulsion and Power 5

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft. For related information see also *20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

08 Aircraft Stability and Control N.A.

Includes flight dynamics, aircraft handling qualities; piloting; flight controls; and autopilots. For related information, see also *05 Aircraft Design, Testing and Performance* and *06 Avionics and Aircraft Instrumentation.*

09 Research and Support Facilities (Air) 6

Includes airports, runways, hangars, and aircraft repair and overhaul facilities; wind tunnels, water tunnels, and shock tubes; flight simulators; and aircraft engine test stands. Also includes airport ground equipment and systems. For airport ground operations see *03 Air Transportation and Safety.* For astronautical facilities see *14 Ground Support Systems and Facilities (Space).*

Subject Categories of the Division B. Astronautics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

12 Astronautics (General) 6

Includes general research topics related to space flight and manned and unmanned space vehicles, platforms or objects launched into, or assembled in, outer space; and related components and equipment. Also includes manufacturing and maintenance of such vehicles or platforms. For specific topics in astronautics see *categories 13 through 20.* For extraterrestrial exploration, see *91 Lunar and Planetary Science and Exploration.*

13 Astrodynamics N.A.

Includes powered and free-flight trajectories; and orbital and launching dynamics.

14 Ground Support Systems and Facilities (Space) 7

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and test chambers and simulators. Also includes extraterrestrial bases and supporting equipment. For related information see also *09 Research and Support Facilities (Air).*

15 Launch Vehicles and Launch Operations N.A.

Includes all classes of launch vehicles, launch/space vehicle systems, and boosters; and launch operations. For related information see also *18 Spacecraft Design, Testing, and Performance; and 20 Spacecraft Propulsion and Power.*

16 Space Transportation and Safety N.A.

Includes passenger and cargo space transportation, e.g., shuttle operations; and space rescue techniques. For related information, see also *03 Air Transportation and Safety* and *15 Launch Vehicles and Launch Vehicles,* and *18 Spacecraft Design, Testing and Performance.* For space suits, see *54 Man/System Technology and Life Support.*

17 Space Communications, Spacecraft Communications, Command and Tracking N.A.

Includes space systems telemetry; space communications networks; astronavigation and guidance; and spacecraft radio blackout. For related information, see also *04 Aircraft Communications and Navigation* and *32 Communications and Radar.*

18 Spacecraft Design, Testing and Performance 7

Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and spacecraft control and stability characteristics. For life support systems, see *54 Man/System Technology and Life Support.* For related information, see also *05 Aircraft Design, Testing and Performance, 39 Structural Mechanics,* and *16 Space Transportation and Safety.*

19 Spacecraft Instrumentation and Astrionics N.A.

Includes the design, manufacture, or use of devices for the purpose of measuring, detecting, controlling, computing, recording, or processing data related to the operation of space vehicles or platforms. For related information, see also *06 Aircraft Instrumentation and Avionics;* For spaceborne instruments not integral to the vehicle itself see *35 Instrumentation and Photography;* For spaceborne telescopes and other astronomical instruments see *89 Astronomy, Instrumentation and Photography;* For spaceborne telescopes and other astronomical instruments see *89 Astronomy.*

20 Spacecraft Propulsion and Power 8

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources. For related information, see also *07 Aircraft Propulsion and Power; 28 Propellants and Fuels; 15 Launch Vehicles and Launch Operations;* and *44 Energy Production and Conversion.*

Subject Categories of the Division C. Chemistry and Materials

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

23 Chemistry and Materials (General) 12

Includes general research topics related to the composition, properties, structure, and use of chemical compounds and materials as they relate to aircraft, launch vehicles, and spacecraft. For specific topics in chemistry and materials see *categories 24 through 29.* For astrochemistry see category *90 Astrophysics.*

Subject Categories of the Division D. Engineering

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

39   Structural Mechanics   40

Includes structural element design, analysis and testing; dynamic responses of structures; weight analysis; fatigue and other structural properties; and mechanical and thermal stresses in structure. For applications see *05 Aircraft Design, Testing and Performance* and *18 Spacecraft Design, Testing and Performance.*

Subject Categories of the Division E. Geosciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

42   Geosciences (General)   N.A.

Includes general research topics related to the Earth sciences, and the specific areas of petrology, minerology, and general geology. For other specific topics in geosciences see *categories 42 through 48.*

43   Earth Resources and Remote Sensing   N.A.

Includes remote sensing of earth features, phenomena and resources by aircraft, balloon, rocket, and spacecraft; analysis or remote sensing data and imagery; development of remote sensing products; photogrammetry; and aerial photographs. For instrumentation see *35 Instrumentation and Photography.*

44   Energy Production and Conversion   41

Includes specific energy conversion systems, e.g., fuel cells; and solar, geothermal, windpower, and waterwave conversion systems; energy storage; and traditional power generators. For technologies related to nuclear energy production see *73 Nuclear Physics.* For related information see also *07 Aircraft Propulsion and Power; 20 Spacecraft Propulsion and Power,* and *28 Propellants and Fuels.*

45   Environment Pollution   N.A.

Includes atmospheric, water, soil, noise, and thermal pollution.

46   Geophysics   N.A.

Includes earth structure and dynamics, aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism. For related information see *47 Meteorology and Climatology;* and *93 Space Radiation.*

47   Meteorology and Climatology   N.A.

Includes weather observation forecasting and modification.

48   Oceanography   N.A.

Includes the physical, chemical and biological aspects of oceans and seas; ocean dynamics, and marine resources. For related information see also *43 Earth Resources and Remote Sensing.*

Subject Categories of the Division F. Life Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

51   Life Sciences (General)   N.A.

Includes general research topics related to plant and animal biology (non–human); ecology; microbiology; and also the origin, development, structure, and maintenance, of animals and plants in space and related environmental conditions. For specific topics in life sciences see *categories 52 through 55.*

52   Aerospace Medicine   N.A.

Includes the biological and physiological effects of atmospheric and space flight (weightlessness, space radiation, acceleration, and altitude stress) on the human being; and the prevention of adverse effects on those environments. For psychological and behavioral effects of aerospace environments see *53 Behavioral Science.* For the effects of space on animals and plants see *51 Life Sciences.*

53   Behavioral Sciences   N.A.

Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

54   Man/System Technology and Life Support   42

Includes human factors engineering; bionics, man–machine, life support, space suits and protective clothing. For related information see also *16 Space Transportation* and *52 Aerospace Medicine..*

55   Exobiology   N.A.

Includes astrobiology; planetary biology; and extraterrestrial life. For the biological effects of aerospace environments on humans see *52 Aerospace medicine*; on animals and plants see *51 Life Sciences.* For psychological and behavioral effects of aerospace environments see *53 Behavioral Science.*

Subject Categories of the Division G. Mathematical and Computer Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

59   Mathematical and Computer Sciences (General)   43

Includes general topics and overviews related to mathematics and computer science. For specific topics in these areas see *categories 60 through 67.*

Subject Categories of the Division H. Physics

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

71   Acoustics   N.A.

Includes sound generation, transmission, and attenuation. For noise pollution see *45 Environment Pollution.* For aircraft noise see also *02 Aerodynamics* and *07 Aircraft Propulsion Propulsion and Power.*

72   Atomic and Molecular Physics   72

Includes atomic and molecular structure, electron properties, and atomic and molecular spectra. For elementary particle physics see *73 Nuclear Physics.*

73   Nuclear Physics   72

Includes nuclear particles; and reactor theory. For space radiation see *93 Space Radiation.* For atomic and molecular physics see *72 Atomic and Molecular Physics.* For elementary particle physics see *77 Physics of Elementary Particles and Fields.* For nuclear astrophysics see *90 Astrophysics.*

74   Optics   N.A.

Includes light phenomena and the theory of optical devices. For lasers see *36 Lasers and Masers.*

75   Plasma Physics   N.A.

Includes magnetohydrodynamics and plasma fusion. For ionospheric plasmas see *46 Geophysics.* For space plasmas see *90 Astrophysics.*

76   Solid-State Physics   N.A.

Includes condensed matter physics, crystallography, and superconductivity. For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers.*

77   Physics of Elementary Particles and Fields   N.A.

Includes quantum mechanics; theoretical physics; and statistical mechanics. For related information see also *72 Atomic and Molecular Physics, 73 Nuclear Physics, and 25 Inorganic, Organic and Physical Chemistry.*

Subject Categories of the Division I. Social and Information Sciences

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80   Social and Information Sciences (General)   N.A.

Includes general research topics related to sociology; educational programs and curricula.

81   Administration and Management   73

Includes management planning and research.

82   Documentation and Information Science   N.A.

Includes information management; information storage and retrieval technology; technical writing; graphic arts; and micrography. For computer documentation see *61 Computer Programming and Software*.

83   Economics and Cost Analysis   N.A.

Includes cost effectiveness studies.

84   Law, Political Science and Space Policy   N.A.

Includes: aviation law; space law and policy; international law; international cooperation; and patent policy.

85   Technology Utilization and Surface Transportation   N.A.

Includes aerospace technology transfer; urban technology; surface and mass transportation. For related information see *03 Air Transportation and Safety, 16 Space Transportation and Safety*, and *44 Energy Production and Conversion*. For specific technology transfer applications see also the category where the subject is treated.

Subject Categories of the Division J. Space Sciences

Select a category to view the collection of records cited. N.A. means no abstracts in that category.

88   Space Sciences (General)   N.A.

Includes general research topics related to the natural space sciences. For specific topics in Space Sciences see *categories 89 through 93*.

89   Astronomy   73

Includes observations of celestial bodies, astronomical instruments and techniques; radio, gamma-ray, x–ray, ultraviolet, and infrared astronomy; and astrometry.

90   Astrophysics   N.A.

Includes cosmology; celestial mechanics; space plasmas; and interstellar and interplanetary gases and dust.

91   Lunar and Planetary Science and Exploration   N.A.

Includes planetology; selenology; meteorites; comets; and manned and unmanned planetary and lunar flights. For spacecraft design or space stations see *18 Spacecraft Design, Testing and Performance*.

92   Solar Physics   N.A.

Includes solar activity, solar flares, solar radiation and sunspots. For related information see *93 Space Radiation*.

93   Space Radiation N.A.

Includes cosmic radiation; and inner and outer Earth radiation belts. For biological effects of radiation on plants and animals see *52 Aerospace Medicine*. For theory see *73 Nuclear Physics*.

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99   General 74

Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs such as Apollo, Gemini, and Mercury spacecraft, Earth Resources Technology Satellite (ERTS), and Skylab; NASA appropriations hearings.

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Typical Report Citation and Abstract

❶ 19970001126 NASA Langley Research Center, Hampton, VA USA

❷ Water Tunnel Flow Visualization Study Through Poststall of 12 Novel Planform Shapes

❸ Gatlin, Gregory M., NASA Langley Research Center, USA Neuhart, Dan H., Lockheed Engineering and Sciences Co., USA;

❹ Mar. 1996; 130p; In English

❺ Contract(s)/Grant(s): RTOP 505-68-70-04

❻ Report No(s): NASA-TM-4663; NAS 1.15:4663; L-17418; No Copyright; Avail: CASI; A07, Hardcopy; A02, Microfiche

❼   To determine the flow field characteristics of 12 planform geometries, a flow visualization investigation was conducted in the Langley 16- by 24-Inch Water Tunnel. Concepts studied included flat plate representations of diamond wings, twin bodies, double wings, cutout wing configurations, and serrated forebodies. The off-surface flow patterns were identified by injecting colored dyes from the model surface into the free-stream flow. These dyes generally were injected so that the localized vortical flow patterns were visualized. Photographs were obtained for angles of attack ranging from 10' to 50', and all investigations were conducted at a test section speed of 0.25 ft per sec. Results from the investigation indicate that the formation of strong vortices on highly swept forebodies can improve poststall lift characteristics; however, the asymmetric bursting of these vortices could produce substantial control problems. A wing cutout was found to significantly alter the position of the forebody vortex on the wing by shifting the vortex inboard. Serrated forebodies were found to effectively generate multiple vortices over the configuration. Vortices from 65' swept forebody serrations tended to roll together, while vortices from 40' swept serrations were more effective in generating additional lift caused by their more independent nature.

❽ Author

❾ *Water Tunnel Tests; Flow Visualization; Flow Distribution; Free Flow; Planforms; Wing Profiles; Aerodynamic Configurations*

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FAULT TREE ANALYSIS

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01
AERONAUTICS (GENERAL)

Includes general research topics related to manned and unmanned aircraft and the problems of flight within the Earth's atmosphere. Also includes manufacturing, maintenance, and repair of aircraft. For specific topics in aeronautics see categories 02 through 09. For information related to space vehicles see 12 Astronautics.

19850008446 McDonnell Aircraft Co., Saint Louis, MO, USA
Avionics fault tree analysis and artifical intelligence for future aircraft maintenance
Harris, M. E., McDonnell Aircraft Co., USA; Snodgrass, T. D., McDonnell Aircraft Co., USA; AGARD Design for Tactical Avionics Maintainability; Oct 1, 1984, pp. 12 p; In English; See also N85-16731 08-01; Avail: CASI; A03, Hardcopy; A03, Microfiche

The avionics fault tree analyzer (AFTA) was developed as an interim support tool for the Navy prior to attainment of total organic support capability, and as an alternate method of support to reduce life cycle/cost for F/A-18 foreign military sales. With the transformation of the AFTA concept from ground support equipment to avionics, a quantitative improvement in life cycle costs will be obtained through the application of artificial intelligence (AT) techniques. The AI is expected to see applications to practical problems in many disciplines; and one of which is the implementation of military fault diagnostic systems. A smart BIT was developed which will reduce false alarms, identify intermittent failures, and improve fault isolation to the lowest possible element by AI technique. Increasing density of computer memory, modularly designed avionic functions and the use of very large scale, and high speed integrated devices will allow future aircraft to fly with the AFTA function. Ramifications such as eliminating the need for intermediate avionic repair facilities, increased aircraft operational readiness, decrease in aircraft recurring costs, and a reduction in spares investment are discussed. The AFTA concept, life cycle cost advantages, and the implementation of artificial intelligence in future avionic designs relative to improved reliability and maintainability are summarized.
E.A.K.
Aircraft Maintenance; Artificial Intelligence; Avionics; Fault Trees

19910032617
Aging Army aircraft
Neri, Lewis, U.S. Army, Aviation Systems Command, Corpus, USA; Jan 1, 1990; 10p; In English; 46th; AHS, Annual Forum, May 21-23, 1990, Washington, DC, USA; See also A91-17201; Copyright; Avail: Issuing Activity

Reliability-centered maintenance is a broadbased management and system engineering program that emphasizes a preventive approach to maintenance. Corrosion detection and prevention are principal concerns in this program which utilizes an analytical approach based on fault tree analysis to facilitate development of improved airframe condition evaluation/aircraft analytical corrosion evaluation and preshop analysis. The U.S. Army Depot Engineering and Reliability Centered Maintenance Support Office is also investigating ion implantation and plasma chemical vapor deposition techniques to determine their feasiblity for prevention of corrosion.
AIAA
Aging (Materials); Corrosion Prevention; Military Aircraft; Military Technology; Structural Failure

Includes passenger and cargo air transport operations; aircraft ground operations; flight safety and hazards; and aircraft accidents. Systems and hardware specific to ground operations of aircraft and to airport construction are covered in 09 Research and Support Facilities (Air). Air traffic control is covered in 04 Aircraft Communications and Navigation. For related information see also 16 Space Transportation and Safety; and 85 Technology Utilization and Surface Transportation.

19950004035 Rolls-Royce Ltd., Industrial and Marine Gas Turbines., Coventry, West Midlands, UK
The application of aerospace safety and reliability analysis techniques to high speed marine transport
Moore, T. C., Rolls-Royce Ltd., UK; Wilkinson, B., Rolls-Royce Ltd., UK; May 7, 1992; 14p; In English; Safety for High Speed Passenger Craft: The Way Ahead, 7-8 May 1992, London, UK
Report No.(s): PNR-91071; Copyright; Avail: Issuing Activity (European Space Agency (ESA)), Unavail. Microfiche; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
    The application of aerospace safety and reliability techniques to high speed marine craft is discussed, taking into account the following: why failures occur; how safety is demonstrated; what is gained from safety and reliability analyses; the techniques used; and the cost of such analyses. It is concluded that the application of aerospace safety and reliability techniques in their entirety to high speed marine craft would impose an unnecessary burden both in terms of the time scales, complexity of the task, and the associated costs involved. The judicious use of Fault Tree Analysis (FTA), coupled with a Failure Mode Effect Significance Analysis (FMESA) study at a functional rather than at a component level, can provide a cost effective means of demonstrating objectively the safety and reliability levels of a high speed marine craft. This is of vital importance to an industry where the individual craft design production levels are unlikely to be high when compared with the aircraft industry. The use of PC (Personal Computer) based FMEA and FTA software could further reduce the cost, particularly the 'first time' cost.
ESA
Air Transportation; Failure Analysis; Fault Trees; Marine Transportation

19980160660
Implementation of an integrated safety-program - The MD-90 antiskid system
Redgate, Marianne L., Douglas Aircraft Co., USA; McKelvey, Michael H., Douglas Aircraft Co., USA; Jolly, Carolyn L., Douglas Aircraft Co., USA; 1994, pp. 52-58; In English; Copyright; Avail: Aeroplus Dispatch
    At Douglas Aircraft Company (DAC), an integrated safety program is comprised of four major analyses, each of which is intended to provide design requirements and results that satisfy DAC, FAA, and Joint Aviation Administration requirements to maximize safety for the airplane, the flying public, and the public-at-large. These four analyses are: functional hazard analysis, system failure mode and effects analysis, fault tree analysis, and zonal analysis. Every new or major-modified system designed for DAC's latest airplane, the MD-90, incorporates an integrated safety program. One such system, the antiskid system, has repeatedly used the integrated safety program as a primary design tool and is a particularly satisfying example of what DAC calls 'Design for Safety'.
Author (AIAA)
Aircraft Safety; Systems Integration; Failure Modes; Fault Trees; Aircraft Design

19980207345
Safety assessment of aircraft mounted systems
Trotta, Luigi, Alenia Aerospazio, Italy; Buffardi, Riccardo, Alenia Aerospazio, Italy; Querzoli, Rodolfo, Alenia Aerospazio, Italy; Sep. 1998; In English
Report No.(s): ICAS Paper 98-6,7,3; Copyright; Avail: Aeroplus Dispatch
    This contribution highlights methodology to assess the safety aspects of military aircraft systems, a part of a fly-by-wire A/C. The correlations between FMECA and Safety Assessment will be shown to identify all possible hazards caused by single failures. A tool using fault tree analysis approach, to assess from a quantitative and qualitative point of view the discovered hazards, identifies the minimal cut sets and critical items in the system configuration. Zonal hazard analysis is used to show how to identify the hazards due to the physical location of the system components and the possible effects due to component failures, disadvantageous operating conditions, maintenance errors, and environment induced faults. Software safety assessment is performed to analyze and assess the safety of the software configuration items of a system and ensure that a risk classification is allocated appropriate to the severity of hazard which could be caused by a software error. These results lead to a definition of

the critical areas and the possible corrective actions, providing a compliance statement for system qualification and airworthiness requirements.
Author (AIAA)
Military Aircraft; Aircraft Safety; Fly by Wire Control; Fault Trees; Software Development Tools

19980210315 Brookhaven National Lab., Upton, NY USA
On the safety of aircraft systems: A case study
Martinez–Guridi, G., Brookhaven National Lab., USA; Hall, R. E., Brookhaven National Lab., USA; Fullwood, R. R., Brookhaven National Lab., USA; May 14, 1997; 45p; In English
Contract(s)/Grant(s): DE-AC02-76CH-00016; 95-G-039
Report No.(s): BNL-64946; DE98-002766; No Copyright; Avail: Issuing Activity (Natl Technical Information Service (NTIS)), Hardcopy, Microfiche

An airplane is a highly engineered system incorporating control- and feedback-loops which often, and realistically, are non-linear because the equations describing such feedback contain products of state variables, trigonometric or square-root functions, or other types of non-linear terms. The feedback provided by the pilot (crew) of the airplane also is typically non-linear because it has the same mathematical characteristics. An airplane is designed with systems to prevent and mitigate undesired events. If an undesired triggering event occurs, an accident may process in different ways depending on the effectiveness of such systems. In addition, the progression of some accidents requires that the operating crew take corrective action(s), which may modify the configuration of some systems. The safety assessment of an aircraft system typically is carried out using ARP (Aerospace Recommended Practice) 4761 (SAE, 1995) methods, such as Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA). Such methods may be called static because they model an aircraft system on its nominal configuration during a mission time, but they do not incorporate the action(s) taken by the operating crew, nor the dynamic behavior (non-linearities) of the system (airplane) as a function of time. Probabilistic Safety Assessment (PSA), also known as Probabilistic Risk Assessment (PRA), has been applied to highly engineered systems, such as aircraft and nuclear power plants. PSA encompasses a wide variety of methods, including event tree analysis (ETA), FTA, and common-cause analysis, among others. PSA should not be confused with ARP 4761's proposed PSSA (Preliminary System Safety Assessment); as its name implies, PSSA is a preliminary assessment at the system level consisting of FTA and FMEA.
DOE
Failure Analysis; Safety Factors; Feedback Control; Aeronautics

05
AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also 18 Spacecraft Design, Testing and Performance and 39 Structural Mechanics. For land transportation vehicles, see 85 Technology Utilization and Surface Transportation.

19720011367 University of Southern California, Inst. of Aerospace Safety and Management., Los Angeles, CA, USA
Analytical techniques for effective maintenance
Hall, D. S., University of Southern California, USA; Holt, E. L., University of Southern California, USA; Jan 1, 1971; 14p; In English; 7th; Ann. Intern. Aviation Maintenance Symp., 7-9 Dec. 1971, Oklahoma City; Avail: CASI; A03, Hardcopy; A01, Microfiche

Systems analysis techniques are applied to aircraft maintenance to achieve aviation safety. The failure mode analysis method is discussed along with the fault tree analysis method. It is concluded: (1) The maintenance manager needs to know how to make decisions and that these decisions affect the safety and efficiency of his operation. (2) Many of these decisions can be made in advance when time or other pressure is not a factor. (3) Greater knowledge of the implications of a decision is available to the individual who approaches each problem systematically. (4) Systematic and analytical decision making is within the capability of today's maintenance activity.
CASI
Aircraft Maintenance; Aircraft Safety; Failure Analysis; Systems Analysis

19760057160
Seeking failure-free systems
Merkling, R. E., USAF, USA; Air University Review; Aug 1, 1976; 27, pp. July-Aug; In English; 1976, p. 41-50; Avail: Issuing Activity

The need for developing failure-free systems for USAF aircraft is advocated, with figures relating major aircraft accidents and costs. Fault tree analysis is described and applied to fire threat and prevention on fighter aircraft.
AIAA
Accident Prevention; Aircraft Accidents; Fail-Safe Systems; Fighter Aircraft; Fire Prevention

19890059099
Probabilistic analysis of aircraft structure
Zielinski, Paul A., Boeing Military Airplane Co., USA; Jan 1, 1989; 6p; In English; Annual Reliability and Maintainability Symposium, Jan. 24-26, 1989, Atlanta, GA, USA; See also A89-46451 20-38; Copyright; Avail: Issuing Activity

Probabilistic structural mechanics (PSM) has been promoted for use in the design of products. The author presents the practical methods for applying PSM to critical aircraft component fault-tree analysis. The B-1B Common Strategic Rotary Launcher (CSRL) fault-tree analysis is used as a demonstative example of mechanical component failure probabilities calculated using PSM. The CSRL components demonstrate how this methodology accounts for aircraft limit loads, limit load exceedances per flight hour, material properties, and stress analysis or structural test results.
AIAA
Aircraft Structures; Failure Analysis; Fault Trees; Probability Theory; Stress Analysis; Structural Reliability

19980117945
The service reliability analysis for the brake unit of a certain model aircraft
Fu, Changan, Air Force Aero College No. 2, China; Wang, Yuanda, Air Force Aero College No. 2, China; 1995, pp. 79-82; In English; Copyright; Avail: Aeroplus Dispatch

When aircraft of certain models land and the pilots brake, the service tire skidding and tire blowout are frequently occurring faults, endangering the landing safety. After having investigated and analyzed such incidents, the departments concerned think the fault is mainly caused by the improper brake operation when the aircraft lands. Using the fault tree analysis method, the paper first discusses the causes which result in severe tire skidding and blowout when the aircraft is braked, then presents some factors which the pilots and the ground crew should pay attention to in the actual use and maintenance work. Finally, improvements in the structure of the decelostat are proposed.
Author (AIAA)
Service Life; Reliability Analysis; Aircraft Brakes; Aircraft Models; Fault Trees; Skidding

19980139158
Heavy transport aircraft reliability study
Chiesa, S., Torino, Politecnico, Italy; Gianotti, P., Torino, Politecnico, Italy; Maggiore, P., Torino, Politecnico, Italy; 1996, pp. 682-690; In English; Copyright; Avail: AIAA Dispatch

The analysis of safety and reliability is of primary importance during the design of a modern, large complex aircraft. On the other other hand, the intrinsic complexity of large, multiple-redundant systems usually impose severe limitations on both the depth and the extension of this analysis. In this work, a computer program for the reliability analysis of a generic system is presented, underlining the advantages of a computer-based approach to the problem. The philosophy which stands behind such an approach consists of a tailoring of well-known Failure Modes and Effect Analysis and Fault Tree Analysis techniques. The results of the automatic analysis include symbolic evaluation of fault and functional trees, minimal-paths and minimal cut sets determination, and sensitivity analysis.
Author (AIAA)
Transport Aircraft; Aircraft Reliability; Aircraft Design; Expert Systems; Fault Trees

4

Includes all stages of design of aircraft and aircraft structures and systems. Also includes aircraft testing, performance, and evaluation, and aircraft and flight simulation technology. For related information, see also 18 Spacecraft Design, Testing and Performance and 39 Structural Mechanics. For land transportation vehicles, see 85 Technology Utilization and Surface Transportation.

19940034825 NASA Ames Research Center, Moffett Field, CA, USA
A quantitative analysis of the F18 flight control system
Doyle, Stacy A., Duke Univ., USA; Dugan, Joanne B., Virginia Univ., USA; Patterson–Hine, Ann, NASA Ames Research Center, USA; In: AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 (A94-11401 01-62); 1993, pp. 668-675.; In English; See also A94-11401
Contract(s)/Grant(s): NCA2-617
Report No.(s): AIAA PAPER 93-4574; Copyright; Avail: Issuing Activity
    This paper presents an informal quantitative analysis of the F18 flight control system (FCS). The analysis technique combines a coverage model with a fault tree model. to demonstrate the method's extensive capabilities, we replace the fault tree with a digraph model of the F18 FCS, the only model available to us. The substitution shows that while digraphs have primarily been used for qualitative analysis, they can also be used for quantitative analysis. Based on our assumptions and the particular failure rates assigned to the F18 FCS components, we show that coverage does have a significant effect on the system's reliability and thus it is important to include coverage in the reliability analysis.
Control Systems Design; F-18 Aircraft; Failure Modes; Fault Trees; Flight Control; Reliability Analysis

19980147707
Dynamic fault tree analysis for the Digital Fly-By-Wire Flight Control System
Yao, Yiping, Beijing Univ. of Aeronautics and Astronautics, China; Yang, Xiaojun, Beijing Univ. of Aeronautics and Astronautics, China; Li, Peiqiong, Beijing Univ. of Aeronautics and Astronautics, China; 1996, pp. 479-484; In English; Copyright; Avail: AIAA Dispatch
    The Digital Fly-By-Wire (FBW) FCS is designed to a achieve high level of reliability, and frequently employs high level of redundancy. The dynamic redundancy employed in the FBW system can realize complex fault and error diagnosis, recovery, and reconfiguration. It is very difficult to analyze the reliability of the FBW system by traditional methods, such as fault tree analysis (FTA) or network analysis. This paper describes dynamic fault-tree modeling techniques for handling these difficulties and provides a Markov chain generation modeling method for converting the dynamic fault tree to the Markov chain. The software failure of the FBW system can also be considered in the model. An example of a quadruple FBW redundant system and a Markov state transition chain software package is given.
Author (AIAA)
Fault Trees; Fly by Wire Control; Digital Systems; Dynamic Models

07
AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft. For related information see also 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels, and 44 Energy Production and Conversion.

19800072732 Science Applications, Inc., Palo Alto, CA, USA
Fault tree analysis for reliability prediction of gas turbine type power plants. Volume 2: Appendixes *Final Report*
Kelly, J. E., Science Applications, Inc., USA; Erdmann, R. C., Science Applications, Inc., USA; Gilbert, K., Science Applications, Inc., USA; Jun 1, 1978; 85p; In English; Sponsored by EPRI
Report No.(s): EPRI-AF-811-VOL-2-APP; Avail: CASI; A05, Hardcopy, Microfiche
    No abstract.
Electric Power Plants; Fault Trees; Gas Turbines; Performance Prediction; Systems Analysis

19950004033 Rolls-Royce Ltd., Industrial and Marine Gas Turbines., Coventry, West Midlands, UK
The reliability of aero-derived marine gas turbines
Moore, Tim C., Rolls-Royce Ltd., UK; Wilkinson, Brian, Rolls-Royce Ltd., UK; Jan 1, 1992; 17p; In English; High Speed Surface Craft Conference, Jan. 1992, London, UK
Report No.(s): PNR-90982; Copyright; Avail: Issuing Activity (European Space Agency (ESA)), Unavail. Microfiche; Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

An overview of work carried out to assess the safety and reliability of the Marine Spey, a marine propulsion gas turbine unit, is reported. The question of the limit of safety inherent in reliability of an aeroengine is considered. Failure probabilities are defined both qualitatively and quantitatively, and it is shown how the combination of failure effect category and probability rank defines the risk level. Means of assessing the capability of a design to comply to the reliability standards are addressed. These can take the form of a Failure Mode Effects Analysis (FMEA), Failure Mode Effect Criticality Analysis (FMECA), or a Failure Mode Effect Systems Analysis (FMESA). The latter investigates the significance of a system or subsystem failure on the operation of the overall plant. The use of FMESA studies on aero derived marine gas turbines is considered, and the safety and reliability in fast ferries is discussed. Modern FEA techniques, which include the Fault Tree Analysis (FTA) used to assess safety, control and protection system reliability, are considered.
ESA
Engine Design; Engine Failure; Failure Analysis; Gas Turbine Engines; Marine Propulsion; Reliability; System Failures

09
RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, runways, hangars, and aircraft repair and overhaul facilities; wind tunnels, water tunnels, and shock tubes; flight simulators; and aircraft engine test stands. Also includes airport ground equipment and systems. For airport ground operations see 03 Air Transportation and Safety. For astronautical facilities see 14 Ground Support Systems and Facilities (Space).

19840068890 Minority Enterprise Service Associates, Orem, UT, USA
Large-coil-test facility fault-tree analysis
May 31, 1982; 168p; In English
Contract(s)/Grant(s): DE-AC01-81ER-52074
Report No.(s): DE83-002783; DOE/ER-52074-T1; Avail: CASI; A08, Hardcopy, Microfiche
No abstract.
Cryogenics; Fault Trees; Parameter Identification; Safety; Systems

19690031585 Battelle Northwest Labs., Pacific Northwest Lab., Richland, WA, USA
Preliminary fault tree analysis for the FFTF
Mc Laughlin, M. A., Battelle Northwest Labs., USA; May 1, 1969; 37p; In English
Contract(s)/Grant(s): AT/45-1/-1830
Report No.(s): BNWL-874; Avail: CASI; A03, Hardcopy; A01, Microfiche
Preliminary fault tree analysis for FFTF
CASI
Failure Analysis; Nuclear Research and Test Reactors; Reactor Safety; Trees (Mathematics)

12
ASTRONAUTICS (GENERAL)

Includes general research topics related to space flight and manned and unmanned space vehicles, platforms or objects launched into, or assembled in, outer space; and related components and equipment. Also includes manufacturing and maintenance of such vehicles or platforms. For specific topics in astronautics see categories 13 through 20. For extraterrestrial exploration, see 91 Lunar and Planetary Science and Exploration.

19920073157 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Making the Hubble Space Telescope servicing mission safe
Bahr, N. J., NASA Goddard Space Flight Center, USA; Depalo, S. V., Hernandez Engineering, Inc., USA; Aug 1, 1992; 12p; In English
Contract(s)/Grant(s): NAS5-30917

Report No.(s): IAF PAPER 92-0380; Copyright; Avail: Issuing Activity

The implementation of the HST system safety program is detailed. Numerous safety analyses are conducted through various phases of design, test, and fabrication, and results are presented to NASA management for discussion during dedicated safety reviews. Attention is given to the system safety assessment and risk analysis methodologies used, i.e., hazard analysis, fault tree analysis, and failure modes and effects analysis, and to how they are coupled with engineering and test analysis for a 'synergistic picture' of the system. Some preliminary safety analysis results, showing the relationship between hazard identification, control or abatement, and finally control verification, are presented as examples of this safety process.

AIAA

Flight Safety; Hubble Space Telescope; NASA Space Programs; Orbital Servicing; Space Shuttle Missions

14
GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters; and test chambers and simulators. Also includes extraterrestrial bases and supporting equipment. For related information see also 09 Research and Support Facilities (Air).

19980173949

Dynamic real-time radioscopy of Space Shuttle reusable solid rocket motor during static firing

Rogerson, D. J., U.S. Navy, Naval Air Warfare Center, USA; Jul. 1995; In English

Report No.(s): AIAA Paper 95-2727; Copyright; Avail: Aeroplus Dispatch

In 1993, engineers were tasked to investigate the cause of the pressure perturbations occurring in the Reusable Solid Rocket Motor (RSRM) following the deviation in the predicted pressure trace in STS-54. An initial fault tree analysis indicated that the most probable source for pressure perturbation in the RSRM was the expulsion of aluminum oxide slag accumulated between the submerged portion of the nozzle and the motor aft dome. Three static firings were completed using real-time radioscopy (RTR). The dynamic data from the RTR system, in conjunction with data from other instrumentation, strongly supported slag expulsion as the primary cause for pressure perturbations in the RSRM.

Author (AIAA)

Real Time Operation; Space Shuttles; Solid Propellant Rocket Engines; Rocket Firing; Reusable Rocket Engines; X Ray Imagery

18
SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes satellites; space platforms; space stations; spacecraft systems and components such as thermal and environmental controls; and spacecraft control and stability characteristics. For life support systems, see 54 Man/System Technology and Life Support. For related information, see also 05 Aircraft Design, Testing and Performance, 39 Structural Mechanics, and 16 Space Transportation and Safety.

19930016042 NASA, Washington, DC, USA

Tethered Satellite System Contingency Investigation Board *Final Report*

Nov 6, 1992; 51p; In English

Report No.(s): NASA-TM-108704; NAS 1.15:108704; Avail: CASI; A04, Hardcopy; A01, Microfiche

The Tethered Satellite System (TSS-1) was launched aboard the Space Shuttle Atlantis (STS-46) on July 31, 1992. During the attempted on-orbit operations, the Tethered Satellite System failed to deploy successfully beyond 256 meters. The satellite was retrieved successfully and was returned on August 6, 1992. The National Aeronautics and Space Administration (NASA) Associate Administrator for Space Flight formed the Tethered Satellite System (TSS-1) Contingency Investigation Board on August 12, 1992. The TSS-1 Contingency Investigation Board was asked to review the anomalies which occurred, to determine the probable cause, and to recommend corrective measures to prevent recurrence. The board was supported by the TSS Systems Working group as identified in MSFC-TSS-11-90, 'Tethered Satellite System (TSS) Contingency Plan'. The board identified five anomalies for investigation: initial failure to retract the U2 umbilical; initial failure to flyaway; unplanned tether deployment stop at 179 meters; unplanned tether deployment stop at 256 meters; and failure to move tether in either direction at 224 meters. Initial observations of the returned flight hardware revealed evidence of mechanical interference by a bolt with the level wind mechanism travel as well as a helical shaped wrap of tether which indicated that the tether had been unwound from the reel beyond the travel by the level wind mechanism. Examination of the detailed mission events from flight data and mission logs related to the initial

failure to flyaway and the failure to move in either direction at 224 meters, together with known preflight concerns regarding slack tether, focused the assessment of these anomalies on the upper tether control mechanism. After the second meeting, the board requested the working group to complete and validate a detailed integrated mission sequence to focus the fault tree analysis on a stuck U2 umbilical, level wind mechanical interference, and slack tether in upper tether control mechanism and to prepare a detailed plan for hardware inspection, test, and analysis including any appropriate hardware disassembly.
Author
Failure Analysis; Space Shuttle Payloads; Spaceborne Experiments; Tethered Satellites; Tethering

19940021785 NASA Ames Research Center, Moffett Field, CA, USA
Simulation modeling for long duration spacecraft control systems
Boyd, Mark A., NASA Ames Research Center, USA; Bavuso, Salvatore J., NASA Langley Research Center, USA; NASA. Langley Research Center, Selected Topics in Robotics for Space Exploration; Dec 1, 1993, pp. p 213-221; In English; See also N94-26278 07-12; Avail: CASI; A02, Hardcopy; A03, Microfiche
    The use of simulation is described and it is contrasted to analytical solution techniques for evaluation of analytical reliability models. The role importance sampling plays in simulation of models of this type was also discussed. The simulator tool used for our analysis is described. Finally, the use of the simulator tool was demonstrated by applying it to evaluate the reliability of a fault tolerant hypercube multiprocessor intended for spacecraft designed for long duration missions. The reliability analysis was used to highlight the advantages and disadvantages offered by simulation over analytical solution of Markovian and non-Markovian reliability models.
Author (revised)
Fault Tolerance; Fault Trees; Hypercube Multiprocessors; Long Duration Space Flight; Mathematical Models; Reliability Analysis

19960047783 Naval Postgraduate School, Monterey, CA USA
Critical Failure Mode Analysis of The Petite Amateur Navy Satellite (PANSAT)
Alldridge, David W., Naval Postgraduate School, USA; Sep. 1995; 174p; In English
Report No.(s): AD-A303881; No Copyright; Avail: CASI; A08, Hardcopy; A02, Microfiche
    System reliability analysis is an essential element is the design process. A reliability study should proceed from system inception through final deployment. As the PANSAT project approaches the final design stage and begins initial flight production, the absence of any significant reliability analysis becomes increasingly troubling. This thesis initiates the program's reliability analysis obligation by investigating spacecraft failure modes. Typically referenced as critical failure modes, these events will cause complete and permanent system failure. A reliability analysis tool, called Fault Tree Analysis (FTA), is used to conduct a systematic review of current hardware design architecture to expose potential critical failure points or weak links. The analytical result is a Boolean logic tree that describes critical failure events and all the potential causes. This causal output relationship describes each component failure (i.e., single point failures), or component failure combinations (i.e., multi-point failures), which could cause the undesirable failure event, or Top Event. The fault tree will provide design engineers and management personnel with an effective tool and reference point from which to implement design modifications to circumvent potential problems.
DTIC
Systems Analysis; Reliability Analysis; Deployment; Failure Modes; System Failures; Logic

20
SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources. For related information, see also 07 Aircraft Propulsion and Power; 28 Propellants and Fuels; 15 Launch Vehicles and Launch Operations; and 44 Energy Production and Conversion.

19740060462
The case for digital techniques applied to powerplant controls
Evans, J. F. O., Smiths Industries, Ltd., UK; Jan 1, 1974; 20p; In English; Symposium on the Application of Electrical Control to Aircraft Propulsion Systems, February 20-21, 1974, London; See also A74-43201 22-28; Avail: Issuing Activity
    The present work argues for the application of digital computing techniques to on-line powerplant control in aircraft. The analysis is based on the cost effectiveness of digital control techniques and hardware solutions in the light of the particular problems associated with aircraft engine control. The use of digital systems with their ability to change programs easily and

cheaply during development permits important decisions to be delayed until the necessary data to base them on becomes available. The computer in a digital system can be employed for overall system check-out, thus avoiding the necessity for separate equipment at dispersed sites and additional connectors for ground check equipment. Digital systems reduce the number and frequency of control setting adjustments, thus improving aircraft availability and maintainability. The application of Fault Tree Analysis is illustrated for a hypothetical analysis of a VTOL aircraft.
AIAA
Aircraft Engines; Digital Techniques; Engine Control; Numerical Control

19850010853 Naval Weapons Center, China Lake, CA, USA
Calculation through Fault Tree Analysis of the probability of a warhead being armed prior to launch
Stefan, G., Jr., Naval Weapons Center, USA; Spille, F., Naval Weapons Center, USA; APL The 1984 JANNAF Propulsion Systems Hazards Subcomm. Meeting, Vol. 1; Jun 1, 1984, pp. p 1-7; In English; See also N85-19162 10-28
Report No.(s): AD-P004339; Avail: Issuing Activity
    This paper is presented to illustrate the usefulness of Fault Tree Analysis (FTA), which, when quantified can yield the probability of occurrence of a given undesired event. A Fault Tree is a symbolic logic diagram which provides the deductive analytical means to identify failure modes contributing to the occurrence of the undesired event. As an illustrative example, an analysis was performed to assess the design safety of the MK 76 MOD 0 Safety-Arming (S-A) device, which is used on Standard Missile SM-1 Block VI. This analysis was performed with the primary intent of determining the various scenarios leading to an armed prior to launch event. These scenarios are made possible only by the assumed failure, or assumed bypassing, of the safety interlocks in the S-A device.
DTIC
Fault Trees; Fuses (Ordnance); Warheads

19920066467
Tutorial on nuclear thermal propulsion safety for Mars
Buden, David, Idaho National Engineering Laboratory, USA; Jul 1, 1992; 15p; In English
Contract(s)/Grant(s): DE-AC07-76ID-O1570
Report No.(s): AIAA PAPER 92-3696; Avail: Issuing Activity
    A range of safety topics related to the use of nuclear thermal propulsion (NTP) are examined including risk and safety analysis methodologies, NERVA reliability, and life-cycle risk assessments. A list of goals for the safe use of NTP is given which includes low radiation levels, avoiding unplanned core destruction, and preventing inadvertent criticality. Safety analysis and failure-mode analysis for NTP are illustrated by means of the fault tree analysis, event tree analysis, failure modes and effects analysis, and preliminary hazards analysis. Data from the NERVA propulsion program show that safety requirements built into the NTP engine are important for diagnostic and preventive assessments. Other key issues affecting the safety of an NTP program encompass precautions at the launch pad, crew isolation from reactor radiation, flight operations safety, and final disposal of the NTP engines and wastes.
AIAA
Failure Modes; Flight Safety; Mars (Planet); Nuclear Engine For Rocket Vehicles; Nuclear Propulsion; Space Exploration

19930017833 NASA Lewis Research Center, Cleveland, OH, USA
Reliability studies of integrated modular engine system designs
Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., Sverdrup Technology, Inc., USA; Jun 1, 1993; 19p; In English; 29th; Joint Propulsion Conference and Exhibit, 28-30 Jun. 1992, Monterey, CA, USA; Sponsored by AIAA
Contract(s)/Grant(s): RTOP 468-02-11
Report No.(s): NASA-TM-106178; E-7774; NAS 1.15:106178; AIAA PAPER 93-1886; Avail: CASI; A03, Hardcopy; A01, Microfiche
    A study was performed to evaluate the reliability of Integrated Modular Engine (IME) concepts. Comparisons were made between networked IME systems and non-networked discrete systems using expander cycle configurations. Both redundant and non-redundant systems were analyzed. Binomial approximation and Markov analysis techniques were employed to evaluate total system reliability. In addition, Failure Modes and Effects Analyses (FMEA), Preliminary Hazard Analyses (PHA), and Fault Tree

Analysis (FTA) were performed to allow detailed evaluation of the IME concept. A discussion of these system reliability concepts is also presented.
Author
Engine Design; Failure Analysis; Failure Modes; Fault Trees; Modularity; Propulsion System Configurations; Reliability Analysis; Rocket Engine Design

19930065762 NASA Lewis Research Center, Cleveland, OH, USA
Reliability studies of Integrated Modular Engine system designs
Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., Sverdrup Technology, Inc., USA; Jun 1, 1993, pp. 18 p.; In English; 29th; AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, June 28-30, 1993, Monterey, CA, USA; Sponsored by AIAA; Previously announced in STAR as N93-27022
Report No.(s): AIAA PAPER 93-1886; Copyright; Avail: Issuing Activity
    A study was performed to evaluate the reliability of Integrated Modular Engine (IME) concepts. Comparisons were made between networked IME systems and non-networked discrete systems using expander cycle configurations. Both redundant and non-redundant systems were analyzed. Binomial approximation and Markov analysis techniques were employed to evaluate total system reliability. In addition, Failure Modes and Effects Analyses (FMEA), Preliminary Hazard Analyses (PHA), and Fault Tree Analysis (FTA) were performed to allow detailed evaluation of the IME concept. A discussion of these system reliability concepts is also presented.
Engine Design; Failure Analysis; Failure Modes; Fault Trees; Modularity; Propulsion System Configurations; Reliability Analysis; Rocket Engine Design

19940024900 NASA Lewis Research Center, Cleveland, OH, USA
Rocket engine system reliability analyses using probabilistic and fuzzy logic techniques
Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., NASA Lewis Research Center, USA; Apr 1, 1994; 18p; In English; 30th; Joint Propulsion Conference, 27-29 Jun. 1994, Indianapolis, IN, USA; Sponsored by AIAA, ASME, SAE, and ASEE
Contract(s)/Grant(s): RTOP 506-42-72
Report No.(s): NASA-TM-106519; E-8640; NAS 1.15:106519; AIAA PAPER 94-2750; Avail: CASI; A03, Hardcopy; A01, Microfiche
    The reliability of rocket engine systems was analyzed by using probabilistic and fuzzy logic techniques. Fault trees were developed for integrated modular engine (IME) and discrete engine systems, and then were used with the two techniques to quantify reliability. The IRRAS (Integrated Reliability and Risk Analysis System) computer code, developed for the U.S. Nuclear Regulatory Commission, was used for the probabilistic analyses, and FUZZYFTA (Fuzzy Fault Tree Analysis), a code developed at NASA Lewis Research Center, was used for the fuzzy logic analyses. Although both techniques provided estimates of the reliability of the IME and discrete systems, probabilistic techniques emphasized uncertainty resulting from randomness in the system whereas fuzzy logic techniques emphasized uncertainty resulting from vagueness in the system. Because uncertainty can have both random and vague components, both techniques were found to be useful tools in the analysis of rocket engine system reliability.
Author (revised)
Engine Failure; Fault Trees; Fuzzy Systems; Probability Distribution Functions; Reliability; Reliability Analysis; Rocket Engines

19980025783
Current and emerging technology for powering small satellites with secondary cells and batteries
Klein, G. C., Gates Aerospace Batteries, USA; Schmidt, D. F., Gates Aerospace Batteries, USA; 1993; In English; Copyright; Avail: Aeroplus Dispatch
    A generic discussion is presented of cell and battery technologies of 17 A-H capacity and below for application in the emerging small satellite market. Attention is given to NiCd technology, NiMH technology, NiH2 planar cell and battery design concepts. Reliability analyses and assessments, analysis of failure modes and effects and criticality, fault tree analysis, design tradeoffs and simplifications, cell assembly improvements, volume and mass reductions are considered.
AIAA
Small Scientific Satellites; Spacecraft Power Supplies; Electric Batteries; Technology Utilization; Design Analysis

19980071382
Study of synthetic analysis on design reliablity of a liquid rocket engine
Kuang, Wuyue, Shaanxi Engine Design Inst., China; Tan, Songlin, Shaanxi Engine Design Inst., China; Journal of Propulsion Technology; Oct. 1997; ISSN 1001-4055; Volume 18, no. 5, pp. 9-12; In Chinese; Copyright; Avail: Aeroplus Dispatch

A synthetic analysis on the design reliability of a liquid rocket engine is presented. A rigorous yet practicable approach for evaluating engine reliability during the conceptual study phase is put forward. The approach uses the proven reliability methods of reliability modeling analysis, Failure Modes and Effects Analysis (FMEA), failure data analysis, and Fault Tree Analysis (FTA) to estimate the probability of mission success at the vehicle level for different engine designs. An example is provided in which the approach is used to evaluate an engine design concept.
Author (AIAA)
Liquid Propellant Rocket Engines; Rocket Engine Design; Reliability Analysis; Engine Failure; Fault Trees

19980148550
The fault tree analysis on system reliability on solid rocket motor design
Fang, Guoyao, Beijing Univ. of Aeronautics and Astronautics, China; Ma, Zhibo, Beijing Univ. of Aeronautics and Astronautics, China; Tang, Zhidong, Beijing Univ. of Aeronautics and Astronautics, China; Sun, Zhexi, Beijing Univ. of Aeronautics and Astronautics, China; Journal of Propulsion Technology; Oct. 1994; ISSN 1001-4055, no. 5, pp. 28-33; In Chinese; Copyright; Avail: Aeroplus Dispatch

A fault tree analysis is carried out based on a real air-air missile solid rocket motor. Thus, the frame figure of system reliability, the fault tree analysis, and structure functions are developed, and the reliability is predicted. The results show that the model developed is correct and available for other solid rocket motors.
Author (AIAA)
Solid Propellant Rocket Engines; Fault Trees; Rocket Engine Design; Reliability Analysis

19980188713
Rocket engine system reliability analyses using probabilistic and fuzzy logic techniques
Hardy, Terry L., NASA Lewis Research Center, USA; Rapp, Douglas C., Sverdrup Technology, Inc., USA; Jun. 1994; In English Report No.(s): AIAA Paper 94-2750; Copyright; Avail: Aeroplus Dispatch

The reliability of rocket engine systems was analyzed by using probabilistic and fuzzy logic techniques. Fault trees were developed for Integrated Modular Engine (IME) and Discrete engine systems, and then were used with the two techniques to quantify reliability. The IRRAS (Integrated Reliability and Risk Analysis System) computer code, developed for the U.S. Nuclear Regulatory Commission, was used for the probabilistic analyses, and FUZZYFTA (Fuzzy Fault Tree Analysis), a code developed at NASA Lewis Research Center, was used for the fuzzy logic analyses. Although both techniques provided estimates of the reliability of the IME and Discrete systems, probabilistic techniques emphasized uncertainty resulting from randomness in the system whereas fuzzy logic techniques emphasized uncertainty resulting from vagueness in the system. Because uncertainty can have both random and vague components, both techniques were found to be useful tools in the analysis of rocket engine system reliability.
Author (AIAA)
Rocket Engines; Reliability Analysis; Fuzzy Systems; Logic Programming; Systems Integration; Fault Trees

19990038408
Propellants, explosives, rockets, and guns; Proceedings of the 2nd International High Energy Materials Conference and Exhibit, Indian Inst. of Technology, Chennai, India, Dec. 8-10, 1998
1998; In English; ISBN 81-7023-885-4; Copyright; Avail: AIAA Dispatch

The papers presented in this volume are grouped under the following headings: ballistics; combustion; emergetic material chemistry; explosives and igniters; hazards, safety, and implementation; measurement technology; and reactive systems modeling. Specific topics discussed include development of large solid propulsion systems for launch vehicles; high muzzle velocity guns; combustion of high energy heterogeneous condensed systems; low temperature behavior of polymeric systems used in rocket motors; and performance of metallized liquid propellants. Papers are also included on studies of the ignition characteristics of boron-potassium nitrate pellets; fault tree analysis of powder compaction in fuel rich propellant processing; neutron radiography of pyrodevices used in spacecraft; and underwater ignition of a solid propellant system.
AIAA
Conferences; Rocket Propellants; Explosives; Guns (Ordnance); Propellant Combustion; Propellant Properties

19990104529
Application of quantitative hazard analysis technique in mixing operations of high energy materials
Jain, A. K., Cent. for Environment & Explosives Safety, India; Rajagopal, C.; Defence Science Journal; Jan, 1999; ISSN 0011-748X; Volume 49, no. 1, pp. 19-26; In English; Copyright; Avail: Issuing Activity

Production of composite propellants involves a variety of operations, of which mixing of various ingredients is a key step. Given the intrinsically hazardous nature of many of these ingredients, mixing operation, which is carried out in a stepwise manner with carefully weighed ratios of the reactants and under controlled conditions, is one of the hazardous steps in the production process. In this paper, quantitative assessment of the hazards involved in such a mixing operation has been carried out using fault-tree analysis technique to identify all the possible basic event combinations which could lead to the occurrence of a selected 'top event', such as fire or explosion in the mixer building. Measures to improve the safety features in the mixer building are also suggested.
Author (EI)
Solid Propellants; Mixing; Assessments; Risk; Accident Prevention

23
CHEMISTRY AND MATERIALS (GENERAL)

Includes general research topics related to the composition, properties, structure, and use of chemical compounds and materials as they relate to aircraft, launch vehicles, and spacecraft. For specific topics in chemistry and materials see categories 24 through 29. For astrochemistry see category 90 Astrophysics.

19910032228 NASA White Sands Test Facility, NM, USA
Flammability and sensitivity of materials in oxygen-enriched atmospheres; Proceedings of the Fourth International Symposium, Las Cruces, NM, Apr. 11-13, 1989. Volume 4
Stoltzfus, Joel M., editor, NASA White Sands Test Facility, USA; Benz, Frank J., editor, NASA White Sands Test Facility, USA; Stradling, Jack S., editor, NASA White Sands Test Facility, USA; Jan 1, 1989; 426p; In English; 4th; International Symposium on Flammability and sensitivity of materials in oxygen-enriched atmospheres, Apr. 11-13, 1989, Las Cruces, NM, USA; Sponsored by ASTM
Report No.(s): ASTM STP-1040; Copyright; Avail: Issuing Activity

The present volume discusses the ignition of nonmetallic materials by the impact of high-pressure oxygen, the promoted combustion of nine structural metals in high-pressure gaseous oxygen, the oxygen sensitivity/compatibility ranking of several materials by different test methods, the ignition behavior of silicon greases in oxygen atmospheres, fire spread rates along cylindrical metal rods in high-pressure oxygen, and the design of an ignition-resistant, high pressure/temperature oxygen valve. Also discussed are the promoted ignition of oxygen regulators, the ignition of PTFE-lined flexible hoses by rapid pressurization with oxygen, evolving nonswelling elastomers for high-pressure oxygen environments, the evaluation of systems for oxygen service through the use of the quantitative fault-tree analysis, and oxygen-enriched fires during surgery of the head and neck.
AIAA
Conferences; Controlled Atmospheres; Flammability; Liquid Oxygen; Materials Science; Oxygen Tension

24
COMPOSITE MATERIALS

Includes physical, chemical, and mechanical properties of laminates and other composite materials.

19770045905
A qualitative fault tree analysis for the tensile failure of fibrous laminated composites
Masters, J. E.; Yeow, Y. T.; Louthan, M. R., Jr.; Reifsnider, K. L.; Brinson, H. F., Virginia Polytechnic Institute and State University, USA; Composites; Apr 1, 1977; 8, pp. Apr. 197; In English; p. 111-117; Copyright; Avail: Issuing Activity

A fault tree is referred to as a graphical technique that provides a systematic description of the combinations of possible occurrences in a system which can result in a fault or undesirable event. It is shown that by defining the failure of a structure as the undesirable event, one can apply a fault tree to determine the pertinent underlying factors and their interrelations. A qualitative

fault tree technique is proposed for examining the static tensile failure of a fibrous composite laminate. The technique is suitable for relating the basic micromechanical mechanisms to the macroscopic events of delamination and oblique/transverse failure.

AIAA

Carbon Fiber Reinforced Plastics; Failure Analysis; Laminates; Tensile Tests; Trees (Mathematics)

25
INORGANIC, ORGANIC AND PHYSICAL CHEMISTRY

Includes the analysis, synthesis, and use inorganic and organic compounds; combustion theory; electrochemistry; and photochemistry. For related information see also 34 Fluid Dynamics and Thermodynamics, For astrochemistry see category 90 Astrophysics.

19800072749 California Univ., Berkeley. Lawrence Berkeley Lab, CA, USA

Application of fault tree analysis to ignition of fire

Ling, W. C. T., California Univ., USA; Williamson, R. B., California Univ., USA; Oct 1, 1978; 23p; In English

Contract(s)/Grant(s): W-7405-ENG-48

Report No.(s): LBL-8297; CONF-781060-1; Avail: CASI; A03, Hardcopy, Microfiche

No abstract.

Failure Analysis; Fault Trees; Fire Damage; Fires; Flame Propagation; Ignition

31
ENGINEERING (GENERAL)

Includes general research topics to engineering and applied physics, and particular areas of vacuum technology, industrial engineering, cryogenics, and fire prevention. For specific topics in engineering see categories 32 through 39.

19790049590

A method of schedule acceleration for system safety programs

Lemon, G. H., General Dynamics Corp., USA; Jan 1, 1979; 6p; In English; 16th; Survival and Flight Equipment Association, Annual Symposium, October 8-12, 1978, San Diego, CA; See also A79-33601 13-03; Copyright; Avail: Issuing Activity

The principal advantage of an accelerated program is that the cost of redesign and retrofit for safety improvement is minimized. Current fault tree analysis provides its greatest payoff after retrofit becomes expensive. This paper presents a method for solving this problem: It is suggested that subsystem hazard analysis data be purchased from equipment suppliers and fault tree logic allocation be developed concurrently with data preparation.

AIAA

Human Factors Engineering; Project Management; Safety Management; Work Capacity

19810034877

An example of predictive rather than responsive safety research for fusion energy systems

Alvares, N. J.; Hasegawa, H. K., California, University, USA; Jan 1, 1979; 6p; In English; 8th; Symposium on Engineering Problems of Fusion Research, November 13-16, 1979, San Francisco, CA; See also A81-18901 06-75

Contract(s)/Grant(s): W-7405-ENG-48; Copyright; Avail: Issuing Activity

A fault tree analysis is used to study the fire-management system of fusion experiments. The technique is shown to identify failure modes of the existing system components and indicate the possible effects of component failure in the event of fire in the protected spaces. The results of the initial analytical phase of the project are presented together with critical unknown parameters required for further analysis.

AIAA

Fusion Reactors; Nuclear Research; Reactor Safety; Safety Management

19860011164 IIT Research Inst., Chicago, IL, USA

Total system hazards analysis for the western area demilitarization facility

Pape, R., IIT Research Inst., USA; Mniszewski, K., IIT Research Inst., USA; Swider, E., IIT Research Inst., USA; Department of Defense Explosives Safety Board Minutes of the 21st Explosives Safety Seminar, Volume 2; Aug 1, 1984, pp. p 1529-1551; In English; See also N86-20623 11-31

Report No.(s): AD-P004894; Avail: CASI; A03, Hardcopy; A10, Microfiche

The results of a hazards analysis of the Western Area Demilitarization facility (WADF) at Hawthorne, Nevada are summarized. An overview of the WADF systems, the hazards analysis methodology that was applied, a general discussion of the fault tree analysis results, and a compilation of the conclusions and recommendations for each area of the facility are given.

CASI

Disposal; Explosives; Hazards; Systems Analysis

19910032248

Evaluating systems for oxygen service through the use of quantitative fault tree analysis

Santay, Anthony J., Air Products and Chemicals, Inc., USA; Jan 1, 1989; 10p; In English; 4th; International Symposium on Flammability and sensitivity of materials in oxygen-enriched atmospheres, Apr. 11-13, 1989, Las Cruces, NM, USA; Sponsored by ASTM; See also A91-16851; Copyright; Avail: Issuing Activity

In the event of a process plant upset, systems not normally intended for use in oxygen service may be suddenly subject to an oxygen-enriched atmosphere. If the upset condition occurs frequently, a conservative approach would be to design all components as if they were normally in oxygen service. As an alternative, one could calculate the probability of the upset condition to quantitatively assess the risk and recommend corrective measures to further reduce the risk. Quantified fault tree techniques are used to determine a system's compatibility when exposed to oxygen in this manner.

AIAA

Controlled Atmospheres; Fault Trees; Flammability; High Pressure Oxygen; Oxygen Supply Equipment

19930049795

The safety of process automation

Toola, A., Technical Research Centre of Finland, USA; Automatica; March 1993; ISSN 0005-1098; 29, 2, pp. 541-548.; In English; Copyright; Avail: Issuing Activity

The effect of automation on process safety is examined. The methods of safety analysis can be applied during the designing stages of safe process automation. The hazard and operability study makes it possible to take into account the potential process disturbances and to develop countermeasures. Action error analysis studies the consequences of potential human errors in task execution. Fault tree analysis can be used to study the causes of potential accidents and to examine the control actions suitable for providing protection against them thereby reducing the probability of accidents. Event tree analysis is a method for considering the consequences of potential hazardous situations and for developing countermeasures to reduce such consequences. Failure mode and effect analysis is a method for checking that the potential failures of the control and automation system are not overlooked. Reliability assessment can be used with safety analysis methods to study the bottlenecks in the design and to prioritize the countermeasures whereby the risk can be reduced to attain an acceptable level.

AIAA

Automation; Process Control (Industry); Safety

19950056419 NASA Goddard Space Flight Center, Greenbelt, MD, USA

Making the Hubble Space Telescope servicing mission safe

Bahr, N. J., Hernandez Engineering, Inc., USA; Depalo, S. V., Hernandez Engineering, Inc., USA; 1992; ISSN 0278-4017, pp. : Composite material; In English; See also A95-88012

Contract(s)/Grant(s): NAS5-30917; Copyright; Avail: Issuing Activity

This paper will detail how the Hubble Space Telescope (HST) system safety program is conducted. Numerous safety analyses are conducted through the various phases of design, test, and fabrication, and results are presented to NASA management for discussion during dedicated safety reviews. This paper will then address the system safety assessment and risk analysis methodologies used (i.e. hazard analysis, fault tree analysis, and failure modes and effects analysis), and how they are coupled with enginering and test analyses for a 'synergistic picture' of the system. Some preliminary safety analysis results, showing the relationship between hazard identification, control or abatement, and finally control verification, will be presented as examples of this safety process.

Author (Herner)

Aerospace Safety; Hubble Space Telescope; Orbital Servicing; Risk; Space Maintenance

Includes radar; radio, wire, and optical communications; land and global communications; communications theory. For related information see also 04 Aircraft Communications and Navigation; and 17 Space Communications, Spacecraft Communications, Command and Tracking; for search and rescue see 03 Air Transportation and Safety, and 16 Space Transportation and Safety.

19970001445 Sandia National Labs., Risk Assassment and Systems Modeling., Albuquerque, NM USA
Risk and Reliability Assessment for Telecommunications Networks
Wyss, Gregory D., Sandia National Labs., USA; Schriner, Heather K., Sandia National Labs., USA; Gaylor, Timothy R., Sandia National Labs., USA; 1996; 9p; In English; Probabilistic Safety Assessment - Moving Toward Risk Based Regulation, 29 Sep. 1996 - 3 Oct. 1996, Park City, UT, USA
Contract(s)/Grant(s): DE-AC04-94AL-85000
Report No.(s): SAND-96-1543C; CONF-960912-8; DE96-011708; No Copyright; Avail: Issuing Activity (Department of Energy (DOE)), Microfiche

Sandia National Laboratories has assembled an interdisciplinary team to explore the applicability of probabilistic logic modeling (PLM) techniques to model network reliability for a wide variety of communications network architectures. The authors have found that the reliability and failure modes of current generation network technologies can be effectively modeled using fault tree PLM techniques. They have developed a 'plug-and-play' fault tree analysis methodology that can be used to model connectivity and the provision of network services in a wide variety of current generation network architectures. They have also developed an efficient search algorithm that can be used to determine the minimal cut sets of an arbitrarily-interconnected (non-hierarchical) network without the construction of a fault tree model. This paper provides an overview of these modeling techniques and describes how they are applied to networks that exhibit hybrid network structures (i.e., a network in which some areas are hierarchical and some areas are not hierarchical).
DOE
Risk; Reliability; Fault Trees; Computer Networks; Information Systems; Data Transfer (Computers)

19980047381 Department of the Navy, Washington, DC USA
Constant False Probability Data Fusion System
Pawlak, Robert J., Inventor, Department of the Navy, USA; Aug. 26, 1997; 6p; In English; Supersedes US-Patent-Appl-SN-972339, AD-D015624.
Patent Info.: Filed 6 Nov. 1992; US-Patent-Appl-SN-972339; US-Patent-5,661,666
Report No.(s): AD-D018729; No Copyright; Avail: US Patent and Trademark Office, Microfiche

A system for determining whether a given phenomenon has occurred based on multiple sensor decisions is provided. Each sensor samples input data and attempts to decide if the given phenomenon exists. These sensor decisions are provided to the data fusion processor. The data fus ion processor uses a sum of the sensor decisions multiplied by a logarithmic gain indicating the relative reliability of each sensor to generate a test existence metric. The test existence metric is compared to two threshold limits. The results of this comparison are used to provide a final decision indicating the existence of the given phenomenon. An optimization is used to determine the threshold values used in the threshold table to guarantee that the false alarm rate and the data fusion processor is constant, even in cases where data from some sensor is missing.
DTIC
Data Processing Equipment; Multisensor Fusion; Probability Theory

33
ELECTRONICS AND ELECTRICAL ENGINEERING

Includes development, performance, and maintainability of electrical/electronic devices and components; related test equipment. and microelectronics and integrated circuitry. For related information see also 60 Computer Operations and Hardware; and 76 Solid-State Physics. For communications equipment and devices see 32 Communications and Radar.

19860048102
General methodologies for assessing EMI/EMC in complex electronic circuits and systems
Slauson, W. E.; Lessard, B. J.; Hurley, M. T.; Bossart, R. K., Sanders Associates, Inc., USA; Paludi, C. A., Jr., USAF, Rome Air Development Center, USA; Jan 1, 1985; 2p; In English; See also A86-32801
Contract(s)/Grant(s): F30602-82-C-0174; Copyright; Avail: Issuing Activity

This paper introduces the procedures for utilizing two techniques, namely Fault Tree Analysis (FTA) and Electromagnetic Effects Criticality Analysis (EMECA), for assessing EMI/EMC in complex electronic circuits and systems. Application of these techniques are demonstrated by means of examples where, because of the use of digital, high-speed, high-density integrated circuit technologies, EMI/EMC assessments by traditional deterministic methods are inappropriate. The results illustrate the probability of achieving EMC while accounting for the statistical nature of EMI.
AIAA
Electromagnetic Compatibility; Electromagnetic Interference; Electromagnetic Noise; Electronic Equipment Tests; Fault Trees; Integrated Circuits

19880001643 Johns Hopkins Univ., Space Reliability Group., Laurel, MD, USA
Fault tree safety analysis of a large Li/SOCl(sub)2 spacecraft battery
Uy, O. Manuel, Johns Hopkins Univ., USA; Maurer, R. H., Johns Hopkins Univ., USA; NASA Goddard Space Flight Center, Greenbelt, Md. The 1986 Goddard Space Flight Center Battery Workshop; Sep 1, 1987, pp. p 93-119; In English; See also N88-11021 02-33; Avail: CASI; A03, Hardcopy; A03, Microfiche

The results of the safety fault tree analysis on the eight module, 576 F cell Li/SOCl2 battery on the spacecraft and in the integration and test environment prior to launch on the ground are presented. The analysis showed that with the right combination of blocking diodes, electrical fuses, thermal fuses, thermal switches, cell balance, cell vents, and battery module vents the probability of a single cell or a 72 cell module exploding can be reduced to .000001, essentially the probability due to explosion for unexplained reasons.
B.G.
Electrochemistry; Failure Analysis; Fault Trees; Lithium Sulfur Batteries; Requirements

19910007993 Sandia National Labs., Albuquerque, NM, USA
Lithium battery safety and reliability
Levy, Samuel C., Sandia National Labs., USA; Jan 1, 1991; 12p; In English; 5th; International Seminar on Lithium Battery Technology and Applications, 4-8 Mar. 1991, Deerfield Beach, FL, USA
Contract(s)/Grant(s): DE-AC04-76DP-00789
Report No.(s): DE91-005800; SAND-91-0012C; CONF-910344-1; Avail: CASI; A03, Hardcopy; A01, Microfiche

Lithium batteries have been used in a variety of applications for a number of years. As their use continues to grow, particularly in the consumer market, a greater emphasis needs to be placed on safety and reliability. There is a useful technique which can help to design cells and batteries having a greater degree of safety and higher reliability. This technique, known as fault tree analysis, can also be useful in determining the cause of unsafe behavior and poor reliability in existing designs.
DOE
Electric Batteries; Lithium; Reliability Engineering; Safety

19980053939
Combining functional and structural reasoning for safety analysis of electrical designs
Price, C. J., Univ. of Wales, UK; Snooke, N.; Pugh, D. R.; Hunt, J. E.; Wilson, M. S.; Knowledge Engineering Review; Sep, 1997; ISSN 0269-8889; Volume 12, no. 3, pp. 271-287; In English; Copyright; Avail: Issuing Activity

Increasing complexity of design in automotive electrical systems has been paralleled by increased demands for analysis of the safety and reliability aspects of those designs. Such demands can place a great burden on the engineers charged with carrying out the analysis. This paper describes how the intended functions of a circuit design can be combined with a qualitative model of the electrical circuit that fulfills the functions, and used to analyze the safety of the design. FLAME, an automated failure mode and effects analysis system based on these techniques, is described in detail. FLAME has been developed over several years, and is capable of composing an FMEA report for many different electrical subsystems. The paper also addresses the issue of how the use of functional and structural reasoning can be extended to sneak circuit analysis and fault tree analysis.
Author (EI)
Failure Analysis; Failure Modes; Structural Analysis; Computer Techniques; Network Analysis; Artificial Intelligence; Human-Computer Interface

19990068673
Hybrid escalation mechanism for the efficient restoration of ATM networks
Lee, Dong–Hee, Kyungpook Natl. Univ., Republic of Korea; Park, Jong–Tae; Lee, Kil–Haeng; Woo, Wang–Don; Computers & Industrial Engineering; Oct, 1998; ISSN 0360-8352; Volume 35, no. 1-2, pp. 279-282; In English; 1997 23rd International

Conference on Computers and Industrial Engineering, Mar. 29-Apr. 1, 1997, Chicago, IL, USA; Copyright; Avail: Issuing Activity

In this paper, we comparatively analyze the characteristics of various escalation mechanisms for the restoration of ATM networks. We propose a new escalation method, called hybrid escalation, which is able to restore the defective services according to the conditions of faults. Additionally, we propose the Telecommunication Management Network (TMN) based management architecture incorporating the escalation strategy.
Author (EI)
Data Transmission

19990093859
Fault diagnosis of large scale analog circuits based on symbolic method
Wei, T., The Hong Kong Polytechnic Univ., China; Wong, M. W. T.; Lee, Y. S.; Chinese Journal of Electronics; Oct, 1998; ISSN 1022-4653; Volume 7, no. 4, pp. 395-399; In English; Copyright; Avail: Issuing Activity

The problem of testing and diagnosis of large linear analog circuits has not been adequately addressed. In this paper, an effective procedure to test and diagnose faults in large scale linear analog circuits has been proposed. We first use large change sensitivity analysis to obtain the diagnostic voltages and currents. Decomposition technique is then applied and algorithms for isolation of faulty nodes, faulty connections and faulty subcircuits are proposed. Next the hardware overhead problem is considered and it leads to an optimization of test nodes. The circuit analysis is based on a new symbolic technique which is less costly than traditional method in terms of time complexity. We apply the proposed fault diagnosis technique to a benchmark circuit to demonstrate the efficiency of this method.
Author (EI)
Electric Current; Electric Networks; Sensitivity; Algorithms

37
MECHANICAL ENGINEERING

Includes mechanical devices and equipment; machine elements and processes. For cases where the application of a device or the host vehicle is emphasized see also the specific category where the application or vehicle is treated. For robotics see 63 Cybernetics, Artificial Intelligence, and Robotics; and 54 Man/System Technology and Life Support.

19720005773 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Reliability computation using fault tree analysis
Chelson, P. O., Jet Propulsion Lab., California Inst. of Tech., USA; Dec 1, 1971; 23p; In English
Contract(s)/Grant(s): NAS7-100
Report No.(s): NASA-CR-124740; JPL-TR-32-1542; Avail: CASI; A03, Hardcopy; A01, Microfiche

A method is presented for calculating event probabilities from an arbitrary fault tree. The method includes an analytical derivation of the system equation and is not a simulation program. The method can handle systems that incorporate standby redundancy and it uses conditional probabilities for computing fault trees where the same basic failure appears in more than one fault path.
CASI
Distribution Functions; Probability Theory; Reliability Engineering

19740014961 California Univ., Operations Research Center., Berkeley, CA, USA
Introduction to fault tree analysis
Barlow, R. E., California Univ., USA; Purnendu, C., California Univ., USA; Dec 1, 1973; 48p; In English
Contract(s)/Grant(s): N00014-69-A-0200-1036; F33615-73-C-4078
Report No.(s): AD-774072; ORC-73-30; Avail: CASI; A03, Hardcopy; A01, Microfiche

Fault tree analysis has proved to be a useful analytical tool for the reliability and safety analysis of complex systems. This is a semi-expository introduction to the mathematics of fault tree analysis. Many of the concepts of coherent structure theory have been used. Bounds on the system reliability when components are dependent (that is, are associated) are given. Algorithms to find the min-cut-sets and related bounds, together with various means for computing the probability of the Top Event are presented. Measures of event importance are discussed. Numerical examples are presented to illustrate the concepts.
CASI
Electrical Faults; Reliability Engineering; Statistical Distributions

19930002773 Rice Univ., Dept. of Electrical and Computer Engineering., Houston, TX, USA
Fault detection and fault tolerance in robotics

Visinsky, Monica, Rice Univ., USA; Walker, Ian D., Rice Univ., USA; Cavallaro, Joseph R., Rice Univ., USA; NASA. Lyndon B. Johnson Space Center, Fifth Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 1; Jan 1, 1992, pp. p 262-271; In English; Sponsored in part by Mitre Corp.

Robots are used in inaccessible or hazardous environments in order to alleviate some of the time, cost and risk involved in preparing men to endure these conditions. In order to perform their expected tasks, the robots are often quite complex, thus increasing their potential for failures. If men must be sent into these environments to repair each component failure in the robot, the advantages of using the robot are quickly lost. Fault tolerant robots are needed which can effectively cope with failures and continue their tasks until repairs can be realistically scheduled. Before fault tolerant capabilities can be created, methods of detecting and pinpointing failures must be perfected. This paper develops a basic fault tree analysis of a robot in order to obtain a better understanding of where failures can occur and how they contribute to other failures in the robot. The resulting failure flow chart can also be used to analyze the resiliency of the robot in the presence of specific faults. By simulating robot failures and fault detection schemes, the problems involved in detecting failures for robots are explored in more depth.
Author
Algorithms; Component Reliability; Fault Detection; Fault Tolerance; Fault Trees; Redundancy Encoding; Robots

19990036253 Department of Energy, Washington, DC USA
Evaluation of spindle-shaft seizure accident sequences for the Schenck Dynamic Balancer

Bott, T. F., Department of Energy, USA; Fischer, S. R., Department of Energy, USA; Dec. 31, 1998; 150p; In English

This study was conducted at the request of the USDOE/AL Dynamic Balancer Project Team to develop a set of representative accident sequences initiated by rapid seizure of the spindle shaft of the Schenck dynamic balancing machine used in the mass properties testing activities in Bay 12-60 at the Pantex Plant. This Balancer is used for balancing reentry vehicles. In addition, the study identified potential causes of possible spindle-shaft seizure leading to a rapid deceleration of the rotating assembly. These accident sequences extend to the point that the reentry vehicle either remains in stable condition on the balancing machine or leaves the machine with some translational and rotational motion. Fault-tree analysis was used to identify possible causes of spindle-shaft seizure, and failure modes and effects analysis identified the results of shearing of different machine components. Cause-consequence diagrams were used to help develop accident sequences resulting from the possible effects of spindle-shaft seizure. to make these accident sequences physically reasonable, the analysts used idealized models of the dynamics of rotating masses. Idealized physical modeling also was used to provide approximate values of accident parameters that lead to branching down different accident progression paths. The exacerbating conditions of balancing machine over-speed and improper assembly of the fixture to the face plate are also addressed.
NTIS
Test Facilities; Shafts (Machine Elements); Seizures; Fault Trees; Spindles; Balancing; Accidents

38
QUALITY ASSURANCE AND RELIABILITY

Includes approaches to, and methods for reliability analysis and control, inspection, maintainability, and standardization.

19750008795 Lawrence Livermore National Lab., Livermore, CA, USA
Fault tree analysis: An overview

Lambert, H., Lawrence Livermore National Lab., USA; Aug 6, 1974; 17p; In English; Conf. on Reliability and Fault Tree Analysis, 3-4 Sep. 1974, Berkeley, CA, USA; Sponsored by AEC

The construction, evaluation, and uses of the fault tree analysis of systems are discussed.
NSA
Safety Management; System Failures; Systems Analysis; Systems Engineering

19750011642, USA

Reliability analysis on electronic circuits. Practical application of reliability predictions with application of failure mode analysis and fault tree analysis *palidlighedsanalyse af elektroniske kredslob. prakisk brug af palidelighedsforudsigelse samt brug af fejleffektanalyse og fejltraeanalyse*

Hogsholm, A., USA; Nov 1, 1974; 61p; In Danish

Report No.(s): ECR-46; Avail: CASI; A04, Hardcopy; A01, Microfiche

Two phases in the design of a reliable electronic circuit are treated. In the first phase the aim is to estimate the circuit reliability and if the latter is not sufficient, advise how the reliability can be improved. The circuit reliability is computed using parts count technique and reliability block diagrams. In second, the phase, the effects of component failures that will occur are investigated. In applying failure mode effect analysis and fault tree analysis the critical failures are found. Some general rules for avoiding critical failures are presented and examples showing the use of these are given.

CASI

Circuit Diagrams; Failure Analysis; Reliability Engineering

19750019337 California Univ., Operations Research Center., Berkeley, CA, USA

Fault tree analysis: Reliability theory and systems safety analysis

Chatterjee, P., California Univ., USA; Nov 1, 1974; 130p; In English

Contract(s)/Grant(s): N00014-69-A-0200-1036; F33615-73-C-4078; NR PROJ. 042-238

Report No.(s): AD-A004209; ORC-74-34; Avail: CASI; A07, Hardcopy; A02, Microfiche

In this report the author solves various problems in fault tree analysis and coherent structure theory. In Chapter 1, fault tree construction methodology and mathematical notations are presented. Chapter 2 deals with minimal cut sets. Two algorithms, complete with proofs, are presented. In Chapter 3, the concept of module and an algorithm to obtain the finest modular decomposition is presented. Its potential use in obtaining various systems characteristics efficiently is pointed out. The concept of module is similar to that of committee in Game Theory. In Chapter 4, various concepts of importance and methods for computing them are presented.

DTIC

Reliability; Safety Factors; Systems Analysis

19750062855

Reliability and fault tree analysis: Theoretical and applied aspects of system reliability and safety assessment; Proceedings of the Conference, University of California, Berkeley, Calif., September 3-7, 1974

Barlow, R. E., editor, California, University, USA; Fussell, J. B., Aerojet Nuclear Co., USA; Singpurwalla, N. D., George Washington University, USA; Jan 1, 1975; 965p; In English; Reliability and fault tree analysis: Theoretical and applied aspects of system reliability an safety assessment: Conference, September 3-7, 1974, Berkeley, CA; Sponsored by AEC

Contract(s)/Grant(s): N00014-69-A-0200-1070; N00014-67-A-0214; NR PROJECT 347-020; NAVY TASK 0001; Copyright; Avail: Issuing Activity

Aspects of fault tree methodology are examined, taking into account a computer aided fault tree construction for electrical systems, a safety simulation language for chemical processes, and a method to reduce the cost of analysis. The computer analysis of fault trees and systems is discussed along with the mathematical theory of reliability, the theory of maintained systems, the statistical theory of reliability, questions of network reliability, and computer reliability. Subjects related to reliability and fault tree applications are also considered, giving attention to reliability quantification techniques used in the Rasmussen study, the application of the fault tree technique to a nuclear reactor containment system, and an approach to reliability assessment.

AIAA

Computerized Simulation; Conferences; Failure Analysis; Reliability Engineering; System Failures; Trees (Mathematics)

19760006423 Stanford Univ., Dept. of Statistics., CA, USA

The first passage time distribution for a parallel exponential system with repair

Brown, M., Stanford Univ., USA; Aug 15, 1974; 21p; In English

Contract(s)/Grant(s): N00014-67-A-0112-0085; NR PROJ. 042-267

Report No.(s): AD-A013276; SU-TR-205; Avail: CASI; A03, Hardcopy; A01, Microfiche

In system reliability studies, one obtains via a fault tree analysis, the various combinations of possible events which lead to system failure. These events can be characterized by a collection of minimal cut sets; a minimal cut set of components has the property that if all components in the set are simultaneously out of order the system fails, independently of the behavior of other components, and is minimal in that none of its proper subsets has this property. The author obtains the generating function,

moments and asymptotic distribution for the first passage time distribution of a parallel system. These, used in conjunction with the ESAry-Proschan inequality, should yield good approximations to system reliability.

DTIC

Exponential Functions; Reliability Engineering; Statistical Analysis

19760009395 Kaman Sciences Corp., Colorado Springs, CO, USA

GO evaluation of PWR spray system *Final Report*

Long, W. T., Kaman Sciences Corp., USA; Aug 1, 1975; 92p; In English; Sponsored by Electric Power Research Inst.

Report No.(s): PB-245114/4; EPRI-350-1; Avail: CASI; A05, Hardcopy; A01, Microfiche

GO methodology is presented and its application demonstrated by performing a reliability analysis of a conceptual PWR containment spray system. Certain numerical results obtained are compared with those of a prior fault tree analysis of the same system. Basic data on the PWR containment spray system analyzed herein was provided in the form of schematics, functional descriptions, and subsystem failure data. Using this information, a GO model was created and exercised to ascertain the probabilities of occurrence (point estimates) of all events of interest including specifically the likelihoods of reducing pressure and removing radioactive iodine. These results do not vary significantly from those obtained in the prior study. Reasons for variations are noted.

GRA

Nuclear Power Reactors; Reliability Engineering; Sprayers

19760017527 Aerojet Nuclear Co., Idaho Falls, ID, USA

Review of fault tree analysis with emphasis on limitations

Fussell, J. B., Aerojet Nuclear Co., USA; Jan 1, 1975; 18p; In English; Conf. on Intern. Federation of Autom. Control, Cambridge, MA, USA

Report No.(s): CONF-750860-1; Avail: CASI; A03, Hardcopy; A01, Microfiche

An overview, with references for additional detail, is given for the analyst who wishes to apply the fault tree method for system reliability and safety analysis to industrial situations. The applicability of fault tree analysis and the limitations of such analysis are discussed. The various quantitative measures of system safety and reliability are presented.

CASI

Reliability Engineering; Systems Analysis; Trees (Mathematics)

19760045890

Computer-aided reliability and safety analysis of complex systems

Inoue, K., Kyoto University, Japan; Henley, E. J., Houston, University, USA; Jan 1, 1975; 10p; In English; 6th; International Federation of Automatic Control, Triennial World Congress, August 24-30, 1975, oston, Cambridge, MA, US; Sponsored by International Federation of Automatic Control; See also A76-28778 13-63; Copyright; Avail: Issuing Activity

This paper is a review of the state of the art in the area of computer-aided reliability and safety analysis. It covers both reliability graph analysis and fault tree analysis. by comparing the methods developed for reliability graph analysis with those of fault tree analysis, it is seen that the two fields have been developed rather independently and yet a unified view and a more integrated approach to the problem is shown to be possible. Several new algorithms developed by the authors are given which detect minimal path and cut sets from a reliability graph and a fault tree.

AIAA

Complex Systems; Computer Techniques; Reliability Analysis; System Failures; Systems Analysis

19760045891

An integrated approach to system failure effects

Reid, R. A., Philips' Gloeilampenfabrieken, Netherlands; Jan 1, 1975; 7p; In English; 6th; International Federation of Automatic Control, Triennial World Congress, August 24-30, 1975, oston, Cambridge, MA, US; Sponsored by International Federation of Automatic Control; See also A76-28778 13-63; Copyright; Avail: Issuing Activity

The failure modes and fault tree analysis techniques as used on spacecraft have been applied to a transport system study. A general approach to systems reliability has evolved and been applied to other systems. Based on an analysis of systems functional modes, the system level effects of component deviation from nominal are derived. A grouped tree analysis of these events facilitates the allocation of probabalistic reliability requirements and provides good visibility when fail-safe or similar conditions

apply. The approach is not limited to hardware. Computer programs and other software can also be analyzed and risks defined and minimized.
AIAA
Failure Modes; Reliability Engineering; System Failures; Systems Analysis; Transportation; Trees (Mathematics)

19760045893
A review of fault tree analysis with emphasis on limitations
Fussell, J. B., Aerojet Nuclear Co., USA; Jan 1, 1975; 6p; In English; 6th; International Federation of Automatic Control, Triennial World Congress, August 24-30, 1975, oston, Cambridge, MA, US; Sponsored by International Federation of Automatic Control; See also A76-28778 13-63; Copyright; Avail: Issuing Activity

The fault tree method for system reliability and safety analysis is reviewed, with particular reference to industrial applications. A fault tree is a graphical representation of a Boolean failure logic associated with the development of a particular top event for a particular system. The top event of a fault tree occurs when the system passes from the unfailed to the failed state. Components reliability characteristics are completely described by their time-dependent failure rate and repair rate. The discussion covers such parameters as reliability and unreliability, availability and unavailability, expected number of failures, and failure rate and repair rate. Theoretical and implementational limitations of the fault tree methodology are discussed. In particular, degraded performances other than totally failed cannot be evaluated. Fault tree analysis is shown to be suitable for problems concerning tangible and intangible systems.
AIAA
Component Reliability; Failure Modes; Reliability Analysis; System Failures; Systems Analysis; Trees (Mathematics)

19770003607 Georgia Inst. of Tech., School of Industrial and Systems Engineering., Atlanta, GA, USA
An application of fault tree analysis to operational testing
Rankin, G. L., Georgia Inst. of Tech., USA; Jun 1, 1975; 91p; In English
Contract(s)/Grant(s): DAAG39-75-C-0095
Report No.(s): AD-A024206; Avail: CASI; A05, Hardcopy; A01, Microfiche

The problem of designing an operational test for complex military systems is approached using fault tree analysis. Operational testing, as opposed to developmental testing, must encompass all the various systems, doctrines, organizations, hardwares, and personnel that impact upon the system. Fault tree analysis is suggested as a method of modeling the entire system for various critical issues.
DTIC
Reliability Analysis; Tests; Trees (Mathematics)

19770019584 IIT Research Inst., Chicago, IL, USA
Update to reliability and maintainability planning guide for Army aviation systems and components *Final Report, Jul. 1975 - Aug. 1976*
Mihalkanin, P. A., IIT Research Inst., USA; Aug 1, 1976; 428p; In English
Contract(s)/Grant(s): DAAJ01-75-C-1094
Report No.(s): AD-A037446; IITRI-E6337-FR; USAAVSCOM-TR-77-15; Avail: CASI; A19, Hardcopy; A04, Microfiche

This guidebook has been prepared to serve as a tool for the R and M Division of AVSCOM and for Program Managers to use in planning, managing and monitoring R and M programs for aviation systems. Included in the guidebook are basic concepts, program provisions, guidelines, recommendations and specific R and M plans and procedures. The various provisions presented in this guidebook were formulated to meet the specific mission needs of AVSCOM's R and M Division, and are planned for use in support of the acquisition, operation and maintenance of Army aircraft systems and components. The major thrust of the guidebook is directed toward activities that take place during system development and production. Emphasis has been placed on mechanical reliability prediction, reliability growth testing, fault-tree analysis, and production reliability assurance techniques with specific examples applicable to helicopter systems.
DTIC
Armed Forces (USA); Avionics; Reliability

19770020478 Lawrence Livermore National Lab., Livermore, CA, USA
Fault trees for location of sensors in chemical processing systems
Lambert, H., Lawrence Livermore National Lab., USA; Jul 30, 1976; 28p; In English; Am. Inst. of Chem. Engr. 69th Ann. Meeting, 28 Nov. - 2 Dec. 1974, Chicago

Contract(s)/Grant(s): W-7405-ENG-48
Report No.(s): UCRL-78442; CONF-761109-1; Avail: CASI; A03, Hardcopy; A01, Microfiche

The concepts of probabilistic importance within the context of fault tree analysis is presented. On the basis of probabilistic importance of events in fault trees, it is shown how to optimally locate sensors in a system. Two kinds of sensors are described: preventive sensors to detect early failures of critical redundant components and diagnostic sensors to detect potentially catastrophic system fault conditions. A SO2-O2 conversion process is chosen as an example to illustrate the methods that are presented.
ERA
Chemical Reactions; Circuits; Measuring Instruments

19770036088
On the quantitative analysis of priority-AND failure logic
Fussell, J. B., Tennessee, University, USA; Aber, E. F.; Rahl, R. G., Idaho National Engineering Laboratory, USA; IEEE Transactions on Reliability; Dec 1, 1976; R-25, pp. Dec. 197; In English; p. 324-326; Copyright; Avail: Issuing Activity

An exact and an approximate method for calculating the probability of occurrence of the output event from priority-AND (sequential) failure logic is given. The approximate method can be used during fault-tree analysis without modification to existing quantitative evaluation techniques. Assumptions made include s-independent, exponentially distributed, nonrepairable basic events as input to the priority-AND failure logic.
AIAA
Circuit Reliability; Failure Analysis; Gates (Circuits); Logical Elements; Reliability Analysis

19780021543 National Technical Information Service, Springfield, VA, USA
Reliability: Mathematical techniques, volume 1. A bibliography with abstracts *Progress Report, 1970 - May 1977*
Reimherr, G. W., National Technical Information Service, USA; May 1, 1978; 300p; In English
Report No.(s): NTIS/PS-78/0438/8; Avail: CASI; A13, Hardcopy; A03, Microfiche

Topics covered include statistical analysis, fault tree analysis, life testing, failure analysis, and mathematical models as applied to reliability prediction.
GRA
Reliability Analysis

19780049523
Computer methods for qualitative fault tree analysis
Gangadharan, A. C.; Rao, M. S. M.; Sundararajan, C., Foster Wheeler Development Corp., USA; Jan 1, 1977; 12p; In English; Design Engineering Technical Conference, September 26-28, 1977, Chicago, IL; See also A78-33426 13-39; Copyright; Avail: Issuing Activity

The paper describes the different computer methods used for the reduction of fault trees to minimal cut sets and path sets. The concepts behind the Monte Carlo simulation technique, the combination testing method, the algorithm using Boolean Indicated Cut Sets (BICS) and the use of primary numbers are illustrated with a simple example. Computer programs developed on the basis of these concepts are identified. A new concept of binary bit string (BBS) representation of events and the use of binary logic operators within the computer for reduction of fault tree are introduced. A computer program, FALTREE, written by the second author using this new concept is briefly described. It is shown that BBS representation and the binary reduction can result in substantial savings in computer time.
AIAA
Computer Programs; Failure Analysis; Reliability Analysis; Trees (Mathematics)

19790017233 California Univ., Operations Research Center., Berkeley, CA, USA
Computer-aided fault tree analysis *Topical Research Report*
Willie, R. R., California Univ., USA; Aug 1, 1978; 104p; In English
Contract(s)/Grant(s): N00014-75-C-0781; AF-AFOSR-3179-77
Report No.(s): AD-A066567; ORC-78-14; Avail: CASI; A06, Hardcopy; A02, Microfiche

Part I of this report discusses a computer-oriented methodology for deriving minimal cut and path set families associated with arbitrary fault trees. Part II describes the use of the Fault Tree Analysis Program (FTAP), an extensive FORTRAN computer package that implements the Part I methodology. An input fault tree to FTAP may specify the system state as any logical function of subsystem or component state variables or complements of these variables. When fault tree logical relations involve

complements of state variables, the analyst may instruct FTAP to produce a family of prime implicants, a generalization of the minimal cut set concept. FTAP can also identify certain subsystems associated with the tree as system modules and provide a collection of minimal cut set families that essentially expresses the state of the system as a function of these modules state variables. Another FTAP feature allows a subfamily to be obtained when the family of minimal cut sets of prime implicants is too large to be found in its entirety; this subfamily consists only of sets that are interesting to the analyst in a special sense.
CASI
Boolean Algebra; Computer Programs; Operations Research; Trees (Mathematics)

19790020431 National Technical Information Service, Springfield, VA, USA
Reliability - mathematical techniques, volume 2. A bibliography with abstracts *Progress Report, Jun. 1977 - Apr. 1979*
Reimherr, G. W., National Technical Information Service, USA; May 1, 1979; 87p; In English
Report No.(s): NTIS/PS-79/0451/9; NTIS/PS-78/0439; NTIS/PS-77/0445; NTIS/PS-76/0221; Avail: CASI; A05, Hardcopy; A01, Microfiche
    The cited reports discuss reliability prediction using mathematical techniques. Topics covered include statistical analysis, fault tree analysis, life testing, failure analysis, and mathematical models as applied to reliability prediction.
GRA
Reliability; Statistical Analysis

19790031338
Annual Reliability and Maintainability Symposium, Los Angeles, Calif., January 17-19, 1978, Proceedings
Jan 1, 1978; 557p; In English; Annual Reliability and Maintainability Symposium, January 17-19, 1978, Los Angeles, CA; Sponsored by IEEE; Copyright; Avail: Issuing Activity
    Models of reliability and maintainability of systems are studied, and reliability concepts, attitudes, and policies are described. Topics discussed include logistics supportability testing, Air Force experience with reliability improvement warranties (RIW), time series analysis of failure data, contractor risk associated with RIWs, mechanical reliability for low cycle fatigue, effects of on-off cycling on equipment reliability, a life-cycle management cost model, fault-tree analysis with probability evaluation, computer-graphic design for human performance, and early identification of high-maintenance helicopters.
AIAA
Conferences; Maintainability; Reliability Engineering

19790032572
Application of the fault tree in fault testing and design improvement *Ueber die Anwendung des Fehlerbaumes bei der Fehlersuche und Konstruktionsverbesserung*
Broschk, K.; Keller, H.; Jan 1, 1978; 6p; In German; Copyright; Avail: Issuing Activity
    The method of fault tree analysis is illustrated on some simple systems such as a switchable electric circuit and an aircraft spoiler system. The technique of fault finding by means of the fault tree is described. An example of how fault tree analysis helps improve a design by revealing critical events with high probability that can be replaced by ones with lower probability is discussed.
AIAA
Aircraft Reliability; Design Analysis; Failure Analysis; Reliability Engineering; Systems Analysis; Trees (Mathematics)

19800020238 National Technical Information Service, Springfield, VA, USA
Reliability: Mathematical techniques. Citations from the NTIS data base *Progress Report, Jun. 1977 - Apr. 1980*
Reimherr, G. W., National Technical Information Service, USA; Apr 1, 1980; 106p; In English
Report No.(s): PB80-809486; NTIS/PS-79/0451; NTIS/PS-78/0439; Avail: CASI; A06, Hardcopy; A02, Microfiche
    The cited reports discuss reliability prediction using mathematical techniques. Topics covered include statistical analysis, fault tree analysis, life testing, failure analysis, and mathematical models as applied to reliability prediction. This updated bibliography contains 99 abstracts, 20 of which are new entries to the previous edition.
NTIS
Confidence Limits; Failure Analysis; Reliability

19800037897
An efficient bottom-up algorithm for enumerating minimal cut sets of fault trees
Nakashima, K., Himeji Institute of Technology, Japan; Hattori, Y., Kyoto University, Japan; IEEE Transactions on Reliability; Dec 1, 1979; R-28, pp. Dec. 197; In English; p. 353-357; Copyright; Avail: Issuing Activity

The paper improves the conventional bottom-up algorithm for enumerating minimal cut sets of fault tree. It is proved that, when the logical product of two reduced sum-of-product forms is expanded by the distribution rule, one need only check if each resulting term is absorbed by some terms of two original sum-of-product forms. The algorithm for executing this process is presented and illustrated by an example. The entire computer program is given in a supplement and the computational results for several examples are presented to demonstrate the efficiency of the algorithm.
AIAA
Algorithms; Computer Programs; Fault Trees; Reliability Analysis; Run Time (Computers)

19800054967
Dagger-sampling Monte Carlo for system unavailability evaluation
Kumamoto, H.; Tanaka, K.; Inoue, K., Kyoto University, Japan; Henley, E. J., Houston, University, USA; IEEE Transactions on Reliability; Jun 1, 1980; R-29, pp. June 198; In English; p. 122-125; Copyright; Avail: Issuing Activity
Reliability problems usually result in rare-event simulations, and hence direct Monte Carlo methods are extremely wasteful of computer time. This paper presents a new application of 'dagger-sampling', for calculating the system unavailability of a large complicated system represented by a coherent fault tree. Since a small number of uniform random numbers generate a number of trials, dagger-sampling appreciably reduces computation time, and hence a large number of trials become possible for the rare-event problems. Further, dagger-sampling decreases the variance of the Monte Carlo estimator because it generates negatively correlated samples.
AIAA
Availability; Fault Trees; Monte Carlo Method; Random Sampling; Reliability Analysis; Run Time (Computers)

19800056179
A Boolean approach to common cause analysis
Worrell, R. B.; Stack, D. W., Sandia Laboratories, USA; Jan 1, 1980; 4p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity
It is shown that a transformation of variables can be used to achieve qualitative common cause analysis. Transformation equations that relate cause events to the primary events of a fault tree are described, and the substitutions that change the minimal cut set equation for the top event of the fault tree from a function of primary events to a function of cause events are explained. Examples are presented which show that different kinds of common cause analysis are accomplished by simple modifications of the transformation equations.
AIAA
Boolean Functions; Failure Analysis; Fault Trees; Reliability Analysis; Transformations (Mathematics)

19800064632
Repairable multiphase systems - Markov and fault-tree approaches for reliability evaluation
Clarotti, C. A., Comitato Nazionale per l'Energia Nucleare, Italy; Contini, S., Sigen S.p.A., Italy; Somma, R., Selenia S.p.A., Italy; Jan 1, 1980; 14p; In English; Synthesis and analysis methods for safety and reliability studies, July 3-14, 1978, Urbino, Italy; Sponsored by In: Synthesis and analysis methods for safety and reliability studies; Proceedings of the Advanced Study Institute; See also A80-48801 21-38; Copyright; Avail: Issuing Activity
In order to evaluate the fault-tree technique and the Markov approach to phased mission systems, both approaches are applied to a specified mission. It is shown that while the fault-tree technique leads to an approximate solution to phased mission problems, the Markov approach gives an exact analytical solution. The limitations and advantages of each of these approaches are discussed.
AIAA
Fail-Safe Systems; Fault Trees; Markov Processes; Reliability Analysis; Space Missions; Spacecraft Reliability

19810002898 Science Applications, Inc., Advanced Power Systems Div., Palo Alto, CA, USA
Extension and validation of fault-tree analysis for reliability prediction
Land, R., Science Applications, Inc., USA; Rayes, L., Science Applications, Inc., USA; Burns, E. T., Science Applications, Inc., USA; Sep 1, 1980; 121p; In English
Report No.(s): EPRI-AP-1510; Avail: CASI; A06, Hardcopy; A02, Microfiche
The reliability projection for a type of fossil fueled power plant which makes use of a combustion turbine and heat recovery steam generator in parallel operation with a package boiler is presented. The fault tree methodology was used to estimate both the mean plant reliability plus a confidence interval for the calculated reliability prediction. The input component failure rates, including the error bounds were updated from an integrated data base obtained from the best available data. The estimated

reliability results using a model representative of the initial two years of plant operation were compared with the reliability from plant operating experience data for a similar period, and these are presented. The estimated reliability for continuous plant operation for 500 hours is in good agreement with the plant operating experience. It is concluded that the fault tree methodology can be applied directly to both the qualitative and quantitative prediction of power plant reliability.
DOE
Electric Power Plants; Fault Trees; Prediction Analysis Techniques; Reliability Analysis

19810008957 Massachusetts Inst. of Tech., Energy Lab., Cambridge, MA, USA
Qualitative and quantitative reliability analysis of safety systems
Karimi, R., Massachusetts Inst. of Tech., USA; Rasmussin, N., Massachusetts Inst. of Tech., USA; Wolf, L., Massachusetts Inst. of Tech., USA; May 1, 1980; 288p; In English; Sponsored in part by Boston Edison Co., Mass.
Report No.(s): PB81-118325; MIT-EL-80-015; Avail: CASI; A13, Hardcopy; A03, Microfiche
    A code was developed for the comprehensive analysis of a fault tree. The code designated UNRAC (UNReliability Analysis Code) calculates the following characteristics of an input fault tree: (1) minimal cut sets; (2) top event unavailability as point estimate and/or in time dependent form; (3) quantitative importance of each component involved; and (4) error bound on the top event unavailability. Overall it is demonstrated that UNRAC is an efficient, easy to use code and has the advantage of being able to do a complete fault tree analysis with this single code. Applications of fault tree analysis to safety studies of nuclear reactors are considered.
NTIS
Component Reliability; Computer Programs; Fault Tolerance; Fault Trees; Reliability Analysis

19810011920 Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID, USA
Integrating reliability analysis and design
Rasmuson, D. M., Edgerton, Germeshausen and Grier, Inc., USA; Oct 1, 1980; 68p; In English
Contract(s)/Grant(s): DE-AC07-76ID-01570
Report No.(s): ALO-131; EGG-IS-5187; Avail: CASI; A04, Hardcopy; A01, Microfiche
    The Interactive Reliability Analysis Project is described and the advantages of using computer-aided design systems (CADS) in reliability analysis are enumerated. Common cause failure problems require presentations of systems, analysis of fault trees, and evaluation of solutions to these. Results have to be communicated between the reliability analyst and the system designer. Using a computer-aided design system saves time and money in the analysis of design. Computer-aided design systems lend themselves to cable routing, valve and switch lists, pipe routing, and other component studies.
DOE
Computer Aided Design; Fault Trees; Reliability Analysis; Reliability Engineering; System Failures

19810014944 Battelle Columbus Labs., OH, USA
Comparative analysis of techniques for evaluating the effectiveness of aircraft computing systems
Hitt, E. F., Battelle Columbus Labs., USA; Bridgman, M. S., Battelle Columbus Labs., USA; Robinson, A. C., Battelle Columbus Labs., USA; Apr 1, 1981; 156p; In English
Contract(s)/Grant(s): NAS1-15760
Report No.(s): NASA-CR-159358; Avail: CASI; A08, Hardcopy; A02, Microfiche
    Performability analysis is a technique developed for evaluating the effectiveness of fault-tolerant computing systems in multiphase missions. Performability was evaluated for its accuracy, practical usefulness, and relative cost. The evaluation was performed by applying performability and the fault tree method to a set of sample problems ranging from simple to moderately complex. The problems involved as many as five outcomes, two to five mission phases, permanent faults, and some functional dependencies. Transient faults and software errors were not considered. A different analyst was responsible for each technique. Significantly more time and effort were required to learn performability analysis than the fault tree method. Performability is inherently as accurate as fault tree analysis. For the sample problems, fault trees were more practical and less time consuming to apply, while performability required less ingenuity and was more checkable. Performability offers some advantages for evaluating very complex problems.
S.F.
Fault Tolerance; Fault Trees; Reliability Analysis

19820007581 Los Alamos Scientific Lab., NM, USA
Failure mode analysis using state variables derived from fault trees with application
Bartholomew, R. J., Los Alamos Scientific Lab., USA; Jan 1, 1981; 11p; In English; ANS/ENS Topical Meeting on Probabilistic
Risk Assessment, 20-24 Sep. 1981, Port Chester, NY, USA
Contract(s)/Grant(s): W-7405-ENG-36
Report No.(s): DE81-030239; LA-UR-81-2595; CONF-810905-3; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Fault Tree Analysis (FTA) is used extensively to assess both the qualitative and quantitative reliability of engineered nuclear
power systems employing many subsystems and components. FTA is very useful, but the method is limited by its inability to
account for failure mode rate of change interdependencies (coupling) of statistically independent failure modes. The state variable
approach (using FTA derived failure modes as states) overcomes these difficulties and is applied to the determination of the
lifetime distribution function for a heat pipe thermoelectric nuclear power subsystem. Analyses are made using both Monte Carlo
and deterministic methods and compared with a Markov model of the same subsystem.
DOE
Failure Modes; Fault Trees; Independent Variables; Nuclear Electric Power Generation

19820016495 Beijing Inst. of Control Engineering, China
A new approach for fault-tree analysis
Jion–Sheng, L., Beijing Inst. of Control Engineering, China; ESA 2nd ESA Prod. Assurance Symp.; Jan 1, 1982, pp. p 57-62;
In English; See also N82-24362 15-31; Avail: CASI; A02, Hardcopy; A01, Microfiche
    The disjoint manipulation rules (DMR) of Boolean algebra used to write the disjoint failure function directly from a fault tree
(FT) are discussed. Programs which enumerate minimal cut sets, prime implicit sets, and transform the system failure function
to disjoint form are simplified to a unique program. The coherent and noncoherent systems can be handled consistently. The FT
decomposition and reduction techniques are combined. Each module is replaced by a pseudo basic event from the FT, and
replicated modules are discarded. The effective size of the FT is the number of events remaining after the modules are replaced,
and the amount of computation decreases exponentially.
CASI
Failure Analysis; Fault Trees; Set Theory

19820031852
Fault diagnosis by mathematical programming
Watanabe, T.; Yasunobu, C.; Okuma, M., Hitachi, Ltd., Japan; IEEE Transactions on Reliability; Oct 1, 1981; R-30, pp. Oct. 198;
In English; p. 345-352; Copyright; Avail: Issuing Activity
    This paper presents the problem of fault diagnosis for logically represented continuous systems that can be formulated
through nonlinear mathematical programming. This problem is transformed to an integer-programming problem and solved.
Possible modifications and extensions of the problem are given. Although failure tables must be prepared in ordinary fault
diagnosis, they are not necessary with this mathematical programming approach. by modifying constraints in the mathematical
programming problem, difficulties such as multiple faults, correlated faults, modifications of test conditions and cycles in the
system, which are encountered in the ordinary failure table approach, are made tractable.
AIAA
Boolean Algebra; Digital Systems; Failure Analysis; Fault Trees; Mathematical Programming; Maximum Likelihood Estimates;
Reliability Analysis

19820056837
Analysis of reliability block diagrams by Boolean techniques
Bennetts, R. G., Cirrus Computers, Ltd., UK; IEEE Transactions on Reliability; Jun 1, 1982; R-31, pp. June 198; In English; p.
159-166; Copyright; Avail: Issuing Activity
    A general purpose method for producing reliability expressions from reliability block diagrams based on an analysis of a
pathset expression derived from the reliability block diagram is described. The resulting expression is tested for disjointness and
procedures are defined for making the terms disjoint if the test is failed. Unassigned variables are reintroduced into the terms in
a manner which is consistent with an overall Boolean function and still guarantees disjointness. Relationships between Boolean
and probabalistic algebras are explored and notation is defined, and the solution is found in terms of the test and modify algorithm

without using a truth table. The method is concluded to be applicable to fault-tree analysis and general problems of reliability assessment, using only a hand calculator.

AIAA

Block Diagrams; Boolean Algebra; Fault Trees; Probability Theory; Reliability Analysis

19830011947 Katholieke Univ. te Leuven, Belgium

Interactive reliability analysis by using SALP and Computer-Aided Fault-Tree Synthesis (CAFTS)

Poucet, A., Katholieke Univ. te Leuven, USA; Demeester, P., Katholieke Univ. te Leuven, USA; Amendola, A., Joint Research Centre of the EEC; Caretta, A., Joint Research Centre of the EEC; ESA Reliability and Maintainability; Sep 1, 1982, pp. p 285-289; In English; See also N83-20178 10-38; Avail: CASI; A01, Hardcopy; A06, Microfiche

The SALP-CAFTS software package permits to interactively construct, modify and analyze fault trees and can be used together with libraries containing component reliability models and reliability data. Extensive use of interactive graphics and modern techniques such as selection menus and full screen data entry panels results in an excellent interface between the analyst and the computer. by this interactive approach, the analyst is relieved from routine work, so that his/her attention is better focused on critical points of the analysis. Moreover, one has the possibility to perform sensitivity studies and system design optimization in a very fast and effective way.

M.G.

Computer Programs; Computer Techniques; Fault Trees; Reliability Analysis

19830020199 British Aerospace Dynamics Group, Reliability Technology Dept., Stevenage, UK

Computer programs for design safety, reliability maintainability analysis

Oconnor, P. D. T., British Aerospace Dynamics Group, UK; Defence Quality Assurance Board Sem. on Quality Assurance in Design and Develop.; Jan 1, 1982, pp. p 15-28; In English; See also N83-28468 17-38; Avail: CASI; A03, Hardcopy; A01, Microfiche

Reliability prediction using parts count techniques, and nonconstant failure rates (Weibull life plot shape parameter, Beta + 1) are considered. For electronic systems, MIL-HBK-217C (Notice 1 May 1980) is used to provide the failure rate models and data base, since it includes stress analysis failure rate models. Failure mode, effect and criticality analysis program in conjunction with MIL-HBK-1629 is discussed. Fault tree analysis and block diagram analysis are treated. Maintainability prediction, based on MIL-HBK-472, is reviewed.

CASI

Computer Aided Design; Computer Systems Programs; Maintainability; Prediction Analysis Techniques; Reliability Analysis; Systems Analysis

19830031438

Reliability assessment and techniques

Sampath, R., Defence Research and Development Laboratory, India; Aeronautical Society of India; May 1, 1981, pp. vol. 33; In English; Feb.-May 1981, p. 27-33; Avail: Issuing Activity

Reliability prediction is an important step at the design stage of certain vital equipment whose development is expensive and time consuming. It pays itself by cutting off the time cycle and also building up reliability in the design. A number of techniques are available for reliability prediction: Those using Parts Count Method, Parts Stress Analysis and Fault Tree Analysis are discussed in this paper. The methodology, the strengths and weaknesses of each method are pointed out. Action required to make these methods realistic and of practical significance to industries is also indicated.

AIAA

Component Reliability; Electronic Equipment; Mathematical Models; Prediction Analysis Techniques; Reliability Engineering; Structural Reliability

19830039296

ESCAF - A new and cheap system for complex reliability analysis and computation

Laviron, A.; Manaranche, J. C., Commissariat a l'Energie Atomique, Centre d'Etudes de Valduc, Is-sur-Tille, France; Carnino, A., Commissariat a l'Energie Atomique, France; IEEE Transactions on Reliability; Oct 1, 1982; R-31, pp. Oct. 198; In English; p. 339-349; Copyright; Avail: Issuing Activity

A new apparatus, the electronic simulator to compare and analyze failures (ESCAF), is introduced as a means to analyze the reliability of systems with up to 416 components. ESCAF operates by simulating a system using the electronic gates of ICs mounted on specially configured cards. The component state is input and the failed or nonfailed state of the system is output after

a fault-tree analysis. A fault combination generator simulated the failure of all system components or the occurrence of all basic events, employing increasing orders of simulation until the most complex order of events is accounted for. Input of the individual event probabilities, component failure probabilities, or component unavailabilities yields computation of the overall system failure probability or unavailability. A serial transmission link is provided for interconnect with a mini- or microcomputer. Use of the device for spacecraft or nuclear power plant safety analyses is indicated.
AIAA
Electronic Equipment; Failure Analysis; Fault Trees; Reliability Analysis; Reliability Engineering; Systems Simulation

19830066397
Interval reliability for initiating and enabling events
Dunglinson, C., E.I. Du Pont de Nemours and Co., USA; Lambert, H.; IEEE Transactions on Reliability; Jun 1, 1983; ISSN 0018-9529; R-32, pp. June 198; In English; p. 150-163; Copyright; Avail: Issuing Activity

This paper describes generation and evaluation of logic models such as fault trees for interval reliability. Interval reliability assesses the ability of a system to operate over a specific time interval without failure. The analysis requires that the sequence of events leading to system failure be identified. Two types of events are described: (1) initiating events (cause disturbances of perturbations in system variables) that cause system failure and (2) enabling events (permit initiating events to cause system failure). Control-system failures are treated. The engineering and mathematical concepts are described in terms of a simplified example of a pressure-tank system. Later these same concepts are used in an actual industrial application in which an existing chlorine vaporizer system was modified to improve safety without compromising system availability. Computer codes that are capable of performing the calculations, and pitfalls in computing accident frequency in fault tree analysis, are discussed.
AIAA
Computer Aided Design; Fault Trees; Pressure Vessel Design; Reliability Analysis; System Failures; Systems Analysis

19830069141 British Library Lending Div., Boston Spa, UK
Consequence/cause diagrams
Farris, L.; Mazzocchi, A.; Sep 9, 1982; 15p; Transl. into ENGLISH from Chim. Ind. (Milan), v. 61, no. 3, Mar. 1979; In English
Report No.(s): BLL-RISLEY-TR-4172-(9091.9F); Copyright; Avail: British Library Lending Div., Boston Spa, Engl., Unavail. Microfiche
      No abstract.
Causes; Failure Analysis; Fault Trees; Reliability Analysis

19830071982 Australian Atomic Energy Commission, Lucas Heights, Australia
Fault tree analysis: Method and symbols
Nov 1, 1980; 24p; Transl. into ENGLISH from German Standard DIN-25424, Jun. 1977; In German
Report No.(s): DE81-700889; AAEC-LIB/TRANS-733; Avail: CASI; A03, Hardcopy; Avail: CASI HC A03/; A01, Microfiche; US Sales Only
      No abstract.
Computer Programs; Data Processing; Failure Analysis; Fault Trees; Mathematical Models; Reliability Engineering

19830075603 Science Applications, Inc., Palo Alto, CA, USA
Verification of fault tree analysis. Volume 2: Technical descriptions
Rothbart, G., Science Applications, Inc., USA; Fullwood, R., Science Applications, Inc., USA; Basin, S., Science Applications, Inc., USA; Newt, J., Science Applications, Inc., USA; Escalera, J., Science Applications, Inc., USA; May 1, 1981; 167p; In English; Sponsored by EPRI
Contract(s)/Grant(s): EPRI PROJ. 1223
Report No.(s): DE81-903495; EPRI-NP-1570-VOL-2; Avail: CASI; A08, Hardcopy, Microfiche
      No abstract.
Circuit Boards; Fault Trees; Printed Circuits; Reliability Analysis

19830077066 Science Applications, Inc., Palo Alto, CA, USA
Verification of fault tree analysis. Volume 1: Experiments and results
Rothbart, G., Science Applications, Inc., USA; Fullwood, R., Science Applications, Inc., USA; Basin, S., Science Applications, Inc., USA; Newt, J., Science Applications, Inc., USA; Escalera, J., Science Applications, Inc., USA; May 1, 1981; 147p; In English
Contract(s)/Grant(s): EPRI PROJ. 1233
Report No.(s): DE81-903324; EPRI-NP-1570-VOL-1; Avail: CASI; A07, Hardcopy, Microfiche
    No abstract
Complex Systems; Component Reliability; Maintenance; Reactor Safety; Systems Simulation

19840013823 Los Alamos Scientific Lab., NM, USA
State variable method of fault tree analysis
Bartholomew, R. J., Los Alamos Scientific Lab., USA; Knudsen, H. K., New Mexico Univ., USA; Whan, G. A., New Mexico Univ.; Jan 1, 1984; 28p; In English; Symp. on Space Nucl. Power Systems, 10-12 Jan. 1984, Albuquerque, NM, USA
Contract(s)/Grant(s): W-7405-ENG-36
Report No.(s): DE84-006007; LA-UR-84-53; CONF-840113-5; Avail: CASI; A03, Hardcopy; A01, Microfiche
    The current technique of Fault Tree Analysis (FTA) generally employs computer codes that calculate the minimal cut sets of the Boolean function, where each cut set comprises basic initiator events (roots) whose intersection implies the occurrence of a TOP (system failure) event. Because the number of calculations is very large for typical fault trees, the importance of any given cut set is assessed by qualitative algorithms that includes the number of basic events in the cut set, and quantitative importance algorithms that involve probabilistic upper and lower bound estimates, and the sets are culled before quantitative probability calculations are made. The question addressed in this paper is: can a tractable mathematical model be found that performs quantitative calculations without the need of upper or lower bound simplications and include within its structure the capability of handling common cause/common mode statistical dependence, failure mode coupling interdependence, and sequential failure time dependence.
DOE
Algorithms; Coding; Computer Programs; Fault Trees; Statistical Analysis

19840063709
Fault tree analysis, taking into account causes of common mode failures
Stecher, K., Siemens AG, Germany; Siemens Forschungs- und Entwicklungsberichte; Jan 1, 1984; ISSN 0370-9736; 13, 4, 19; 8p; In English; Copyright; Avail: Issuing Activity
    In evaluating fault trees using Boolean algebra and system function, subsystems can only be separated out if there are no failures of multiple-system components attributable to a common cause; i.e., so-called common-mode failures. For systems with distributed common modes, the effort required for this evaluation increases exponentially with the number of design components. This problem has been solved by means of a method in which the reliability data for the simple components are inserted on the lowest possible level of evaluation, whereas the data for the common modes are substituted at the top of the fault tree. The method described provides the basis for a computer program.
AIAA
Complex Systems; Failure Analysis; Failure Modes; Fault Trees; Reliability Analysis

19840068960 Kernforschungszentrum G.m.b.H., Projekt Nukleare Sicherheit., Karlsruhe, Germany
Failure diagnosis and fault tree analysis
Weber, G., Kernforschungszentrum G.m.b.H., Germany; Jul 1, 1982; 114p; In English
Report No.(s): DE82-750171; KFK-3384; Avail: CASI; A06, Hardcopy; Avail: CASI HC A06/; A02, Microfiche; US Sales Only
    No abstract.
Boolean Algebra; Boolean Functions; Failure Analysis; Fault Trees; Reactor Safety

19850027903
From fault-tree to fault-identification
Kiss, L., Magyar Tudomanyos Akademia, Hungary; IEEE Transactions on Reliability; Dec 1, 1983; ISSN 0018-9529; R-32, pp. 422-425; In English; Copyright; Avail: Issuing Activity

A practical way is given of identifying actual faults, by using a fault tree's complete system of minimal cutsets. For instance, for a fault tree where 20 cutsets are considered with 30 possible primal events, any of them can be found in at most three steps by the proposed FID-algorithm.

AIAA

Boolean Algebra; Fault Trees; Parameter Identification; Reliability Analysis

19850056115

Classification of Characteristics - Rich source of test requirements

Pope, M.; Dirnbach, P. H., Rockwell International Corp., USA; Jan 1, 1984; 6p; In English; 8th; Aerospace Testing Seminar, March 21-23, 1984, Los Angeles, CA; Sponsored by Insititute of Environmental Sciences and Aerospace Corp.; See also A85-38251 17-14; Avail: Issuing Activity

Test requirements are found in connection with three different situations. Thus, a contract may contain test requirements, or interpretations of test requirements. Another situation requiring the conduction of tests is related to design or development processes, while a third situation is produced by the need to conduct failure assessment studies. An analytical technique called 'Classification of Characteristics' provides the means for a detailed and highly graphic assessment of possible failure modes. This technique applies to design characteristics which affect personnel safety or mission reliability. The basic steps for implementing Classification of Characteristics include an identification of the component or system failure modes and their causes by a fault tree analysis, and a classification of the failure modes as critical or major. Attention is also given to the identification of all design characteristics related to possible failure modes, the coordination of the required action with certain organizations, and aspects of documentation.

AIAA

Classifications; Failure Analysis; Failure Modes; Production Planning; User Requirements

19850064527

Fault tree analysis, methods, and applications - A review

Lee, W. S.; Grosh, D. L.; Tillman, F. A., Kansas State University, USA; Lie, C. H., Seoul National University, USA; IEEE Transactions on Reliability; Aug 1, 1985; ISSN 0018-9529; R-34, pp. 194-203; In English; Research supported by the Korea Science and Engineering Foundation

Contract(s)/Grant(s): N00014-76-C-0842; NSF INT-82-15755; Copyright; Avail: Issuing Activity

This paper reviews and classifies fault-tree analysis methods developed since 1960 for system safety and reliability. Fault-tree analysis is a useful analytic tool for the reliability and safety of complex systems. The literature on fault-tree analysis is, for the most part, scattered through conference proceedings and company reports. The literature has been classified according to system definition, fault-tree construction, qualitative evaluation, quantitative evaluation, and available computer codes for fault-tree analysis.

AIAA

Fault Trees; Reliability Analysis

19850064529

A reliability-program case-history on design review

Kitagawa, K., Tokyo Science University, Japan; IEEE Transactions on Reliability; Aug 1, 1985; ISSN 0018-9529; R-34, pp. 212-215; In English; Copyright; Avail: Issuing Activity

This paper summarizes the investigative results of actual design reviews as an important part of reliability program, and describes several reliability engineering efforts to achieve an effective design review. Design data packages (design documentation) which indicate the basic design program and design process are important in design reviews. When attention is concentrated on a data package, the ability of the reviewers is heightened and the results of the review are enhanced. When the design review is concerned with product reliability, then the availability and quality of: (1) a data package with established reliability level objectives and predictions, (2) a Failure Mode Effect Analysis and a Fault Tree Analysis, and (3) other data packages on product reliability and related technology or engineering, all greatly influence the results of the review. The potential weak points in a design can be revealed by over-stress tests and the results of such tests are very useful in the reliability design review. The improved design which can withstand the adequate overstress tests appreciably lessened customer complaints about reliability.

AIAA

Design Analysis; Reliability Engineering

19850067381
Mechanical R&M modeling and simulation methods
Bazovsky, I., Sr., IBA, Inc., USA; Benz, G. E.; Jan 1, 1984; 6p; In English; Annual Reliability and Maintainability Symposium, January 24-26, 1984, San Francisco, CA; Sponsored by IEEE, AIAA, ASME; See also A85-49526 24-38; Copyright; Avail: Issuing Activity

Theory is developed for the reliability of mechanical components as a function of their age and for the reliability of mechanical systems. It is shown that renewal theory can be used in practical applications to avoid the burden of keeping age records on every part. Two classes of maintenance policies are investigated; one replaces only failed components, the other replaces components preventively and at failure. It is shown that a logic tree approach to simulation provides for a mix of techniques which can treat such problems as reduction in maintenance float for expensive weapons, and reduction in parts disposal for machines processing hazardous materials.
AIAA
Component Reliability; Fault Trees; Maintenance; Mechanical Engineering; Reliability Analysis; Systems Simulation

19850070711 Nuclear Regulatory Commission, Div. of Systems and Reliability Research., Washington, DC, USA
Fault tree handbook
Haasl, D. F., Nuclear Regulatory Commission, USA; Roberts, N. H., Nuclear Regulatory Commission, USA; Vesely, W. E., Nuclear Regulatory Commission, USA; Goldberg, F. F., Nuclear Regulatory Commission, USA; Jan 1, 1981; 215p; In English
Report No.(s): NUREG-0492; Avail: CASI; A10, Hardcopy, Unavail. Microfiche

No abstract.
Fault Trees; Nuclear Power Plants; Reliability Analysis; Systems Analysis

19860036268
Digraph matrix analysis
Sacks, I. J., Analytic Information Processing, Inc., USA; IEEE Transactions on Reliability; Dec 1, 1985; ISSN 0018-9529; R-34, pp. 437-446; In English; Research supported by the U.S. Nuclear Regulatory Commission and Analytic Information Processing, Inc; Copyright; Avail: Issuing Activity

This paper describes a systematic procedure for constructing a Boolean reliability model from plant schematics, and a technique for determining all sets of single and double component failures which will cause system failure. This technique, called digraph matrix analysis, uses a fault graph instead of the more traditional fault tree. Digraph matrix analysis was recently applied to the system interaction analysis of a very large safety system (over ten thousand components) and is being used to determine security system vulnerabilities.
AIAA
Boolean Algebra; Fault Trees; Graph Theory; Matrices (Mathematics); Reliability Analysis; System Failures

19860036270
Fault-tree analysis using a binary decision tree
Schneeweiss, W. G., Fernuniversitaet, Germany; IEEE Transactions on Reliability; Dec 1, 1985; ISSN 0018-9529; R-34, pp. 453-457; In English; Copyright; Avail: Issuing Activity

A new algorithm for the production of a short disjoint-products form of a fault-tree output function is presented and discussed. This algorithm consists of a sequential binary decision process to find first big, then smaller sets of elementary system-failure states which correspond to disjoint-product terms. The identification of bad and good system states can be eased by a simple ternary (3-state) decision for which an auxiliary procedure is presented. The main advantages of this algorithm appear to be its efficiency, simplicity, and usefulness as an alternative (in the sense of multiversion programming for software fault tolerance) for the Shannon decomposition algorithm.
AIAA
Boolean Functions; Decision Theory; Fault Trees; Reliability Analysis; System Failures; System Identification

19860036271
Uncertainty analysis of fault-tree outputs
Rushdi, A. M., King Abdulaziz University, Saudi Arabia; IEEE Transactions on Reliability; Dec 1, 1985; ISSN 0018-9529; R-34, pp. 458-462; In English; Copyright; Avail: Issuing Activity

The multiaffine nature of the top-event probability as a function of component unavailability is recognized. This leads, under the assumption of statistically independent failures, to the derivation of an exact formula relating the variance of the system

unavailability to the variances of the component unavailability. Concise expressions for other central moments of the system unavailability are obtained. The variance formula partitions contributions due to the input variables and their interactions, and can be used to rank these variables by an importance that is related to well known measures of statistical importance. The variance formula is extended to handle linearly correlated input variables through the inclusion of certain joint central moment terms.
AIAA
Availability; Fault Trees; Partitions (Mathematics); Probability Theory; Reliability Analysis; Variance (Statistics)

19860045366
Failure analysis - Present concepts and future perspectives
Raghuram, A. C., National Aeronautical Laboratory, India; Shamala, A. R., Indian Space Research Organization, Satellite Centre, India; Jan 1, 1986; 15p; In English; See also A86-29951; Copyright; Avail: Issuing Activity

Aspects of failure analysis methodology are discussed, taking into account questions which arise with many failure problems, the common causes and defects in failure, the graphical technique provided by the 'fault tree', the quantitative evaluation of the fault tree, and the applications of fault tree analysis. Attention is given to the tools and techniques used in failure analysis, a fault tree for a boiler tube failure, the role of fracture mechanics, storage and retrieval of failure data, a failure experience matrix, reliability and failure analysis, and the economics of quality performance. It is concluded that failure analysis and fracture mechanics when used in combination judiciously will help reduce incidence of failures and improve reliability of engineering structures in an economical way.
AIAA
Failure Analysis; Fracture Mechanics; Structural Failure; Technology Assessment

19870027551
Fault tree analysis - Two case histories
Strauss, B. M., Teledyne Engineering Services, USA; Damin, D. G., E. I. du Pont de Nemours and Co., USA; Materials Evaluation; Aug 1, 1986; ISSN 0025-5327; 44, pp. 1132-113; In English; Copyright; Avail: Issuing Activity

The technique of fault tree analysis and its relation to a nondestructive testing (NDT) inspection plan is introduced. The use of fault tree diagrams in conjunction with NDT encourages the use of predictive analysis rather than after-the-fact failure analysis, resulting in obvious cost benefits. Two case histories are cited.
AIAA
Case Histories; Fault Trees; Nondestructive Tests; Numerical Analysis

19880005868 Naval Postgraduate School, Monterey, CA, USA
Fault tree reliability analysis of the Naval Postgraduate School mini-satellite (ORION)
Keeble, Trenton G., Naval Postgraduate School, USA; Sep 1, 1987; 82p; In English
Report No.(s): AD-A186283; Avail: CASI; A05, Hardcopy; A01, Microfiche

Fault tree analysis, which has proved to be a useful analytical tool for the reliability and safety analysis of complex systems, is applied to the Naval Postgraduate School Mini-Satellite (ORION). A general background to reliability analysis, fault tree analysis, and fault tree construction is given. Impact of a phased mission is included in the analysis. A fault tree for ORION is constructed and used to identify minimal cut sets and minimal path sets. The cuts sets and path sets are, in turn, used to calculate an estimate of ORION's reliability to perform a three year mission. The reliability model was constructed in a Lotus 1-2-3 spreadsheet to enable the designers to do what-if analysis.
CASI
Computer Aided Design; Fault Trees; Reliability Analysis; Safety; Satellite Design

19880015598 Brookhaven National Lab., Upton, NY, USA
Applications of fault tree analysis to the design process
Youngblood, R. W., Brookhaven National Lab., USA; Jan 1, 1988; 10p; In English
Contract(s)/Grant(s): DE-AC02-76CH-00016
Report No.(s): DE88-007048; BNL-40839; CONF-880112-1; Avail: CASI; A02, Hardcopy; A01, Microfiche

Fault tree analysis of a system can provide a complete characterization of system failure modes, i.e., what combinations of component failures can give rise to system failure. This can be applied to the design process at several levels: confirmatory analysis, in which a fault tree development is used to verify design adequacy, importance analysis, in which fault tree analysis is used to highlight system vulnerabilities, and design optimization, in which fault tree analysis is used to pick the least expensive

configuration from a collection of possibilities satisfying a given constraint. Experience shows that the complexity of real systems warrants the systematic and structured development of fault trees for systems whose failure can have severe consequences.
DOE
Design Analysis; Failure Modes; Fault Trees; Optimization; System Failures

19880026195
Reliability analysis for a real non-coherent system
Zhang, Qin; Mei, Qizhi, Qinghua University, USA; IEEE Transactions on Reliability; Oct 1, 1987; ISSN 0018-9529; R-36, pp. 436-439; In English; Copyright; Avail: Issuing Activity

This paper shows a real noncoherent system, calculates its unavailability, failure frequency, some measures for the element importance, and the optimum sequence for diagnosis and repair. The unique characteristic of its noncoherence is discussed.
AIAA
Fault Trees; Maintenance; Mtbf; Reliability Analysis

19880056132
Automated fault tree analysis via AI/ES
Kuzawinski, Karla M.; Smurthwaite, Richard, Xerox Corp., USA; Jan 1, 1988; 5p; In English; Annual Reliability and Maintainability Symposium, Jan. 26-28, 1988, Los Angeles, CA, USA; See also A88-43326; Copyright; Avail: Issuing Activity

A description is given of FTA, an interactive fault tree analysis tool that integrates the creation of fault trees with the propagation of failure rates. This tool allows the engineer to create, modify and manipulate fault trees easily, and requires little instruction on how to use the software. The fault trees generated are directly used in the propagation of failure rates without having to exit from the design environment. FTA software runs on a Xerox 1100 series workstation and is written in INTERSLIP-D. The workstation has a large bit-mapped screen, and users interact with the workstation by input through a keyboard or selection by a mouse.
AIAA
Automatic Test Equipment; Expert Systems; Fault Trees; Maintainability; Reliability Analysis

19890059119 Texas Univ., Austin, TX, USA
Reliability database development for use with an object-oriented fault tree evaluation program
Heger, A. Sharif, Texas Univ., USA; Harringtton, Robert J., Texas Univ., USA; Koen, Billy V., Texas, University, USA; Patterson–Hine, F. Ann, NASA Ames Research Center, USA; Jan 1, 1989; 5p; In English; Annual Reliability and Maintainability Symposium, Jan. 24-26, 1989, Atlanta, GA, USA; See also A89-46451 20-38
Contract(s)/Grant(s): NSF DMC-86-15432; Copyright; Avail: Issuing Activity

A description is given of the development of a fault-tree analysis method using object-oriented programming. In addition, the authors discuss the programs that have been developed or are under development to connect a fault-tree analysis routine to a reliability database. to assess the performance of the routines, a relational database simulating one of the nuclear power industry databases has been constructed. For a realistic assessment of the results of this project, the use of one of existing nuclear power reliability databases is planned.
AIAA
Data Bases; Fault Trees; Nuclear Power Plants; Object Programs; Object-Oriented Programming; Reliability Analysis

19900006971 Sandia National Labs., Exploratory Batteries Div., Albuquerque, NM, USA
Fault tree analysis: A tool for battery safety and reliability studies
Levy, Samuel C., Sandia National Labs., USA; Jan 1, 1989; 7p; In English; 5th; Annual Battery Conference on Applications and Advances, 16-18 Jan. 1990, Long Beach, CA, USA
Contract(s)/Grant(s): DE-AC04-76DP-00789
Report No.(s): DE90-002582; SAND-89-2312C; CONF-900138-2; Avail: CASI; A02, Hardcopy; A01, Microfiche

Fault tree analysis was used by engineers as a means of defining system failure. It provides a method of system examination which increases the level of understanding of the system and is helpful in logically determining the underlying causes of potential failures. A fault tree is composed of a number of symbols, describing different types of events, which are operated on by logic gates. Construction of a battery fault tree is discussed in terms of two types of event and two logic gates. An example is given of how fault tree analysis was used to determine the cause of a safety incident. A string of lithium cells on test for several years

suddenly vented violently. Fault tree analysis quickly pointed out the underlying faults leading to this event, and a means of prevention was suggested.
DOE
Electric Batteries; Fault Trees; Logic Circuits; Reliability; Systems Analysis

199000038446
A model for system reliability with common-cause failures
Page, Lavon B.; Perry, Jo Ellen, North Carolina State University, USA; IEEE Transactions on Reliability; Oct 1, 1989; ISSN 0018-9529; 38, pp. 406-410; In English; Copyright; Avail: Issuing Activity
    A model for the analysis of systems subject to common-cause failures is proposed. The system consists of a finite number of components that are subject to: (1) statistically independent failures, and (2) external failure causes (they need not be mutually statistically independent) for groups of components. Applications to fault-tree analysis and network reliability problems are discussed.
AIAA
Component Reliability; Failure Modes; Fault Trees; Reliability Engineering; Systems Engineering

199100007082 Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID, USA
Living PRAs (Probabilistic Risk Analysis) made easier with IRRAS (Integrated Reliability and Risk Analysis System)
Russell, K. D., Idaho National Engineering Lab., USA; Sattison, M. B., Idaho National Engineering Lab., USA; Rasmuson, D. M., Nuclear Regulatory Commission, USA; Jan 1, 1989; 33p; In English; 10th; International Conference on Structural Mechanics in Reactor Technology (SMIRT), 14-18 Aug. 1989, Anaheim, CA, USA
Contract(s)/Grant(s): DE-AC07-76ID-01570
Report No.(s): DE90-010938; EGG-M-89329; CONF-890855-60; Avail: CASI; A03, Hardcopy; A01, Microfiche
    The Integrated Reliability and Risk Analysis System (IRRAS) is an integrated PRA software tool that gives the user the ability to create and analyze fault trees and accident sequences using an IBM-compatible microcomputer. This program provides functions that range from graphical fault tree and event tree construction to cut set generation and quantification. IRRAS contains all the capabilities and functions required to create, modify, reduce, and analyze event tree and fault tree models used in the analysis of complex systems and processes. IRRAS uses advanced graphic and analytical techniques to achieve the greatest possible realization of the potential of the microcomputer. When the needs of the user exceed this potential, IRRAS can call upon the power of the mainframe computer. The role of the Idaho National Engineering Laboratory of the IRRAS program is that of software developer and interface to the user community. Version 1.0 of the IRRAS program was released in February 1987 to prove the concept of performing this kind of analysis on microcomputers. This version contained many of the basic features needed for fault tree analysis and was received very well by the PRA community. Since the release of Version 1.0, many user comments and enhancements have been incorporated into the program providing a much more powerful and user-friendly system. This version is designated IRRAS 2.0. Version 3.0 will contain all of the features required for efficient event tree and fault tree construction and analysis.
DOE
Architecture (Computers); Computer Graphics; Fault Trees; Reactor Safety; Reliability Analysis; Risk

199100025515
Quantification of risk of extreme and catastrophic events
Haimes, Yacov Y.; Li, Duan, Virginia, University, USA; Sep 1, 1990; 4p; In English
Report No.(s): AIAA PAPER 90-3772; Copyright; Avail: Issuing Activity
    Recent research results from fault-tree risk analysis of extreme events within a multiobjective framework are reported. In particular, the incorporation of the partitioned multiobjective risk method with fault-tree analysis is discussed. The use of a software package that is being developed for this purpose is presented, and its utility and advantages over existing fault-tree software packages are discussed.
AIAA
Computer Programs; Fault Trees; Risk; Systems Engineering

199100046438
Reliability analysis of redundant aircraft systems with possible latent failures
Sharma, Tilak C.; Zilberman, Benyamin, Boeing Co., USA; Jan 1, 1990; 6p; In English; See also A91-31032; Copyright; Avail: Issuing Activity

A methodology has been developed to calculate unreliability of redundant airplane systems containing latent failures with differing inspection intervals. The usual assumption that all components are unfailed at the start of a flight is not valid for the airplane systems investigated. The analysis method consists of representing a redundant system either as a fault tree or a reliability block diagram. The bottom-up approach is recommended for the fault-tree representation where one starts from the lowest AND gate and calculates failure probability. The number obtained for the top fault-tree gate would represent the system failure probability in which the system logic and latency have been appropriately considered. Alternatively, for a system represented by a reliability block diagram, the top-down approach is recommended.

AIAA

Aircraft Parts; Fault Trees; Markov Processes; Quality Control; Redundant Components; Reliability Analysis

19910046458

Fault tree analysis - Using spreadsheet

Liu, Ming C., Wichita State University, USA; Jan 1, 1990; 4p; In English; See also A91-31032; Copyright; Avail: Issuing Activity

Design considerations are given for fault-tree analysis (FTA) using spreadsheet software. The objective is to demonstrate, by means of examples, how microcomputer spreadsheet software can be used as an alternative to the mainframe commercial FTA package for designing the fault tree and performing tedious computations. Experiences in using this approach for FTA are described, and the sensitivity analysis of fault-tree research is addressed.

AIAA

Applications Programs (Computers); Fault Trees; Microcomputers; Reliability Engineering; System Failures

19920050552

How to use event sequence analysis tools for supporting concurrent engineering

Jackson, Tyrone, Aerospace Corp., USA; Feb 1, 1992; 11p; In English

Report No.(s): AIAA PAPER 92-0973; Copyright; Avail: Issuing Activity

The benefits of employing the event sequence analysis method as a better means of integrating reliability analysis with the design process are presented. An example analysis illustrates that the results provided by the methodology are the same as those found utilizing reliability block diagram analysis, failure modes and effects analysis, and fault tree analysis. The purpose is to demonstrate that the technique helps to broaden the prospective of reliability analysis by providing features which have multidiscipline application.

AIAA

Concurrent Engineering; Design Analysis; Production Engineering; Reliability Analysis; Sequential Analysis

19920059448

A technique for proper design and impact analysis of 'Event Sequencing' for safety and availability

Agarwala, Ajay S., Boeing Co., Helicopters Div., Philadelphia, USA; Jan 1, 1991; 5p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Copyright; Avail: Issuing Activity

This paper discusses 'Event Sequencing', that is, the requirement for certain events to occur in a particular order to achieve a desirable effect or to avoid an undesirable effect. Such requirements are often motivated by Functionality and Safety considerations. A simple structured technique is formed from a combination of Goal Tree Analysis and broad Fault Tree analysis to analyze 'Event Sequencing' in each operational mode. In addition, this technique provides an effective tool for managing and communicating the design requirements in a concurrent engineering environment involving complex designs with interactive functions.

AIAA

Availability; Design Analysis; Safety Devices; Sequencing; Systems Engineering

19920073616 NASA Ames Research Center, Moffett Field, CA, USA

Automatic translation of digraph to fault-tree models

Iverson, David L., NASA Ames Research Center, USA; Jan 1, 1992; 9p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Avail: Issuing Activity

The author presents a technique for converting digraph models, including those models containing cycles, to a fault-tree format. A computer program which automatically performs this translation using an object-oriented representation of the models has been developed. The fault-trees resulting from translations can be used for fault-tree analysis and diagnosis. Programs to calculate fault-tree and digraph cut sets and perform diagnosis with fault-tree models have also been developed. The digraph to fault-tree translation system has been successfully tested on several digraphs of varying size and complexity. Details of some

representative translation problems are presented. Most of the computation performed by the program is dedicated to finding minimal cut sets for digraph nodes in order to break cycles in the digraph. Fault-trees produced by the translator have been successfully used with NASA's Fault-Tree Diagnosis System (FTDS) to produce automated diagnostic systems.
AIAA
Fault Trees; Mathematical Models; Object-Oriented Programming

199200073617 NASA Ames Research Center, Moffett Field, CA, USA
Modular techniques for dynamic fault-tree analysis
Patterson–Hine, F. A., NASA Ames Research Center, USA; Dugan, Joanne B., Duke University, USA; Jan 1, 1992; 7p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201
Contract(s)/Grant(s): NAC2-478; Copyright; Avail: Issuing Activity
       It is noted that current approaches used to assess the dependability of complex systems such as Space Station Freedom and the Air Traffic Control System are incapable of handling the size and complexity of these highly integrated designs. A novel technique for modeling such systems which is built upon current techniques in Markov theory and combinatorial analysis is described. It enables the development of a hierarchical representation of system behavior which is more flexible than either technique alone. A solution strategy which is based on an object-oriented approach to model representation and evaluation is discussed. The technique is virtually transparent to the user since the fault tree models can be built graphically and the objects defined automatically. The tree modularization procedure allows the two model types, Markov and combinatoric, to coexist and does not require that the entire fault tree be translated to a Markov chain for evaluation. This effectively reduces the size of the Markov chain required and enables solutions with less truncation, making analysis of longer mission times possible. Using the fault-tolerant parallel processor as an example, a model is built and solved for a specific mission scenario and the solution approach is illustrated in detail.
AIAA
Computer Systems Design; Fault Tolerance; Fault Trees; Object-Oriented Programming; Parallel Processing (Computers); Reliability Engineering

199200073618
Approximate fault-tree analysis without cut sets
Schneeweiss, Winfrid G., Fernuniversitaet, Germany; Jan 1, 1992; 6p; In English; Annual Reliability and Maintainability Symposium, Jan. 21-23, 1992, Las Vegas, NV, USA; Sponsored by IEEE; See also A92-56201; Copyright; Avail: Issuing Activity
       It is shown that a rather efficient approximate fault tree analysis is possible on the basis of the Shannon decomposition. The main advantages are: (1) no preprocessing is necessary to determine all the mincuts; (2) the maximum error can be prespecified; and (3) noncoherent systems and systems with dependent component states can be treated. The main disadvantage is the fact that the cutting off of certain subtrees of the decomposition tree (for upper bound results) may need some trial and error test calculations.
AIAA
Boolean Algebra; Fault Trees; Reliability Analysis

199700016788 California Univ., Engineering Systems Research Center, Berkeley, CA USA
Failure Models Derived Through the Indifference Principle (UCB-ENG-8293) Final Report, 1 Oct. 1992 - 31 Mar. 1996
Barlow, Richard E., California Univ., USA; Mar. 1996; 7p; In English
Contract(s)/Grant(s): F49620-93-1-0011; AF Proj. 2304
Report No.(s): AD-A315265; AFOSR-TR-96-0489; No Copyright; Avail: CASI; A02, Hardcopy; A01, Microfiche
       This draft of a new book entitled ENGINEERING RELIABILITY concerns failure data analysis, the economics of maintenance policies and system reliability. The purpose of this book is to develop the use of probability in engineering reliability and maintenance problems. We use probability models in the (1) analysis of failure data; (2) decision relative to planned maintenance; and (3) prediction relative to preliminary design. Engineering applications are emphasized and are used to motivate the methodology presented. Part 1 is devoted to the analysis of failure data, particularly lifetime data and failure counts. We begin by using a new approach to probability applications. The approach starts with finite populations and derives conditional probability models based on engineering and economic considerations. Infinite population conditional probability models most often used are approximations to these finite population models. The derived conditional probability models are then the basis for likelihood functions useful for the analysis of failure data. Part 2 is devoted to the economics of maintenance decisions. We begin with the economics of replacement decisions. Emphasis is on the time value of money and discounting. Then we consider

inspection policies relative to operating systems and production sampling. Part 3 is devoted to system reliability. We begin with efficient algorithms for computing network reliability. Networks or block diagrams are abstract system representations useful for both reliability prediction and maintenance considerations. Availability and maintainability formulas are derived and used in applications. Fault tree analysis as presented is one of the most useful tools in identifying system failure modes and effects.
DTIC
Failure Analysis; Failure Modes; Performance Prediction; Probability Theory; Reliability Engineering; System Failures

19980002720 NERAC, Inc., Tolland, CT USA
Reliability: Mathematical Techniques. (Latest citations from the NTIS Bibliographic Database)
Jan. 1997; In English; Page count unavailable. Supersedes PB96-864442
Report No.(s): PB97-855290; Copyright Waived; Avail: Issuing Activity (Natl Technical Information Service (NTIS)), Microfiche
The bibliography contains citations concerning mathematical, statistical, and logic techniques used to develop reliability prediction theories and systems. Topics include fault tree analysis, life testing, failure analysis, probability theory, maximum likelihood estimation, and Bayesian analysis. Computer modeling, simulation, and related programming are discussed. (Contains 50-250 citations and includes a subject term index and title list.)
NTIS
Bibliographies; Reliability Analysis; Performance Prediction; Statistical Analysis; Prediction Analysis Techniques; Mathematical Logic

19980016089 NERAC, Inc., Tolland, CT USA
Reliability: Mathematical Techniques. (Latest Citations from the NTIS Bibliographic Database)
Mar. 1996; In English; Page count unavailable.
Report No.(s): PB96-864442; Copyright Waived; Avail: Issuing Activity (Natl Technical Information Service (NTIS)), Microfiche
The bibliography contains citations concerning mathematical, statistical, and logic techniques used to develop reliability prediction theories and systems. Topics include fault tree analysis, life testing, failure analysis, probability theory, maximum likelihood estimation, and Bayesian analysis. Computer modeling, simulation, and related programming are discussed.
NTIS
Bibliographies; Reliability; Failure Analysis; Fault Trees; Mathematical Logic; Performance Prediction

19980032455
Reliability of composite structures with multi-design criteria
Shiao, Michael C., NYMA, Inc., USA; Chamis, Christos C., NASA Lewis Research Center, USA; 1994, pp. 606-615; In English
Report No.(s): AIAA Paper 94-1382; Copyright; Avail: Aeroplus Dispatch
The system (combined) reliability of a composite structure for multidesign criteria is computationally simulated. System reliability calculation is achieved by probabilistic fault tree analysis with adaptive important sampling (AIS) simulation method. Two types of AIS simulations are performed. One is based on approximated failure (limit state) functions. Another one is based on finite element analysis. Three performance criteria are used for demonstration: structural frequency range, safety margin for stress, and displacement constraint. A probabilistic fault tree analysis using AIS methods for system reliability calculation considering failure function dependency is demonstrated. It is found that, for this specific example, the system reliabilities calculated using both AIS approaches agree well to each other. However, the computational time for AIS with approximated failure functions is ten times less than that for AIS with finite element analysis.
Author (AIAA)
Reliability Analysis; Composite Structures; Structural Design Criteria

19980087666
IEEE Annual Reliability and Maintainability Symposium, Philadelphia, PA, Jan. 13-16, 1997, Proceedings
1997; In English; ISBN 0-7803-3783-2; Copyright; Avail: AIAA Dispatch
The present conference discusses reliability and maintainability (R&M)-related topics in the fields of concurrent engineering, quality assurance, aerospace industry maintenance and aircraft performance, fault-tree modeling, fault-tree analysis automation, reliability of commercial components, life cycle reliability assessment, software reliability, and commercial off-the-shelf equipment for military systems. Also discussed are R&M simulation processes in network and large-systems design, Weibull and Monte Carlo simulations in computer-aided engineering, stress testing for circuit surface mounts, fault tolerance techniques for

safety-critical applications, system reliability modeling via Markov chains and search algorithms, quality-oriented design using the Shewhart X-bar chart and neural networks, and system maintenance considerations.
AIAA
Conferences; Reliability Analysis; Maintainability; Concurrent Engineering

19980120613
Continuous state reliability analysis
Yang, Kai, Wayne State Univ., USA; Xue, Jianan, Wayne State Univ., USA; 1996, pp. 251-257; In English
Contract(s)/Grant(s): NSF DMI-95-00126; Copyright; Avail: Aeroplus Dispatch
    We extend binary state reliability analysis to continuous state reliability analysis. This extension enables us to analyze both catastrophic failure and performance degradation simultaneously. The modeling of degradation is based on independent increment random process or normal random process. Regression analysis is used to estimate degradation parameters. State tree method is introduced to conduct system reliability analysis for both degradation and catastrophic failure. ANOVA and DOE techniques are used to assess the criticality of product parameters or components to performance degradation.
Author (AIAA)
Reliability Analysis; Regression Analysis; Fault Trees; Failure Modes

19980160655
1994 Annual Reliability and Maintainability Symposium; Proceedings, Anaheim, CA, Jan. 24-27, 1994
1994; In English
Report No.(s): ISSN 0149-144X; ISBN 0-7803-1786-6; Copyright; Avail: Aeroplus Dispatch
    The present volume on reliability and maintainability (R&M) discusses built-in-test and testability; safety and quality systems, environment and life testing; and Fault-Tree analysis tools and applications. Attention is given to effective reliability-growth models and applications; test and evaluation; system-reliability modeling; and risk-assessment and tradeoff techniques for space systems. Other topics addressed include concurrent-engineering enabling technologies; R&M requirements; failure modes and effects analysis; and application of fuzzy logic to reliability and maintainability.
AIAA
Conferences; Reliability Analysis; Quality Control; Aerospace Industry

19980160711
1994 Annual Reliability and Maintainability Symposium, Tutorial Notes, Anaheim, CA, Jan. 24-27, 1994
1994; In English; Copyright; Avail: Aeroplus Dispatch
    Various papers on reliability and maintainability are presented. Individual topics addressed include: subroutines for product assurance; failure mode, effects, and criticality analysis; what Markov modeling can do for you; basic reliability; management, models, and standards for reliability growth; basic maintainability; practical reliability engineering and management; current practices in reliability-based probabilistic risk assessment; overview of concurrent engineering; understanding part failure mechanisms. Also discussed are: software reliability concepts; basic fault-tree analysis; design for reliability; probabilistic models and statistical methods in reliability; concepts of the statistical design of experiments; using the Taguchi method for improved reliability; reliability modeling using practical iterative techniques; fault-tolerant computing; experimental analysis of computer system dependability.
AIAA
Conferences; Maintainability; Reliability Engineering

19980170799
Reliability analysis for integrated navigation systems
Wang, Zengxi, Nanjing Univ. of Aeronautics and Astronautics, China; Nanjing University of Aeronautics and Astronautics, Journal; Apr. 1995; ISSN 1005-2615; Volume 27, no. 2, pp. 206-214; In Chinese; Copyright; Avail: Aeroplus Dispatch
    This paper analyses the reliability of GPS/INS/RA integrated navigation systems via the Fault Tree Analysis (FTA) method. We establish the fault trees with the fault of integrated navigation systems as the top event and the fault of the altitude tunnel as the top event separately, which provides an intuitive and effective approach to the analysis of the reliability of integrated navigation systems. On the basis of the resultant fault trees, the mathematical model of the system reliability is derived. Furthermore, every state of integrated sensors in the maintainable integrated navigation systems is analyzed using Markov process

theory, and the state translation diagram is presented. Finally, the corresponding mathematical models of the availability A and MTBF are yielded, which are valuable in the quantitative evaluation of the system reliability.
Author (AIAA)
Inertial Navigation; Reliability Engineering; Fault Trees

19980175168
1995 Annual Reliability and Maintainability Symposium, Tutorial Notes, Washington, DC, Jan. 16-19, 1995
1995; In English; Copyright; Avail: Aeroplus Dispatch
    Tutorial papers are presented on Failure Mode, Effects, and Criticality Analysis (FMECA); an introduction to Markov modeling; basic reliability; management, models, and standards for reliability growth; practical maintainability; practical reliability engineering and management; reliability prediction for the next generation; an overview of concurrent engineering; reliability program planning in a commercial environment; software reliability and quality; and basic fault-tree analysis. Papers are also presented on an overview of human reliability, probabilistic models and statistical methods in reliability, an introduction to benchmarking, the application of accelerated testing techniques in design and production, concepts of statistical design of experiments, the use of the Taguchi method for improved reliability, reliability modeling using practical iterative techniques, fault-tolerant computing, the experimental analysis of computer system dependability, and understanding part failure mechanisms.
AIAA
Conferences; Reliability; Maintainability

19990044304
Fault Tree Analysis for igniting the sequential circuit and emergency cut-off circuit of a launch vehicle control system
Yang, Shunagjin, Beijing Aerospace Automatic Control Inst., China; Liu, Zhiqing, Beijing Aerospace Automatic Control Inst., China; Aerospace Control; Jun. 1998; ISSN 1006-3242; Volume 16,, no. 62, pp. 46-53; In Chinese; Copyright; Avail: AIAA Dispatch
    By using Fault Tree Analysis (FTA) technology, we have analyzed the igniting sequential circuit and the emergency cut-off circuit of a launch vehicle control system. Some problems are found through FTA, even though some reliability design methods have been applied to the circuit design, for example, 2/3 vote. For these, improvement methods and suggestions are proposed.
Author (AIAA)
Fault Trees; Ignition; Sequential Control; Launch Vehicles

19990056022
1999 Annual Reliability and Maintainability Symposium, Washington, DC, Jan. 18-21, 1999, Tutorial Notes
1999; In English
Report No.(s): ISSN 0897-5000; Copyright; Avail: AIAA Dispatch
    Various papers on reliability and maintainability are presented. Some individual topics addressed are: failure modes, effects, and criticality analysis; product reliability through stress testing; fault-tree analysis of computer-based systems; intelligent use of regression analysis; practical reliability engineering and management; risk assessment in human reliability analysis; case studies of uncertainty analysis in reliability and risk assessment; using reliability tools in the new product development process; basic reliability; reliability prediction; reliability programming planning in a commercial environment; and understanding electronic-part failure mechanisms. Also considered are: product, process, and accelerated stress testing in benchmarking; simulation modeling for reliability analysis; software fault tolerance; understanding Weibull analysis; statistical analysis of reliability, maintainability, and supportability data; software engineering of critical software tools; introduction to software reliability engineering; and reliability-centered maintenance.
AIAA
Conferences; Reliability Analysis; Maintainability; Reliability Engineering

19990056038
Annual Reliability and Maintainability Symposium, Washington, DC, Jan. 18-21, 1999, Proceedings
1999; In English
Report No.(s): ISBN 0-7803-5143-6; ISBN 0-7803-5143-6@ISSN 0149-1; Copyright; Avail: AIAA Dispatch
    The present volume on reliability and maintainability discusses reliability for space applications; failure modes, effects, and criticality analysis; reliability prediction; accelerated testing and stress screening; maintenance optimization; and fault-tree analysis. Attention is given to methods in reliability analysis; risk assessment; software reliability; modeling for design

improvement; test and demonstration; and risk management. Specific topics addressed include rocket-engine control-system reliability-enhancement analysis; equivalence relations within the failure modes and effects analysis; an electronic-module environmental-stress-screening data-evaluation technique; the effect of failure-distribution specification errors on maintenance costs; a design image for automatic synthesis of fault trees; reliability analysis of systems which operate in duty cycles; and Bayes analysis for system-reliability inferences.
AIAA
Conferences; Reliability Analysis; Maintenance; Failure Analysis

19990069924 Hernandez Engineering, Inc., Huntsville, AL USA
Beauty and The Beast: Use and Abuse of the Fault Tree as a Tool
Long, R. Allen, Hernandez Engineering, Inc., USA; 1999; 10p; In English; Systems Safety, 16-21 Aug. 1999, Orlando, FL, USA
Contract(s)/Grant(s): NAS8-40364; No Copyright; Avail: Issuing Activity, Hardcopy
    Fault Tree Analysis (FTA) has become a popular too[for use in the Space Industry for the System Safety Engineer. The fault tree is used for everything from tracking hazard reports to investigating accidents, as well as presentations to management. Yet, experience in the space industry has shown the fault tree is used most often for purposes other than its original intent, namely for evaluating inappropriate behavior in complex systems This paper describes proper application and common misapplications of the fault tree as a too[when evaluating inappropriate behavior in complex systems. The paper addresses common misconceptions and pitfalls about FrA such as tracking only failures, and the belief that Failure Modes and Effects Analysis (FMEA) can be used in lieu of the fault tree.
Author
Failure Analysis; Trees (Mathematics); Complex Systems

19990090861
Sensitivity analysis and design of observer-based fault diagnosis systems
Ding, S. X., FH Lausitz, Germany; Jeinsch, T.; Ding, E. L.; Systems Science; 1998; ISSN 0137-1223; Volume 24, no. 1, pp. 51-71; In English; Copyright; Avail: Issuing Activity
    Problems related to observer-based FDI for uncertain dynamic systems are studied. The core of this study is a sensitivity analysis used for the performance evaluation and an optimization of observer-based FDI systems. Some new results in design and analysis of observer-based FDI systems are presented.
Author (EI)
Warning Systems; Sensitivity; Diagnosis

39
STRUCTURAL MECHANICS

Includes structural element design, analysis and testing; dynamic responses of structures; weight analysis; fatigue and other structural properties; and mechanical and thermal stresses in structure. For applications see 05 Aircraft Design, Testing and Performance and 18 Spacecraft Design, Testing and Performance.

19980127608
Design of a framed building using a probabilistic fault tree analysis method
Chen, F. C., Tennessee State Univ., Nashville, USA; Onwubiko, C., Tennessee State Univ., Nashville; Onyebueke, L. C., Tennessee State Univ., Nashville; 1996, pp. 2504-2510; In English
Contract(s)/Grant(s): NAG3-1479
Report No.(s): AIAA Paper 96-1608; Copyright; Avail: Aeroplus Dispatch
    This paper shows the application of the probabilistic fault tree analysis (PFTA) method to the design of a framed structure. The PFTA includes the development of a fault tree to represent the system, construction of an approximation function for bottom events, computation of sensitivity factors of design variables, and the calculation of the system reliability. The effect of uncertainty in the design parameters is quantified by changing the standard deviation of some of the design parameters and recomputing the probability of failure. The computer code employed for the analyses is NESSUS (Numerical Evaluation of Stochastic Structure Under Stress). A design example is presented. The importance of considering geometry among the random variables in structural design is quantified.
Author (AIAA)
Frames; Structural Design; Probability Theory; Fault Trees; Structural Analysis

40

19980192754
An assessment method for blade vibration reliability
Ou, Yangde, Beijing Univ. of Aeronautics and Astronautics, China; Kong, Ruilian, Beijing Univ. of Aeronautics and Astronautics, China; Song, Zhaohong, Beijing Univ. of Aeronautics and Astronautics, China; Journal of Aerospace Power; Apr. 1998; ISSN 1000-8055; Volume 13, no. 2, pp. 161-164; In Chinese; Copyright; Avail: Aeroplus Dispatch

A method is presented to assess the vibration reliability for blade design. The method, which is based on the Campbell diagram and the PFTA (Probability Fault Tree Analysis) concept, is used to improve conventional assessment methods and to develop an effective method for resonance identification and assessment of the characteristics of a blade resonance system that consists of multiple resonant interception on the Campbell diagram at or near the operating speed. This PFTA analysis is useful for improving the vibration characteristics of this blade and in eliminating blade failure from vibration fatigue.
Author (AIAA)
Structural Vibration; Turbine Blades; Fault Trees; Resonant Vibration; Aircraft Engines; Reliability Analysis

19990075078
Study on modular fault tree analysis technique with cut sets matrix method
Chen, Jinshui, Tianjin Univ., China; Zhang, Li; Cai, Huiming; Zhang, Chengpu; Chinese Journal of Mechanical Engineering (English Edition); Jun, 1998; ISSN 1000-9345; Volume 11, no. 2, pp. 81-88; In English; Copyright; Avail: Issuing Activity

A new fault tree analysis (FTA) computation method is put forth by using modularization technique in FTA with cut sets matrix, and can reduce NP (Nondeterministic polynomial) difficulty effectively. This software can run in IBM-PC and DOS 3.0 and up. The method provides theoretical basis and computation tool for application of FTA technique in the common engineering system.
Author (EI)
Matrix Theory; Computation; Polynomials; Computer Programs

44
ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells; and solar, geothermal, windpower, and waterwave conversion systems; energy storage; and traditional power generators. For technologies related to nuclear energy production see 73 Nuclear Physics. For related information see also 07 Aircraft Propulsion and Power; 20 Spacecraft Propulsion and Power, and 28 Propellants and Fuels.

19810011109 Aeronautical Research Inst. of Sweden, Structures Dept., Stockholm., USA
Study of Wind Energy Conversion Systems (WECS) in a farm area and WECS safety limit requirements. Minutes from expert meeting IEA, research and development WECS, annex one, subtask A1
Eggwertz, S., Aeronautical Research Inst. of Sweden, USA; Jun 1, 1980; 114p; In English; In Dutch; IEA WECS Sub-Task A1 Meeting, 25 Feb. 1980, Stockholm, Sweden
Contract(s)/Grant(s): SWEDBESD-5060-601
Report No.(s): FFA-TN-HU-2218; Avail: CASI; A06, Hardcopy; A02, Microfiche

The proceedings include the description of two 2500 kW windmill prototypes, safety studies performed in several countries, and a contribution concerning fault tree analysis and load case recommendations. The introduction of safe zone, the crack detection system, and operation during icing conditions are discussed.
CASI
Conferences; Energy Policy; Safety Factors; Windmills (Windpowered Machines); Windpower Utilization

19810040027
Availability modeling methodology applied to solar power systems
Unione, A.; Burns, E.; Husseiny, A., Science Applications, Inc., USA; Solar Energy; Jan 1, 1981; 26, 1, 19, pp. 1981; In English; p. 55-; Copyright; Avail: Issuing Activity

Availability is discussed as a measure for estimating the expected performance for solar- and wind-powered generation systems and for identifying causes of performance loss. Applicable analysis techniques, ranging from simple system models to probabilistic fault tree analysis, are reviewed. A methodology incorporating typical availability models is developed for

estimating reliable plant capacity. Examples illustrating the impact of design and configurational differences on the expected capacity of a solar-thermal power plant with a fossil-fired backup unit are given.

AIAA

Electric Power Plants; Fault Trees; Mathematical Models; Solar Energy Conversion

19890001929 Sandia National Labs., Exploratory Batteries Div., Albuquerque, NM, USA

Reliability analysis of lithium cells

Levy, Samuel C., Sandia National Labs., USA; Bro, Per, Southwest Electrochemical Co., USA; Jan 1, 1988; 16p; In English; 4th; International Meeting on Lithium Batteries, 23 May 1988, Vancouver, British Columbia, Canada

Contract(s)/Grant(s): DE-AC04-76DP-00789

Report No.(s): DE88-009258; SAND-87-2129C; CONF-880598-2; Avail: CASI; A03, Hardcopy; A01, Microfiche

Fault tree analysis has been used for many years in safety and reliability analyses of nuclear reactors and other large systems. This technique can also be useful in the design of high reliability lithium cells/batteries and in improving the reliability of existing designs. The basic building blocks of a fault tree are discussed and an example, using the lithium-sulfur cell, is given.

DOE

Electrochemical Cells; Fault Trees; Reliability Analysis

19920013534 Gates Aerospace Batteries, Gainesville, FL, USA

Fault tree analysis: NiH2 aerospace cells for LEO mission

Klein, Glenn C., Gates Aerospace Batteries, USA; Rash, Donald E., Jr., Reliability Analysis Center, USA; NASA. Marshall Space Flight Center, The 1991 NASA Aerospace Battery Workshop; Feb 1, 1992, pp. p 779-807; In English; See also N92-22740 13-44; Avail: CASI; A03, Hardcopy; A10, Microfiche

The Fault Tree Analysis (FTA) is one of several reliability analyses or assessments applied to battery cells to be utilized in typical Electric Power Subsystems for spacecraft in low Earth orbit missions. FTA is generally the process of reviewing and analytically examining a system or equipment in such a way as to emphasize the lower level fault occurrences which directly or indirectly contribute to the major fault or top level event. This qualitative FTA addresses the potential of occurrence for five specific top level events: hydrogen leakage through either discrete leakage paths or through pressure vessel rupture; and four distinct modes of performance degradation - high charge voltage, suppressed discharge voltage, loss of capacity, and high pressure.

CASI

Degradation; Electric Discharges; Fault Trees; Nickel Hydrogen Batteries; Reliability Analysis; Spacecraft Orbits; Spacecraft Power Supplies

54
MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human factors engineering; bionics, man-machine, life support, space suits and protective clothing. For related information see also 16 Space Transportation and 52 Aerospace Medicine..

19750023679 Army Materiel Command, Intern Training Center., Texarkana, TX, USA

System safety evaluation of life support systems for chemical and biological protective suits *Final Report*

Belmonte, R. B., Army Materiel Command, USA; Apr 1, 1975; 84p; In English

Report No.(s): AD-A009312; USAMC-ITC-02-08-75-401; Avail: CASI; A05, Hardcopy; A01, Microfiche

The paper presents a system safety analysis of two air supply sub-systems which are to be used with a chemical and biological protective suit system. The backpack assembly sub-system has been developed and tested already, whereas the remote air supply apparatus has not yet been developed. The system safety analysis of each air supply sub-system includes mission analysis, preliminary hazard analysis, failure mode and effect analysis, flow analysis and fault tree analysis. A reliability model and block diagram of each sub-system is also included. The results of these analyses indicate that with proper maintenance and trained personnel the safety provided by these sub-systems should be acceptable.

DTIC

Breathing Apparatus; Life Support Systems; Protective Clothing

19860021752 Edgerton, Germeshausen and Grier, Inc., System Safety Development Center., Idaho Falls, ID, USA
Impact of the human on system safety analysis
Nertney, R. J., Edgerton, Germeshausen and Grier, Inc., USA; Horman, R. L., Edgerton, Germeshausen and Grier, Inc., USA; Sep 1, 1985; 34p; In English
Contract(s)/Grant(s): DE-AC07-76ID-01570
Report No.(s): DE86-008182; SSDC-32; Avail: CASI; A03, Hardcopy; A01, Microfiche
　　　The impact of the human and human reliability on the results of probabilistic risk assessment studies is discussed in terms of some of the standard models used in risk quantification. Three levels of analysis are considered: (1) identification of areas where the human affects the operational risks; (2) rough scaling and quantification of the effect of the human on operational outcome; and (3) complete quantification of the risks including consideration of human reliability.
DOE
Error Analysis; Fault Trees; Human Performance; Probability Theory; Reliability Analysis; Risk; Safety

59
MATHEMATICAL AND COMPUTER SCIENCES (GENERAL)

Includes general topics and overviews related to mathematics and computer science. For specific topics in these areas see categories 60 through 67.

19770066869
National Computer Conference, Dallas, Tex., June 13-16, 1977, Proceedings
Korfhage, R. R., Southern Methodist University, USA; Jan 1, 1977; 1039p; In English; National Computer Conference, June 13-16, 1977, Dallas, TX; Sponsored by AFIPS; Copyright; Avail: Issuing Activity
　　　Computer data base administration, the selection of computer architectures, communication networks using packet-switching, and applications of computing techniques to such topics as clinical research, graphics, information services and transportation networks are discussed. Subjects of the papers include fault tree analysis of computer systems, a technique for automatic acquisition of three-dimensional data, the evaluation of computer architectures through test programs, microprocessor architectures, the impact of microprocessors on health care, computer hardware design, a comprehensive computer base of information on petroleum resources, modular multimicroprocessors, software acquisition, the design and implementation of an information base for use in decision-making, and a multimicroprocessor approach to high-speed low-cost continuous-system simulations.
AIAA
Architecture (Computers); Computer Networks; Computer Systems Design; Computer Techniques; Conferences; Data Bases

60
COMPUTER OPERATIONS AND HARDWARE

Includes hardware for computer graphics, firmware and data processing. For components see 33 Electronics and Electrical Engineering. For computer vision see 63 Cybernetics, Artificial Intelligence and Robotics.

19720006565 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Program listing for fault tree analysis of JPL technical report 32-1542
Chelson, P. O., Jet Propulsion Lab., California Inst. of Tech., USA; Dec 1, 1971; 35p; In English
Contract(s)/Grant(s): NAS7-100
Report No.(s): NASA-CR-125064; JPL-TM-33-512; Avail: CASI; A03, Hardcopy; A01, Microfiche
　　　The computer program listing for the MAIN program and those subroutines unique to the fault tree analysis are described. Some subroutines are used for analyzing the reliability block diagram. The program is written in FORTRAN 5 and is running on a UNIVAC 1108.
CASI
Computer Programs; FORTRAN; Light Emitting Diodes; Trees (Mathematics); Univac 1108 Computer

19720007535 Douglas United Nuclear, Inc., Richland, WA, USA
Fault tree simulation computer program
Crosetti, P. A., Douglas United Nuclear, Inc., USA; Jun 1, 1971; 28p; In English

Fault tree analysis provides a deductive functional development of a specific final undesired event through logic statements of the conditions which could cause the event. The usefulness of fault tree analysis is greatly enhanced through quantitative analysis or probability evaluation of the fault trees to provide a more objective basis for evaluating and improving the systems and to improve the precision of performance measurements and trade-off studies. Since a primary use for the fault tree method is to determine the more significant contributions to the probability of causing the undesired event, a feasible approach to probabilistic evaluation of the trees is to concentrate the effort on the dominant paths. This can be accomplished using Monte Carlo simulation, the simulation being performed on a computer using an event logic simulation program. The computer program discussed was prepared and used for quantitative evaluation of fault tree models as a tool for evaluating the functional performance of nuclear reactor protective systems in terms of system reliability and availability.
CASI
Computerized Simulation; Electrical Faults; Monte Carlo Method; Reactor Safety

19720040352
A moment method for the calculation of a confidence interval for the failure probability of a system.
Murchland, J. D.; Weber, G. G., Karlsruhe, Universitaet, Germany; Jan 1, 1972; 13p; In English; Annual Reliability and Maintainability Symposium, January 25-27, 1972, San Francisco, CA; See also A72-23972 10-15; Copyright; Avail: Issuing Activity
The system considered consists of a number of components, which are basically interconnected. The method developed is an extension of an analytic evaluation approach regarding the failure probability. The analytic approach places a restriction on the degree of complexity of the fault-trees which can be handled. Aspects of fault-tree analysis are discussed, giving attention to explicit Boolean polynomials and probability polynomials. Nonrepairable and repairable components are considered.
AIAA
Complex Systems; Confidence Limits; Failure Analysis; Probability Theory; Reliability Analysis; Trees (Mathematics)

19840054984
Fault tolerance in binary tree architectures
Raghavendra, C. S., Southern California, University, USA; Avizienis, A.; Ercegovac, M. D., California, University, USA; IEEE Transactions on Computers; Jun 1, 1984; ISSN 0018-9340; C-33, pp. 568-572; In English
Contract(s)/Grant(s): N00014-79-C-0866; Copyright; Avail: Issuing Activity
Binary tree network architectures are applicable in the design of hierarchical computing systems and in specialized high-performance computers. In this correspondence, the reliability and fault tolerance issues in binary tree architecture with spares are considered. Two different fault-tolerance mechanisms are described and studied, namely: (1) scheme with spares; and (2) scheme with performance degradation. Reliability analysis and estimation of the fault-tolerant binary tree structures are performed using the interactive ARIES 82 program. The discussion is restricted to the topological level, and certain extensions of the schemes are also discussed.
AIAA
Architecture (Computers); Circuit Reliability; Computer Systems Design; Fault Tolerance; Fault Trees; Reliability Analysis

19850042075
Evaluating response time in a faulty distributed computing system
Garcia-Molina, H.; Kent, J., Princeton University, USA; IEEE Transactions on Computers; Feb 1, 1985; ISSN 0018-9340; C-34, pp. 101-109; In English
Contract(s)/Grant(s): NSF ECS-80-19393; Copyright; Avail: Issuing Activity
This paper presents an evaluation technique which is useful for studying both the performance and the reliability of a distributed computing system. The distributed system is evaluated from the point of view of a user who submits a request for service. The proposed technique computes the average time to successful completion of this request, taking into account the system failures or repairs which may occur before the request is completed. Given a model of the system and its failures, the performance-reliability measures are computed in an automatic numerical fashion. The technique is computationally intensive, so it is limited to relatively small systems. However, it can produce results for many interesting cases without an inordinate amount of computation.
AIAA
Computer Systems Performance; Distributed Processing; Fault Trees; Reliability Analysis; Response Time (Computers)

Includes software engineering, computer programs, routines, algorithms, and specific applications, e.g., CAD/CAM. For computer software applied to specific applications, see also the associated category.

19750060156
Fault tree graphics
Bass, L.; Wynholds, H. W.; Porterfield, W. R., Lockheed Missiles and Space Co., Inc., USA; Jan 1, 1975; 6p; In English; Annual Reliability and Maintainability Symposium, January 28-30, 1975, Washington, DC; See also A75-44202 22-38; Copyright; Avail: Issuing Activity

Described is an operational system that enables the user, through an intelligent graphics terminal, to construct, modify, analyze, and store fault trees. With this system, complex engineering designs can be analyzed. This paper discusses the system and its capabilities. Included is a brief discussion of fault tree analysis, which represents an aspect of reliability and safety modeling.
AIAA
Complex Systems; Computer Graphics; Failure Analysis; Reliability Engineering

19760014845 Atlantic Richfield Hanford Co., Richland, WA, USA
ALLCUTS: A fast, comprehensive fault tree analysis code
Vanslyke, W. J., Atlantic Richfield Hanford Co., USA; Griffing, D. E., Atlantic Richfield Hanford Co., USA; Jul 1, 1975; 133p; In English
Contract(s)/Grant(s): E(45-1)-2130
Report No.(s): ARH-ST-112; Avail: CASI; A07, Hardcopy; A02, Microfiche

A description, user instructions, and a source program listing are presented for ALLCUTS, a FORTRAN computer code for fault tree analysis. The code was specifically designed to be easy to use as well as fast, versatile, and powerful. It may easily be modified by a moderately skilled programer to fit the variable needs of the user and the capabilities of his computer. A code, BRANCH, for determining input data gate and bottom event interrelationships is also presented.
CASI
Coding; FORTRAN; Trees (Mathematics)

19780017856 Battelle Pacific Northwest Labs., Richland, WA, USA
RAFT: A computer program for fault tree risk calculations
Seybold, G. D., Battelle Pacific Northwest Labs., USA; Nov 1, 1977; 67p; In English
Contract(s)/Grant(s): EY-76-C-06-1830
Report No.(s): BNWL-2146; A01, Unavail. Hardcopy

RAFT calculated release quantities and a risk measure based on the product of probability and release quantity for cut sets of fault trees modeling the accidental release of radioactive material from a nuclear fuel cycle facility. Cut sets and their probabilities were supplied as input to RAFT from an external fault tree analysis code. Using the total inventory available of radioactive material, along with release fractions for each event in a cut set, the release terms were calculated for each cut set. Each release term was multiplied by the cut set probability to yield the cut set risk measure. RAFT orders the dominant cut sets on the risk measure.
ERA
Computer Programs; Radioactive Materials; Risk; Trees (Mathematics)

19790006649 Battelle Pacific Northwest Labs., Richland, WA, USA
MFAULT: A computer program for analyzing fault trees
Palto, P. J., Battelle Pacific Northwest Labs., USA; Purcell, W. L., Battelle Pacific Northwest Labs., USA; Nov 1, 1977; 58p; In English; Sponsored by DOE
Report No.(s): BNWL-2145; Avail: CASI; A04, Hardcopy; A01, Microfiche

A description and user instructions are presented for MFAULT, a FORTRAN computer program for fault tree analysis. The cut sets of a fault tree, calculates their probabilities, and screens the cut sets on the basis of specified cut-offs on probability and/or cut set length are identified by MFAULT. MFAULT is based on an efficient upward-working algorithm for cut set identification. The probability calculations are based on the assumption of small probabilities and constant hazard rates (i.e., exponential failure distributions). Cut sets consisting of repairable components (basic events) only, non-repairable components only, or mixtures of

both types can be evaluated. Components can be on-line or standby. Unavailability contributions from pre-existing failures, failures on demand, and testing and maintenance down-time can be handled.
DOE
Computer Programs; FORTRAN; Numerical Analysis; Trees (Mathematics)

19800037902
A simple event-definition notation and associated computer programs
Arnborg, S., Forsvarets Forskningsanstalt, Sweden; IEEE Transactions on Reliability; Dec 1, 1979; R-28, pp. Dec. 197; In English; p. 382-385; Copyright; Avail: Issuing Activity
    A notation for defining events to a computer program is described. It has been used in weapon-effect simulation models. It is simple and can be efficiently processed by computer. Computer codes using the notation have been developed with small effort.
AIAA
Computer Programs; Digital Simulation; Fault Trees; Reliability Analysis; System Effectiveness; Weapon Systems

19800056180
An improvement in cut and path set determination
Malasky, S. W.; Tregarthen, P. J., AiResearch Manufacturing Company of California, USA; Jan 1, 1980; 7p; In English; Annual Reliability and Maintainability Symposium, January 22-24, 1980, San Francisco, CA; See also A80-40301 16-38; Copyright; Avail: Issuing Activity
    An algorithm has been developed which makes cut (or path) set determination less dependent on core size and is faster than conventional computer algorithms used for fault trees in the fields of safety and reliability. The algorithms operate by (1) determining cut (or path) sets at the second level of each of the branches leading into the top gate, (2) converting the base 10 numbers representing the elements in each cut set into binary strings so that the location of each bit so determined corresponds to a specific base 10 number, and (3) utilizing a series of Boolean instruments written in assembly language to select minimal cut sets leading to the top of the tree from those determined at the second level.
AIAA
Algorithms; Computer Programs; Fault Trees; Performance Prediction; Reliability Analysis; System Effectiveness

19830035436
Using fault trees to find design errors in real time software
Leveson, N. G.; Stolzy, J. L., California, University, USA; Burton, B. A., California, University, USA; Jan 1, 1983; 8p; In English; 21st; American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, NV
Report No.(s): AIAA PAPER 83-0325; Copyright; Avail: Issuing Activity
    The application of the technique of software fault tree analysis (SFTA) to the identification of potentially life-threatening run-time software failure modes or scenarios is examined. The use of software fault tree symbols, derived from the corresponding hardware symbols, in the lowest level of fault-tree analysis, the code level, is demonstrated for codes written in ADA. In particular, the backward progress of the interactive analysis, where the user is aided by an automated tool, is illustrated through the high level programming language constructs of the if-then-else statement, the loop statement, assignment statements, procedure calls and case statements. Attention is then given to an SFTA tool currently under development, which will be capable of automatic program construct recognition and fault tree presentation in different program levels. SFTA is concluded to provide a good technique for the safety analysis of software in the short term, and aid in the development of software safety metrics and safe programming techniques in the long term.
AIAA
Computer Program Integrity; Fault Trees; Program Verification (Computers); Real Time Operation

19830035438
Applying existing safety design techniques to software safety
Thomas, J. C.; Leveson, N. G., California, University, USA; Jan 1, 1983; 9p; In English; 21st; American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, NV
Report No.(s): AIAA PAPER 83-0327; Copyright; Avail: Issuing Activity
    Existing software and hardware safety techniques are reviewed to develop techniques for software safety, which is one aspect of system safety. Hazard elimination is considered in terms of deletion or correction of critical errors through fault tree analysis, validation techniques, and automatic testing. Detection of the error at a low enough level can be implemented with monitors to decide whether or not a specific condition exists, if a system is ready for operation or is operating correctly, if the input is

appropriate, if output is occurring, if the limit is being met, and if the measured factor is abnormal. These steps are amenable to software configuring. Warnings from the monitors can lead to lockouts, lockins, and interlocks to isolate hazards or prevent incompatible actions from happening. Fail-safe design is discussed, together with failure minimization and Ada features which enhance reliability.

AIAA

Computer Program Integrity; Error Correcting Devices; Fail-Safe Systems; Fault Trees; Program Verification (Computers); Safety Management

19840003710 Rome Air Development Center, Griffiss AFB, NY, USA
The evolution and practical applications of failure modes and effects analyses
Dussault, H. B., Rome Air Development Center, USA; Mar 1, 1983; 114p; In English
Contract(s)/Grant(s): AF PROJ. 2338
Report No.(s): AD-A131358; RADC-TR-83-72; Avail: CASI; A06, Hardcopy; A02, Microfiche
    Failure effects analysis allows a product to be studied early in its design and development stages where undesirable failure effects can be identified and readily corrected. This report is intended to give the reader a broad, general background in techniques available for failure effects analysis and their usefulness. Sixteen separate techniques, ranging from tabular failure modes and effects analysis and fault tree analysis to lesser known and more recently introduced techniques such as hardware/software interface analysis, are discussed. The current status and prospects for the future failure effects analysis are also discussed in the report.

DTIC

Failure; Failure Analysis; Failure Modes

19840027570
Analyzing software safety
Leveson, N. G.; Harvey, P. R., California, University, USA; IEEE Transactions on Software Engineering; Sep 1, 1983; ISSN 0098-5589; SE-9, pp. 569-579; In English; Research supported by the Hughes Aircraft Co., University of California, and System Development Corp; Copyright; Avail: Issuing Activity
    The application of software controls to critical real time systems in which the consequences of software failure may endanger human life and property prompts the present consideration of software safety, with attention to the novel technique of 'software fault tree analysis'. This technique has been employed on a program controlling the flight and telemetry of a University of California spacecraft. A critical failure scenario has been identified by these means which had not been suspected despite rigorous prior testing of the program. Portions of this analysis are presented as examples of the results obtainable.

AIAA

Computer Program Integrity; Computer Programs; Electronic Control; Fail-Safe Systems; Fault Trees; Real Time Operation; Reliability Analysis

19850027911
Safety analysis of Ada programs using fault trees
Leveson, N. G.; Stolzy, J. L., California, University, USA; IEEE Transactions on Reliability; Dec 1, 1983; ISSN 0018-9529; R-32, pp. 479-484; In English; Research supported by the University of California and Hughes Aircraft Co; Copyright; Avail: Issuing Activity
    The technique of software fault-tree analysis (SFTA) is described using Ada as an example of a real-time programming language. It is shown that the system approach inherent in SFTA helps determine the safety requirements of the software. Thus, the preliminary system hazard analysis can be used to determine potential system hazards, and then the hazards can be traced back to any potential software connection. Particular attention is given to the problems of concurrence and real-time constraints which are common in these types of applications.

AIAA

Ada (Programming Language); Computer Information Security; Fault Trees; Reliability Analysis; Software Engineering

19850072474 Japan Atomic Energy Research Inst., Tokyo, Japan
Users' manual for the FTA-J (Fault Tree Analysis-JAERI) code system
Ishigami, T., Japan Atomic Energy Research Inst., Japan; Watanabe, N., Japan Atomic Energy Research Inst., Japan; Hikawa, M., Japan Atomic Energy Research Inst., Japan; Kaneki, H., Japan Atomic Energy Research Inst., Japan; Horii, H., Japan Atomic Energy Research Inst., Japan; Sasaki, S., Japan Atomic Energy Research Inst., Japan; Nov 1, 1983; 164p; In Japanese

Report No.(s): DE85-701120; JAERI-M-83-169; Avail: CASI; A08, Hardcopy; Avail: CASI HC A08/; A02, Microfiche; US Sales Only

No abstract.

Computer Programming; Data Processing; Fault Trees; Information Systems; Reactor Safety

19860011696 Los Alamos National Lab., NM, USA

A state space method of fault tree analysis with applications *Topical*

Bartholomew, R. J., Los Alamos National Lab., USA; Dec 1, 1984; 198p; In English

Contract(s)/Grant(s): W-7405-ENG-36

Report No.(s): LA-10298-T; Avail: CASI; A09, Hardcopy; A03, Microfiche

Generic fault trees comprising two, three, and four statistically independent initiators in addition to common cause and common mode initiators were developed with their Markov and Adjoint models. Failure Mode State Variable (FMSV) models that represent the probabilities of failure occurrence in 0, t of events depicted by generic fault trees were developed using modern control theory concepts. The FMSV models are contained within the Adjoint Modes. Several practical fault trees of nuclear reactor components and subsystems were modeled by the FMSV method. FMSV method is a symbiosis of fault tree analysis and Markov modeling, therefore is complete and exhaustible as a probability model.

B.G.

Component Reliability; Control Theory; Failure Modes; Fault Trees; Markov Processes

19860037645

An expert system for fault tree construction

Garribba, S.; Guagnini, E., Milano, Politecnico, Italy; Mussio, P., Milano, Universita, Italy; Jan 1, 1985; 7p; In English; See also A86-22376; Copyright; Avail: Issuing Activity

The architecture of an expert system for the interactive data-driven construction of fault trees is presented. Parts of the system are now under realization and testing. The system intends to offer a flexible and easy-to-operate tool to the analyst in reliability assessment of complex engineered installations. The expert system is organized according to a number of knowledge-based modules that contain metarules, allow to establish rules, and to collect and interpret data. The construction process bases upon a representation of the elementary components given a term of multiple-valued logical (MVL) trees and results into an MVL-tree. This tree can be analyzed directly or when requested it can be reduced to a number of binary fault trees.

AIAA

Expert Systems; Fault Trees; Reliability Analysis

19870011332 NASA Langley Research Center, Hampton, VA, USA

The fault-tree compiler

Martensen, Anna L., PRC Kentron, Inc., USA; Butler, Ricky W., NASA Langley Research Center, USA; Jan 1, 1987; 40p; In English

Contract(s)/Grant(s): RTOP 505-66-21-01

Report No.(s): NASA-TM-89098; NAS 1.15:89098; Avail: CASI; A03, Hardcopy; A01, Microfiche

The Fault Tree Compiler Program is a new reliability tool used to predict the top event probability for a fault tree. Five different gate types are allowed in the fault tree: AND, OR, EXCLUSIVE OR, INVERT, and M OF N gates. The high level input language is easy to understand and use when describing the system tree. In addition, the use of the hierarchical fault tree capability can simplify the tree description and decrease program execution time. The current solution technique provides an answer precise (within the limits of double precision floating point arithmetic) to the five digits in the answer. The user may vary one failure rate or failure probability over a range of values and plot the results for sensitivity analyses. The solution technique is implemented in FORTRAN; the remaining program code is implemented in Pascal. The program is written to run on a Digital Corporation VAX with the VMS operation system.

CASI

Compilers; Fault Tolerance; Fault Trees; Problem Solving; Reliability Analysis; Software Engineering

19890059085

Software reliability growth process - A life cycle approach

Raheja, Dev G., Technology Management, Inc., USA; Jan 1, 1989; 4p; In English; Annual Reliability and Maintainability Symposium, Jan. 24-26, 1989, Atlanta, GA, USA; See also A89-46451 20-38; Copyright; Avail: Issuing Activity

The author presents a life-cycle cost-reduction technique to achieve rapid growth rate in software reliability growth. He points out the deficiencies in the current practices in hardware reliability growth process and how to overcome such weaknesses in software engineering. It is suggested that fixing errors in software introduces a negative growth because the programmer may not know which paths are affected by the change. The best way to accelerate the software reliability and maintenance growth is to identify engineering changes in the early design phases. The ATAF program tends to minimize risks and lower life-cycle costs significantly.

AIAA

Computer Program Integrity; Fault Trees; Life Cycle Costs; Reliability Analysis; Software Development Tools

19900056010
Fault-tolerant programs and their reliability
Belli, Fevzi, Paderborn, Universitaet-Gesamthochschule, USA; Jedrzejowicz, Piotr, Wyzsza Szkola Morska, Poland; IEEE Transactions on Reliability; Jun 1, 1990; ISSN 0018-9529; 39, pp. 184-192; In English; Copyright; Avail: Issuing Activity

The authors review and extend available techniques for achieving fault-tolerant programs. The representation of the techniques is uniform and is illustrated by simple examples. For each technique a fault tree has been developed to derive failure probability from the probabilities of the basic fault events. This allows the subsequent analysis of program-failure causes and the reliability modeling of computer programs. Numerical examples are given to support the comparison of the reviewed techniques. The models can be used to evaluate numerical values of program reliability in a relatively simple way. The models deal with program reliability for a single run, which seems more practical and straightforward than dealing with distributions as for hardware systems. Evaluations obtained by using models correspond to those used in the literature; however, the authors' procedures are computationally simpler.

AIAA

Fault Tolerance; Fault Trees; Reliability Analysis

19910013431 Naval Postgraduate School, Monterey, CA, USA
Safety analysis of heterogeneous-multiprocessor control system software
Gill, Janet A., Naval Postgraduate School, USA; Dec 1, 1990; 63p; In English
Report No.(s): AD-A231859; Avail: CASI; A04, Hardcopy; A01, Microfiche

Fault trees and Petri nets are two widely accepted graphical tools used in the safety analysis of software. Because some software is life and property critical, thorough analysis techniques are essential. Independently Petri nets and fault trees serve limited evaluation purposes. This thesis presents a technique that converts and links Petri nets to fault trees and fault trees to Petri nets. It enjoys the combinational benefits of both analysis tools. Software Fault Tree Analysis and timed Petri nets facilitate software safety analysis in heterogeneous multiprocessor control systems. Analysis use a Petri net to graphically organize the selected software. A fault tree supports a hazardous condition with subsequent leaf node paths that lead to the hazard. Through the combination of Petri nets and fault trees, an analyst can determine a software fault if he can reach an undesired Petri net state, comparable with the fault tree root fault, from an initial marking. All transitions leading to the undesired state from the initial marking must be enabled and the states must be marked that represent the leaf nodes of the fault tree path. It is not the intention of this thesis to suggest that an analyst be replaced by an automated tool. There must be analyst interaction focusing the analyst's insight and experience on the hazards of a system. This method is proposed only as a tool for evaluation during the overall safety analysis.

DTIC

Computer Programs; Fault Trees; Graphic Arts; Multiprocessing (Computers); Performance Tests; Petri Nets

19920008841 NASA Langley Research Center, Hampton, VA, USA
Graphical workstation capability for reliability modeling
Bavuso, Salvatore J., NASA Langley Research Center, USA; Koppen, Sandra V., Lockheed Engineering and Sciences Co., USA; Haley, Pamela J., NASA Langley Research Center, USA; Feb 1, 1992; 14p; In English
Contract(s)/Grant(s): RTOP 505-66-21
Report No.(s): NASA-TM-4317; L-16887; NAS 1.15:4317; Avail: CASI; A03, Hardcopy; A01, Microfiche

In addition to computational capabilities, software tools for estimating the reliability of fault-tolerant digital computer systems must also provide a means of interfacing with the user. Described here is the new graphical interface capability of the hybrid automated reliability predictor (HARP), a software package that implements advanced reliability modeling techniques. The graphics oriented (GO) module provides the user with a graphical language for modeling system failure modes through the selection of various fault-tree gates, including sequence-dependency gates, or by a Markov chain. by using this graphical input

language, a fault tree becomes a convenient notation for describing a system. In accounting for any sequence dependencies, HARP converts the fault-tree notation to a complex stochastic process that is reduced to a Markov chain, which it can then solve for system reliability. The graphics capability is available for use on an IBM-compatible PC, a Sun, and a VAX workstation. The GO module is written in the C programming language and uses the graphical kernal system (GKS) standard for graphics implementation. The PC, VAX, and Sun versions of the HARP GO module are currently in beta-testing stages.
CASI
Computer Graphics; Computer Systems Performance; Computer Techniques; Digital Computers; Failure Modes; Fault Tolerance; Fault Trees; Human-Computer Interface; Markov Chains; Reliability; Reliability Analysis; System Failures; Workstations

199200059449
Software safety analysis in heterogeneous multiprocessor control systems
Shimeall, Timothy J.; Mcgraw, Richard J., Jr.; Gill, Janet A., U.S. Naval Postgraduate School, USA; Jan 1, 1991; 5p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Copyright; Avail: Issuing Activity
    Many modern digital control systems use multiprocessor architectures. This paper discusses the analysis of the safety of the software in these control system architectures, presenting an integration of two techniques, software fault tree analysis and timed Petri net analysis. This integration is demonstrated using an analysis of a military flight control system.
AIAA
Control Systems Design; Design Analysis; Multiprocessing (Computers); Safety; Software Engineering

199200066525 NASA Langley Research Center, Hampton, VA, USA
Closed-form solution of decomposable stochastic models
Sjogren, Jon A., U.S. Army, Avionics Research and Development Activity; NASA, Langley Research Center, USA; Computers and Mathematics with Applications; Jan 1, 1992; ISSN 0097-4943; 23, 12, 1; 25p; In English; Copyright; Avail: Issuing Activity
    Equations to compute failure probabilities of the total (combined) model without a complete solution of the combined model are presented. A closed-form analytical approach to presentation of probabilities is used on the bases of the Symbolic Hierarchical Automated Reliability and Performance Evaluator tool. The techniques under consideration make it possible to compute the probability function for a much wider class of systems at a reduced computational cost.
AIAA
Fault Tolerance; Fault Trees; Markov Processes; Reliability Analysis; Stochastic Processes

199300019789 Japan Atomic Energy Research Inst., Tokyo, Japan
Users manual for fault tree analysis code: CUT-TD
Watanabe, Norio, Japan Atomic Energy Research Inst., USA; Kiyota, Mikio, Japan Atomic Energy Research Inst., USA; Jun 1, 1992; 57p; In English
Report No.(s): DE93-753272; JAERI-M-92-089; Avail: CASI; A04, Hardcopy; A01, Microfiche
    The CUT-TD code was developed to find minimal cut sets for a given fault tree and to calculate the occurrence probability of its top event. This code uses an improved top-down algorithm which can enhance the efficiency in deriving minimal cut sets. The features in processing techniques incorporated into CUT-TD are as follows: (1) consecutive OR gates or consecutive AND gates can be coalesced into a single gate, as a result, this processing directly produces cut sets for the redefined single gate with each gate not being developed; (2) the independent subtrees are automatically identified and their respective cut sets are separately found to enhance the efficiency in processing; (3) the minimal cut sets can be obtained for the top event of a fault tree by combining their respective minimal cut sets for several gates of the fault tree; (4) the user can reduce the computing time for finding minimal cut sets and control the size and significance of cut sets by inputting a minimum probability cut off and/or a maximum order cut off; (5) the user can select events that need not to be further developed in the process of obtaining minimal cut sets (this option can reduce the number of minimal cut sets, save the computing time and assists the user in reviewing the result); (6) computing time is monitored by the CUT-TD code so that it can prevent the running job from abnormally ending due to excessive CPU time and produce an intermediate result. The CUT-TD code has the ability to restart the calculation with use of the intermediate result. A users' manual for the CUT-TD code. is provided.
DOE
Data Processing; Fault Trees; User Manuals (Computer Programs)

19940012974 NASA Langley Research Center, Hampton, VA, USA

Tutorial: Advanced fault tree applications using HARP

Dugan, Joanne Bechta, Duke Univ., USA; Bavuso, Salvatore J., NASA Langley Research Center, USA; Boyd, Mark A., Duke Univ., USA; Nov 1, 1993; 30p; In English

Contract(s)/Grant(s): RTOP 505-66-21

Report No.(s): NASA-TM-102747; NAS 1.15:102747; Avail: CASI; A03, Hardcopy; A01, Microfiche

Reliability analysis of fault tolerant computer systems for critical applications is complicated by several factors. These modeling difficulties are discussed and dynamic fault tree modeling techniques for handling them are described and demonstrated. Several advanced fault tolerant computer systems are described, and fault tree models for their analysis are presented. HARP (Hybrid Automated Reliability Predictor) is a software package developed at Duke University and NASA Langley Research Center that is capable of solving the fault tree models presented.

Author (revised)

Fault Tolerance; Fault Trees; Reliability Analysis

19940014909 Loughborough Univ. of Technology, Dept. of Mathematical Sciences., UK

Optimal safety system design using fault tree analysis

Andrews, J. D., Loughborough Univ. of Technology, UK; Jun 1, 1993; 32p; In English

Report No.(s): MATHS-REPT-A-187; Avail: CASI; A03, Hardcopy; A01, Microfiche

A design optimization scheme for systems which require a high likelihood of functioning on demand is described. The final design specification is achieved by solving a sequence of optimization problems. Each of these problems is defined by assuming some form of the objective function and specifying a subregion of the design space over which this function will be representative of the system unavailability. An example of a high pressure protection system was used to demonstrate the technique. Design parameters for this system include redundancy levels, the number of elements required for a voting system to function, component selection options and maintenance inspection intervals. Both implicit and explicit contraint forms were used. The implicit constraints require a full system analysis to determine whether the current design is feasible or not. All system assessments were carried out using fault tree analysis.

ESA

Computer Program Integrity; Design Analysis; Fault Trees; Optimization; Systems Analysis

19940020083 Naval Postgraduate School, Monterey, CA, USA

An automated tool to facilitate code translation for software fault tree analysis

Ordonio, Robert R., Naval Postgraduate School, USA; Sep 1, 1993; 211p; In English

Report No.(s): AD-A273205; Avail: CASI; A10, Hardcopy; A03, Microfiche

A safe system is defined as a system that prevents unsafe states from producing safety failures, where an unsafe state is defined as a state that may lead to safety failure unless some specific action is taken to avert it. The problem addressed is how to find places in Ada programs where faults are likely to occur during program execution. The approach is to build an automated translation tool that translates Ada programs into a software fault tree. The tool works as follows: (1) The Ada parser and lexical analyzer calls the Automated Code Translation Tool (ACTT) upon recognition of an Ada statement; (2) The ACTT produces a template representing the statement; (3) The templates are linked together as a software fault tree. The result is a program that takes Ada source code as input and produces a software fault tree as output.

DTIC

Ada (Programming Language); Fault Trees; Safety; Systems Engineering; Translating

19950013626 Naval Postgraduate School, Monterey, CA, USA

Software fault tree analysis of concurrent Ada processes

Reid, William Samual, Jr., Naval Postgraduate School, USA; Sep 1, 1994; 94p; In English

Report No.(s): AD-A284979; Avail: CASI; A05, Hardcopy; A01, Microfiche

The Automated Code Translation Tool (ACTT) was developed at Naval Postgraduate School to partially automate the translation of Ada programs into software fault trees. The tool works as follows: the Ada parser and lexical analyzer calls the ACTT upon recognition of an Ada statement; the ACTT produces a template representing the statement; the templates are linked together. The tool was lacking in that it only looked at a subset of Ada structures. The problem that this thesis addresses is the implementation of the missing language structures, specifically, concurrency and exception handling, to allow the ACTT to handle

all of the Ada structures. The result is a tool that takes the Ada source code and provides the analyst with a sequence of templates, and summary information to assist in incorporating hazard information for generating a fault tree.
DTIC
Ada (Programming Language); Automatic Control; Computer Programs; Fault Trees; Machine Translation; Program Verification (Computers); Software Engineering

19950019625 Finnish Centre for Radiation and Nuclear Safety, Helsinki, Finland
Reliability analysis of software based safety functions
Pulkkinen, U., Technical Research Centre of Finland, Finland; May 1, 1993; 65p; In English
Report No.(s): DE95-606516; STUK-YTO-TR-53; Avail: CASI; A04, Hardcopy; A01, Microfiche
    The methods applicable in the reliability analysis of software based safety functions are described in the report. Although the safety functions also include other components, the main emphasis in the report is on the reliability analysis of software. The check list type qualitative reliability analysis methods, such as failure mode and effects analysis (FMEA), are described, as well as the software fault tree analysis. The safety analysis based on the Petri nets is discussed. The most essential concepts and models of quantitative software reliability analysis are described. The most common software metrics and their combined use with software reliability models are discussed. The application of software reliability models in PSA is evaluated; it is observed that the recent software reliability models do not produce the estimates needed in PSA directly. As a result from the study some recommendations and conclusions are drawn. The need of formal methods in the analysis and development of software based systems, the applicability of qualitative reliability engineering methods in connection to PSA and the need to make more precise the requirements for software based systems and their analyses in the regulatory guides should be mentioned.
DOE
Checkout; Computer Programs; Failure Analysis; Failure Modes; Fault Trees; Petri Nets; Qualitative Analysis; Quantitative Analysis; Reliability Analysis; Reliability Engineering; Software Reliability

19960000117 Naval Postgraduate School, Monterey, CA, USA
Fault isolator tool for software fault tree analysis
Mason, Russell W., Naval Postgraduate School, USA; Mar 1, 1995; 77p; In English
Report No.(s): AD-A294399; Avail: CASI; A05, Hardcopy; A01, Microfiche
    Software fault tree analysis (SETA) is a technique used to analyze software for faults that could lead to hazardous conditions in systems which contain software components. A necessary element of a SETA process is the construction of software fault trees based upon the syntactical structure of the software being analyzed. The specific problem addressed by this thesis is how can the process of generating software fault trees based upon the translation of Ada source code files be automated. The approach taken to address this problem was to develop an automated tool that manipulates files created by the Automated Code Translation Tool (ACTT) developed earlier at the Naval Postgraduate School. The ACTT is an automated tool that translates Ada source code files into statement template tree structures that can be used to construct software fault trees. This thesis presents the Fault Isolator Tool (FIT), an automated process for locating and isolating those parts of a statement template tree structure generated by the ACTT tool that are related to statements in Ada programs that the analyst selects for evaluation. The FIT tool then generates software fault trees in a form compatible with the Fault Tree Editor (FTE), an interactive graphical editor developed for the display, editing, and evaluation of software fault trees.
DTIC
Ada (Programming Language); Fault Trees; Machine Translation; Program Verification (Computers); Reliability Analysis; Software Development Tools; Software Reliability

19970005320 Virginia Univ., School of Engineering and Applied Science, Charlottesville, VA USA
Development of a Software Safety Process and a Case Study of Its Use *Annual Report, 1 Aug. 1995 - 31 Jul. 1996*
Knight, J. C., Virginia Univ., USA; Nov. 1996; 14p; In English
Contract(s)/Grant(s): NAG1-1123
Report No.(s): NASA-CR-202656; NAS 1.26:202656; UVA/528344/CS97/106; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Research in the year covered by this reporting period has been primarily directed toward: continued development of mock-ups of computer screens for operator of a digital reactor control system; development of a reactor simulation to permit testing of various elements of the control system; formal specification of user interfaces; fault-tree analysis including software; evaluation

of formal verification techniques; and continued development of a software documentation system. Technical results relating to this grant and the remainder of the principal investigator's research program are contained in various reports and papers.
Derived from text
Program Verification (Computers); Safety Factors; Fault Trees; Control Systems Design; Human-Computer Interface; Nuclear Reactors; Digital Techniques

19980002851 Newcastle-upon-Tyne Univ., Dept. of Computing Science, Newcastle, UK
Fault Injection Testing of Software Implemented Fault Tolerance Mechanisms of Distributed Systems, *series*
Tao, S., Newcastle-upon-Tyne Univ., UK; Feb. 1997; 185p; In English
Report No.(s): PB97-181861; TRS-580; Copyright Waived; Avail: CASI; A09, Hardcopy; A02, Microfiche
     The thesis investigates the issues of testing software-implemented fault tolerance mechanisms of distributed systems through fault injection. A fault injection method has been developed. The method requires that the target software system can be structured as a collection of objects interacting via messages. This enables easy insertion of fault injection objects into the target system to emulate incorrect behavior of fault processors by manipulating messages. This approach allows one to inject specific classes of faults while not requiring any significant changes to the target system. The method differs from previous work in that is exploits an object oriented approach of software implementation to support the injection of specific classes of faults at the system level. The thesis describes how various mechanisms (for example, clock synchronization protocol, and atomic broadcast protocol) were tested. The testing revealed flaws in implementation that had not been discovered before, thereby demonstrating the usefulness of the method. Application of the approach to other distributed systems is also described in the thesis.
NTIS
Fault Tolerance; Computer Programs; Software Development Tools; Injection; Object-Oriented Programming; Computer Systems Performance

19980009647 Virginia Univ., School of Engineering and Applied Science, Charlottesville, VA USA
Development of a Software Safety Process and a Case Study of Its Use *Annual Report, 1 Aug. 1996 - 31 Jul. 1997*
Knight, J. C., Virginia Univ., USA; Oct. 1997; 13p; In English
Contract(s)/Grant(s): NAG1-1123
Report No.(s): NASA/CR-97-206152; NAS 1.26:206152; UVA/528344/CS98/107; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche
     Research in the year covered by this reporting period has been primarily directed toward the following areas: (1) Formal specification of user interfaces; (2) Fault-tree analysis including software; (3) Evaluation of formal specification notations; (4) Evaluation of formal verification techniques; (5) Expanded analysis of the shell architecture concept; (6) Development of techniques to address the problem of information survivability; and (7) Development of a sophisticated tool for the manipulation of formal specifications written in Z. This report summarizes activities under the grant. The technical results relating to this grant and the remainder of the principal investigator's research program are contained in various reports and papers. The remainder of this report is organized as follows. In the next section, an overview of the project is given. This is followed by a summary of accomplishments during the reporting period and details of students funded. Seminars presented describing work under this grant are listed in the following section, and the final section lists publications resulting from this grant.
Author
Computer Programming; Safety; Specifications; Evaluation; Technologies

19980111470
A review of research and methods for producing high-consequence software
Collins, E., Sandia National Labs., USA; Dalton, L., Sandia National Labs., USA; Peercy, D., Sandia National Labs., USA; Pollock, G., Sandia National Labs., USA; Sicking, C., Sandia National Labs., USA; 1995, pp. 199-245; In English
Contract(s)/Grant(s): DE-AC04-94AL-85000; Copyright; Avail: Aeroplus Dispatch
     The development of software for use in high-consequence systems mandates rigorous processes, methods, and techniques to improve the safety characteristics of those systems. This paper provides a brief overview of current research and practices in high-consequence software, including applied design methods. Some of the practices that are discussed include: fault tree analysis, failure mode effects analysis, petri nets, both hardware and software interlocks, n-version programming, Independent Vulnerability Analyses, and watchdogs. Techniques that offer improvement in the dependability of software in high-consequence systems applications are identified and discussed. Limitations of these techniques are also explored. Research in formal methods,

the cleanroom process, and reliability models are reviewed. In addition, current work by several leading researchers as well as approaches being used by leading practitioners are examined.
Author (AIAA)
Software Development Tools; Safety Factors; Fault Trees; Failure Modes; Integrated Circuits; Circuit Reliability

19980120597
An extension of Goal-Question-Metric paradigm for software reliability
Stoddard, Robert W., Texas Instruments, Inc., Dallas, USA; 1996, pp. 156-162; In English; Copyright; Avail: Aeroplus Dispatch
      The driving need in software reliability is to mature the 'physics of failure' and design aspects related to software reliability. This type of focus would then enhance one's ability to effect reliable software in a predictable form. A major challenge is that software reliability, in essence, requires one to measure compliance to customer/user requirements. Customer/user requirements can range over a wide spectrum of software product attributes that relate directly or indirectly to software performance. The Goal-Question-Metric paradigm is a popular and effective approach to measurement identification. However, in practice, additional challenges in using this approach have been encountered. Some of these challenges, though, seem to be alleviated with use of a reliability technique called success/fault tree analysis. Experience has shown that the Goal-Question-Metric paradigm is conducive to the building of G-Q-M trees which may be analyzed using reliability success/fault tree logic.
Author (AIAA)
Software Reliability; Quality Control

19980156006
Automated software fault-tree analysis of PASCAL programs
Friedman, Michael A., Hughes Aircraft Co., USA; 1993, pp. 458-461; In English; Copyright; Avail: Aeroplus Dispatch
      A tool is described that largely automates the process of constructing a software fault-tree of a PASCAL program. Software fault-tree analysis is based on a series of templates that each map programming language constructs to a subtree. The tool reads in a PASCAL program and a software-caused hazard (postcondition), and fills it in template subtrees that correspond to the program's constructs. These subtrees are arranged into a tree of AND and OR gates in which the top event is the postcondition.
Author (AIAA)
Fault Trees; Computer Programs; Pascal (Programming Language)

19980205670 Newcastle-upon-Tyne Univ., Dept. of Computing Science, Newcastle, UK
Object-Based Approach to Modelling and Analysis of Failure Properties
Cepin, M., Newcastle-upon-Tyne Univ., UK; deLemos, R., Newcastle-upon-Tyne Univ., UK; Mavko, B., Newcastle-upon-Tyne Univ., UK; Riddle, S., Newcastle-upon-Tyne Univ., UK; Saeed, A., Newcastle-upon-Tyne Univ., UK; Aug. 1997; 22p; In English
Report No.(s): PB98-147887; TRS-598; Copyright Waived; Avail: CASI; A03, Hardcopy; A01, Microfiche
      As a basis for the required qualitative evidence, we propose an object-based approach that allows modeling of both the application and software domains. From the object class model of a system and a formal specification of the failure properties of its components, we generate a graph of failure propagation over object classes, which is then used to generate a graph in terms of object instances in order to conduct fault tree analysis.
NTIS
Software Engineering; Failure; Applications Programs (Computers); Fault Trees; Object-Oriented Programming; Safety

19980212262
An integrated approach to achieving high software reliability
Lyu, Michael R., Chinese Univ. of Hong Kong, Shatin, Hong Kong; 1998, pp. 123-136; In English; Copyright; Avail: Aeroplus Dispatch
      We address the development, testing, and evaluation schemes for software reliability, and the integration of these schemes into a unified and consistent paradigm. Specifically, techniques and tools for the three software reliability engineering phases are described. The three phases are modeling and analysis, design and implementation, and testing and measurement. In the modeling and analysis phase we describe Markov modeling and fault-tree analysis techniques. We present system-level reliability models based on these techniques, and provide modeling examples for reliability analysis and study. We describe how reliability block diagrams can be constructed for a real-world system for reliability prediction, and how critical components can be identified. We

also apply fault tree models to fault tolerant system architectures, and formulate the resulting reliability quantity. Finally, we describe two software tools, SHARPE and UltraSAN, which are available for reliability modeling and analysis purposes.
Author (AIAA)
Software Reliability; Systems Integration; Software Development Tools; Markov Processes; Fault Trees; Failure Analysis

19990054676 Raytheon Systems Co., Fullerton, CA USA
Determining Software (Safety) Levels for Safety-Critical Systems
Tamanaha, Doris Y., Raytheon Systems Co., USA; Yin, Meng–Lai, Raytheon Systems Co., USA; Proceedings of the Twenty-Third Annual Software Engineering Workshop; June 1999; 43p; In English; See also 19990054657; Original contains color illustrations; No Copyright; Avail: CASI; A03, Hardcopy; A04, Microfiche

 For safety-critical software-intensive systems, software (safety) levels are determined so that the appropriate development process is applied. This paper discusses issues of applying the results of fault tree analysis to software (safety) levels determination. In particular, the inconsistency problem, i.e., inconsistent software (safety) levels is addressed and an approach is presented.
Author
Computer Systems Programs; Fault Trees; Software Engineering; Software Reliability; Reliability Analysis; Consistency

19990056035
Software engineering of critical software tools
Sullivan, Kevin J., Virginia, Univ., Charlottesville, USA; 1999; In English; Copyright; Avail: AIAA Dispatch

 This tutorial surveys important concepts in modern software engineering, with a focus on software architecture, formal description, object-orientation, and component-based design. Special attention is given to the Galileo fault tree analysis tool.
AIAA
Software Engineering; Object-Oriented Programming; Software Development Tools; Computer Aided Design; Fault Trees

19990056048
A design language for automatic synthesis of fault trees
Vemuri, Kiran K., Hewlett-Packard Co., USA; Dugan, Joanne B., Virginia, Univ., Charlottesville; Sullivan, Kevin J., Virginia, Univ., Charlottesville; 1999, pp. 91-96; In English
Contract(s)/Grant(s): NSF CCR-95-02029; NSF CCR-95-06779; NSF MIP-95-28258; Copyright; Avail: AIAA Dispatch

 The separation of digital system design and reliability analysis incurs unnecessary costs, delays, and quality penalties. This paper introduces a graphical design language called RIDL (Reliability Information embedded Design Language) for modeling digital systems. In RIDL, redundancy and failure information is embedded within block diagram schematics, without significantly altering the physical block diagram models typically used by design engineers. A system schematic in RIDL has all of the information needed for reliability analysis without a need for additional textual descriptions. A dynamic fault tree model can be automatically synthesized from a RIDL system model. Designers can use the synthesized fault trees to obtain rough reliability analyses at an early conceptual design stage. to evaluate the potential of this approach, we have applied it to several example systems.
Author (AIAA)
Reliability Analysis; Fault Trees; Programming Languages; Digital Systems; Computer Graphics; Failure Analysis

19990056049
Bridging the gap between systems and dynamic fault tree models
Manian, Ragavan, FORE Systems, Inc., USA; Dugan, Joanne B., Virginia, Univ., Charlottesville; Sullivan, Kevin J., Virginia, Univ., Charlottesville; Coppit, David W., Virginia, Univ., Charlottesville; 1999, pp. 105-111; In English
Contract(s)/Grant(s): NSF CCR-95-02029; NSF CCR-95-06779; NSF MIP-95-28258; Copyright; Avail: AIAA Dispatch

 Fault tolerant systems are composed of subsystems that interact with each other, often in complex ways. Analyzing the reliability of these systems calls for sophisticated modeling techniques. One such technique is dynamic fault tree analysis. Because the semantics of dynamic fault trees are themselves complex, there is a question of whether such models are faithful representations of the modeled systems, and whether the underlying analysis techniques are correct. Previous definitions of the modeling constructs employed in dynamic fault trees were not precise or consistent enough, leading to ambiguities in their interpretation. We present our efforts at making the dynamic fault tree modeling and evaluation process precise. Our aim was to improve our confidence in the validity of dynamic fault tree models of system failure behavior. by rigorously specifying fault trees

and their constituent gates and basic events, we were able to reason more effectively about the correctness of fault trees, the underlying analytical Markov models, and the numerical solution to these analytical models.
Author (AIAA)
Reliability Analysis; Fault Trees; Dynamic Models; Fault Tolerance; System Failures; Markov Processes

19990066815
Use of prime implicants in dependability analysis of software controlled systems
Yau, Michael, ASCA, Inc., USA; Apostolakis, George; Guarro, Sergio; Reliability Engineering & System Safety; Oct, 1998; ISSN 0951-8320; Volume 62, no. 1-2, pp. 23-32; In English; Copyright; Avail: Issuing Activity

The behavior of software controlled systems is usually non-binary and dynamic. It is, thus, convenient to employ multi-valued logic to model these systems. Multi-valued logic functions can be used to represent the functional and temporal relationships between the software and hardware components. The resulting multi-valued logic model can be analyzed deductively, i.e. by tracking causality in reverse from undesirable 'top' events to identify faults that may be present in the system. The result of this deductive analysis is a set of prime implicants for a user-defined system top event. The prime implicants represent all the combinations of basic component conditions and software input conditions that may result in the top event; they are the extension to multi-valued logic of the concept of minimal cut sets that is used routinely in the analysis of binary fault trees. This paper discusses why prime implicants are needed in the dependability analysis of software controlled systems, how they are generated, and how they are used to identify faults in a software controlled system.
Author (EI)
Computer Programs; Computers; Mathematical Models; Failure Analysis

19990100484
Incremental retrieval mechanism for case-based electronic fault diagnosis
Cunningham, P., Trinity Coll. Dublin, Ireland; Smyth, B.; Bonzano, A.; Knowledge-Based Systems; Nov 12, 1998; ISSN 0950-7051; Volume 11, no. 3-4, pp. 239-248; In English; Copyright; Avail: Issuing Activity

One problem with using CBR for diagnosis is that a full case description may not be available at the beginning of the diagnosis. The standard CBR methodology requires a detailed case description in order to perform case retrieval and this is often not practical in diagnosis. We describe two fault diagnosis tasks where many features may make up a case description but only a few features are required in an individual diagnosis. We evaluate an incremental CBR mechanism that can initiate case retrieval with a skeletal case description and will elicit extra discriminating information during the diagnostic process.
Author (EI)
Computer Techniques; Software Engineering; Electronic Equipment; Problem Solving

19990107733
Architectural model for software reliability quantification: Sources of data
Smidts, C., Univ. of Maryland, USA; Sova, D.; Reliability Engineering & System Safety; May, 1999; ISSN 0951-8320; Volume 64, no. 2, pp. 279-290; In English; Copyright; Avail: Issuing Activity

An architecturally based software reliability model called FASRE is introduced. The model is based on an architecture derived from the requirements which captures both functional and nonfunctional requirements and on a generic classification of functions, attributes and failure modes. The model focuses on evaluation of failure mode probabilities and uses a Bayesian quantification framework. Failure mode probabilities of functions and attributes are propagated to the system level using fault trees. It can incorporate any type of prior information such as results of developers' testing, historical information on a specific functionality and its attributes, and, is ideally suited for reusable software.
EI
Computer Programs; Evaluation; Reliability; Computerized Simulation

Includes computer networks and distributed processing systems. For information systems see 82 Documentation and Information Science. For computer systems applied to specific applications, see the associated category.

19820058732
Automatic generation of symbolic reliability functions by processor-memory-switch structures
Kini, V., Southern California, University, USA; Siewiorek, D. P., Carnegie-Mellon University, USA; IEEE Transactions on Computers; Aug 1, 1982; C-31, pp. Aug. 198; In English; p. 752-771
Contract(s)/Grant(s): N0014-77-C-0103; NSF GJ-32758X; NR PROJECT 048-645; Copyright; Avail: Issuing Activity
     A methodology is proposed for automating the computation of symbolic reliability functions for arbitrary interconnection structures at the Processor-Memory-Switch (PMS) level, with emphasis on the automation of the task of case analysis and problem partitioning in the hard failure reliability computation of PMS structures. A program, the Avanced Interactive Symbolic Evaluator of Reliability (ADVISER) was constructed as a research vehicle that accepts as its inputs the interconnection graph of the PMS structure and a succinct statement of the operational requirements of the structure in the form of a regular expression. ADVISER considers such communication structures in the PMS system as buses and crosspoint switches, in addition to the explicitly stated requirement of determining the effect of the interconnection structure on system reliability. The program's output is a symbolic reliability equation for the system.
AIAA
Circuit Reliability; Computer Aided Design; Computer Systems Design; Fail-Safe Systems; Fault Trees; Reliability Analysis

19890015444 NASA Langley Research Center, Hampton, VA, USA
The Fault Tree Compiler (FTC): Program and mathematics
Butler, Ricky W., NASA Langley Research Center, USA; Martensen, Anna L., PRC Kentron, Inc., Hampton, USA; Jul 1, 1989; 40p; In English
Contract(s)/Grant(s): RTOP 505-66-21-01
Report No.(s): NASA-TP-2915; L-16529; NAS 1.60:2915; Avail: CASI; A03, Hardcopy; A01, Microfiche
     The Fault Tree Compiler Program is a new reliability tool used to predict the top-event probability for a fault tree. Five different gate types are allowed in the fault tree: AND, OR, EXCLUSIVE OR, INVERT, AND m OF n gates. The high-level input language is easy to understand and use when describing the system tree. In addition, the use of the hierarchical fault tree capability can simplify the tree description and decrease program execution time. The current solution technique provides an answer precisely (within the limits of double precision floating point arithmetic) within a user specified number of digits accuracy. The user may vary one failure rate or failure probability over a range of values and plot the results for sensitivity analyses. The solution technique is implemented in FORTRAN; the remaining program code is implemented in Pascal. The program is written to run on a Digital Equipment Corporation (DEC) VAX computer with the VMS operation system.
CASI
Computer Programs; Computer Techniques; Fault Tolerance; Fault Trees; Probability Theory; Reliability Analysis

19920059468 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, USA
Fault tree models for fault tolerant hypercube multiprocessors
Boyd, Mark A., Duke University, USA; Tuazon, Jezus O., JPL, USA; Jan 1, 1991; 5p; In English; Annual Reliability and Maintainability Symposium, Jan. 29-31, 1991, Orlando, FL, USA; See also A92-42051; Copyright; Avail: Issuing Activity
     Three candidate fault tolerant hypercube architectures are modeled, their reliability analyses are compared, and the resulting implications of these methods of incorporating fault tolerance into hypercube multiprocessors are discussed. In the course of performing the reliability analyses, the use of HARP and fault trees in modeling sequence dependent system behaviors is demonstrated.
AIAA
Computer Systems Design; Fault Tolerance; Fault Trees; Hypercube Multiprocessors; Reliability Analysis

19970018571 Sandia National Labs., Albuquerque, NM USA
Probabilistic logic modeling of network reliability for hybrid network architectures
Wyss, G. D., Sandia National Labs., USA; Schriner, H. K., Sandia National Labs., USA; Gaylor, T. R., Sandia National Labs., USA; 1996; 10p; In English; Local Computer Networking, 13-16 Oct. 1996, Minneapolis, MN, USA
Contract(s)/Grant(s): DE-AC04-94AL-85000

Report No.(s): SAND-96-2048C; CONF-9610171-1; DE96-014080; No Copyright; Avail: Issuing Activity (Department of Energy (DOE)), Microfiche

Sandia National Laboratories has found that the reliability and failure modes of current-generation network technologies can be effectively modeled using fault tree-based Probabilistic Logic Modeling (PLM) techniques. We have developed fault tree models that include various hierarchical networking technologies and classes of components interconnected in a wide variety of typical and a typical configurations. In this paper we discuss the types of results that can be obtained from PLMs and why these results are of great practical value to network designers and analysts. After providing some mathematical background, we describe the 'plug-and-play' fault tree analysis methodology that we have developed for modeling connectivity and the provision of network services in several current- generation network architectures. Finally, we demonstrate the flexibility of the method by modeling the reliability of a hybrid example network that contains several interconnected ethernet, FDDI, and token ring segments.
DOE
Computer Networks; Architecture (Computers); Fault Trees; Mathematical Models

19980155979
Fault trees and imperfect coverage - A combinatorial approach
Doyle, Stacy A., Duke Univ., USA; Dugan, Joanne B., Duke Univ., USA; 1993, pp. 214-219; In English
Contract(s)/Grant(s): NCA2-617; Copyright; Avail: Aeroplus Dispatch

We present a new technique for combining a coverage model with a fault tree. For a class of systems, this technique is simpler and faster than those currently being used. Given a fault tree model of the system structure, the minimum cutsets are generated using standard techniques. This set of cutsets represents the effects of covered faults and can be used to determine if the system contains sufficient redundancy to achieve the desired reliability. This set of minimum cutsets is augmented by a set of cutsets that represent uncovered faults. This set of additional cutsets is disjoint from the original cutsets, but they are not independent since covered and uncovered faults are mutually exclusive. We solve the resulting set of cutsets by combining standard multi-state and sum-of-disjoint products solution techniques.
Author (AIAA)
Fault Trees; Combinatorial Analysis; Reliability Analysis

19980175133
Combinatorial-models and coverage - A binary decision diagram (BDD) approach
Doyle, Stacy A., Duke Univ., USA; Dugan, Joanne B., Virginia, Univ., Charlottesville; Boyd, Mark, NASA Ames Research Center, USA; 1995, pp. 82-89; In English
Contract(s)/Grant(s): NCA2-825; NGT-51313; Copyright; Avail: Aeroplus Dispatch

This paper presents the DREDD (Dependability and Risk Analysis using Decision Diagrams) algorithm which incorporates coverage modeling into a binary decision diagram (BDD) solution of a combinatorial model. The DREDD algorithm takes advantage of the efficiency of the BDD solution approach and the increased accuracy afforded by coverage modeling. BDDs have been used to find exact solutions for extremely large systems, including those with as many as 10 to the 20 prime implicants (Coudert and Madre, 1992). Including coverage in this process will increase the validity of the results, since a more complete model allows for more realistic analysis. The reliability of life critical systems, which previously could only be approximated, may now be analyzed more accurately.
Author (AIAA)
Fault Tolerance; Combinatorial Analysis; Decision Theory; Risk; Reliability Analysis; Fault Trees

19990056024
Fault-tree analysis of computer-based systems
Dugan, Joanne B., Virginia, Univ., Charlottesville, USA; 1999; In English; Copyright; Avail: AIAA Dispatch

This tutorial discusses several new and exciting approaches to fault tree analysis of computer-based systems. After a brief introduction to fault trees, we present an example analysis of a simple control system and then discuss the use of fault trees as a design aid for software systems. The largest part of tutorial deals with methods for adapting the fault tree techniques to the analysis of computer-based systems. These methods include the incorporation of coverage models in the fault tree and the use of special gates for sequence dependencies. Several examples of fault tree models for computer systems are presented. These new techniques have allowed the fault tree model, long appreciated for its concise and unambiguous representational form, to be applicable to the analysis of complex fault-tolerant systems.
Author (AIAA)
Computer Techniques; Fault Trees; Reliability Analysis; Software Development Tools; Complex Systems

19990056052

System reliability analysis of an embedded hardware/software system using fault trees

Kaufman, Lori M., Virginia, Univ., Charlottesville, USA; Dugan, Joanne B., Virginia, Univ., Charlottesville; Manian, Ragavan, FORE Systems, Inc., USA; Vemuri, Kiran K., Hewlett-Packard Co., USA; 1999, pp. 135-141; In English; Copyright; Avail: AIAA Dispatch

The use of fault trees allows for the unified modeling of embedded hardware/software systems. Fault trees can also produce a sensitivity analysis to provide insight as to which hardware and software components are potentially the most problematic for a given system. From this analysis, the effects that the various hardware and software components have on the overall system reliability can be quantified. Using an example system, it is demonstrated that the various software components contained within a system have a significant impact on the overall system reliability. Hence, software and hardware must be integrated in the reliability analysis of embedded systems to properly represent system behavior and to properly predict the overall system reliability.
Author (AIAA)
Fault Trees; Software Development Tools; Hardware; Reliability Analysis; Embedded Computer Systems

19990056056

Reliability analysis of complex hardware-software systems

Vemuri, Kiran K., Hewlett-Packard Co., USA; Dugan, Joanne B., Virginia, Univ., Charlottesville; 1999, pp. 178-182; In English; Copyright; Avail: AIAA Dispatch

We demonstrate how fault tree analysis could be used to perform reliability analysis of hardware-software systems. The functional dependence of the hardware components on the interfacing software components is appropriately modeled using fault trees. The Massachusetts Institute of Technology Center for Space Research Advanced X-ray Astrophysics Facility Imaging Charge Couple Device Imaging Spectrometer (ACIS) system is used to illustrate the fault tree analysis method in reliability analysis of complex hardware-software systems. The ACIS science instrument system is a spaceborne system to acquire and process X-ray images over the sky, and sends them to Earth. It has hardware and software components with interfaces between them, making it a very good example of a complex hardware-software system. This approach could be used in analyzing other complex systems being designed today and in identifying the critical components to make the system safe and more reliable.
Author (AIAA)
Reliability Analysis; Software Reliability; Hardware; Fault Trees; X Ray Imagery

20000006854

The technique of tree diagnosis for a test system

Zhang, Wen–Qi, CASC, 4th Academy, Xian, China; Journal of Solid Rocket Technology; Jun. 1999; ISSN 1006-2793; Volume 22, no. 2, pp. 72-74; In Chinese; Copyright; Avail: Aeroplus Dispatch

The basic principle, model construction, and application of a fault tree analysis model for a test system are presented. As the fault database of the diagnosis system is improved, the model will play an important role in accurately and rapidly diagnosing the fault location of the test system for a solid rocket motor.
Author (AIAA)
Fault Trees; Solid Propellant Rocket Engines

63
CYBERNETICS, ARTIFICIAL INTELLIGENCE AND ROBOTICS

Includes feedback and control theory, information theory, machine learning, and expert systems. For related information see also 54 Man/System Technology and Life Support.

19850015029 Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID, USA

Contribution of instrumentation and control software to system reliability

Fryer, M. O., Edgerton, Germeshausen and Grier, Inc., USA; Jan 1, 1984; 7p; In English; Symp. on New Technol. in Nucl. Power Plant Instrumentation and Control, 28 Nov. 1984, Washington, DC, USA
Contract(s)/Grant(s): DE-AC07-76ID-01570
Report No.(s): DE85-004693; EGG-M-25484; CONF-841122-3; Avail: CASI; A02, Hardcopy; A01, Microfiche

A new method of reliability assessment of combined software/hardware systems is presented. The method is based on a procedure called fault tree analysis which determines how component failures can contribute to system failure. Fault tree analysis

is a well developed method for reliability assessment of hardware systems and produces quantitative estimates of failure probability based on component failure rates. It is shown how software control logic can be mapped into a fault tree that depicts both software and hardware contributions to system failure.
DOE
Computer Systems Programs; Failure Analysis; Fault Trees; Reliability; System Failures

19870029408
An architecture for consideration of multiple faults
Maletz, M. C., Inference Corp., USA; Jan 1, 1985; 8p; In English; See also A87-16676; Copyright; Avail: Issuing Activity

A context graphs architecture is presented for fault diagnostic systems which reason from symptoms and tests to suspected faults. The rooted, directed, acyclic graphs (DAG) feature directional arcs which indicate parent-child relationships for tracking fact inheritance across the graphs. Root contexts have no parents, while all other contexts have one or more parents. The architecture permits use of heuristic search strategies through the space of possible faults. A 'merge' context is described which involves finding unique solutions for a particular context (fault) by tracking a distinct set of ancestors. Implementation of such an architecture is illustrated with a diagnostic system for Shuttle simulation hardware.
AIAA
Architecture (Computers); Expert Systems; Fault Trees; Flight Simulators; Graph Theory; Reliability Analysis; Space Shuttle Orbiters

19890005389 McDonnell Aircraft Co., Saint Louis, MO, USA
Avionics fault tree analysis and artificial intelligence for future aircraft maintenance
Harris, Michael E., McDonnell Aircraft Co., USA; Snodgrass, Thomas D., McDonnell Aircraft Co., USA; Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics; Jul 1, 1987, pp. p 363-374; In English; See also N89-14740 06-63; Avail: CASI; A03, Hardcopy; A04, Microfiche

The F/A-18 aircraft has demonstrated that reduced Life Cycle Costs and improved operational readiness can be designed-in without retreating from performance requirements when emphasis is properly balanced between Reliability, Maintainability and Design. The Avionics Fault Tree Analyzer (AFTA) is a suitcase size flight line tester capable of extending the F/A-18 fighter's built-in-test (BIT) fault isolation capabilities beyond the Weapon Replaceable Assembly (WRA), to the Shop Replaceable Assembly (SRA) Level. The AFTA was developed as an interim support tool for the Navy prior to attainment of total organic support capability, and as an alternate method of support to reduce Life Cycle Cost for F/A-18 foreign military sales. With the transformation of the AFTA concept from ground support equipment to avionics, a quantitative improvement in Life Cycle Costs will be obtained through the application of Artificial Intelligence (AI) techniques. AI is expected to see applications to practical problems in many disciplines; and one of which is the implementation of the military fault diagnostic system. Using AI techniques, a smart BIT is being developed which will reduce false alarms, identify intermittent failures, and improve fault isolation to the lowest possible element. Increasing density of computer memory, modularly designed avionic functions and the use of very large scale and high speed integrated devices will allow future aircraft to fly with the AFTA function. Ramifications such as eliminating the need for intermediate avionic repair facilities, increased aircraft operational readiness, decrease in aircraft recurring cost, and a reduction in spares investment are discussed. This paper will summarize the AFTA concept, Life Cycle Cost advantages, and the implementation of Artificial Intelligence in future avionic designs relative to improved reliability and maintainability.
CASI
Artificial Intelligence; Automatic Test Equipment; Avionics; Fault Trees; Maintenance; Onboard Equipment

19960035597 Naval Postgraduate School, Monterey, CA USA
Software Fault Tree Analysis of an Automated Control System Device Written in Ada
Winter, Mathias W., Naval Postgraduate School, USA; Sep. 1995; 112p; In English
Report No.(s): AD-A303377; No Copyright; Avail: CASI; A06, Hardcopy; A02, Microfiche

Software Fault Tree Analysis (SFTA) is a technique used to analyze software for faults that could lead to hazardous conditions in systems which contain software components. Previous thesis works have developed three Ada-based, semi-automated software analysis tools, the Automated Code Translation Tool (ACm) an Ada statement template generator, the Fault Tree Editor (Fm) a graphical fault tree editor, and the Fault Isolator (FL) an automated software fault tree isolator. These previous works did not apply their tools on a real system. Therefore, the question addressed by this thesis is 'Do these tools actually work on a real-world software control system?' This thesis developed and implemented a sample Software System Analysis Methodology (SSAM) using these semi- automated s oftware tools. The research applied this methodology to a real-world distributed control system written in Ada. The Missile Engagement Simulation Arena's (MESA) control software was developed by the Naval Air Warfare

Center, Weapons Division, China Lake, CA. The SSAM was used to show that the analysis of the Sphere-HWCI control module's 74,000 lines of code could be thoroughly analyzed in less than 100 man-hours. This practical, 740 lines-of-code per hour rate was a direct result of the incorporation of the semi-automated tools into the process.
DTIC
Computer Programs; Computerized Simulation; Distributed Parameter Systems; Machine Translation; Systems Analysis; Active Control; Ada (Programming Language)

19970034829 Society of Instrument and Control Engineers, Tokyo, Japan
Investigational report on the trend of control technology *Seigyo gijutsu doko chosa hokokusho*
Jun. 1996; 188p; In Japanese
Report No.(s): ETDE/JP-MF-97750119; DE97-750119; No Copyright; Avail: Issuing Activity (Natl Technical Information Service (NTIS)), Microfiche

For the purpose of corresponding to changes of the industrial structure and making full use of the control technology, the paper investigated the state of the application. High-grade automation in the manufacturing industry has reached the spread of use at big companies for these 10 years. The hierarchical structure of business/process/DCS has been completed, and the optimal control and the advanced control have been realized. The development and spread to the much wider field is anticipated. The soft structure system is needed for equipment improvement in view of the life cycle of equipment and toward the elimination of bottlenecking. For the design of the control system, commercial tools began to be much used, and it is expected in future to accumulate and recycle the knowledge/knowhow for effective design work. Further, strict simulation models based material balance and heat balance have also been on the rise, and the advance in technology is expected. Because of the total productivity of the production equipment, the control technology is anticipated not only for the pursuit of controllability but for the use as supporting technology in the operation/driving/failure diagnosis for working out, carrying out and evaluating the optimum operation plan.
DOE
Control Systems Design; Controllability; Automation; Control Theory; Forecasting; Information Systems; Optimal Control; Productivity; Commerce; Production Management; Fault Trees

19980060039
Safety and reliability assessment techniques in robotics
Dhillon, B. S., Univ. of Ottawa, Canada; Fashandi, A. R. M.; Robotica; Nov-Dec, 1997; ISSN 0263-5747; Volume 15, pt 6, pp. 701-708; In English; Copyright; Avail: Issuing Activity

A robot has to be safe and reliable. An unreliable robot may become the cause of unsafe conditions, high maintenance costs, inconvenience, etc. Over the years, in general safety and reliability areas various assessment methods have been developed, e.g. failure mode and effects analysis, fault tree analysis, and Markovian analysis. In view of these, this paper presents an overview of the most suitable robot safety and reliability assessment techniques.
Author (EI)
Robotics; Accident Prevention; Reliability; Failure Analysis; Markov Processes

19980078682
Robot reliability using fuzzy fault trees and Markov models
Leuschen, Martin L., Rice Univ., USA; Walker, Ian D., Rice Univ., USA; Cavallaro, Joseph R., Rice Univ., USA; 1996, pp. 73-91; In English; Copyright; Avail: AIAA Dispatch

Robot reliability has become an increasingly important issue in the last few years, in part due to the increased application of robots in hazardous and unstructured environments. However, much of this work leads to complex and nonintuitive analysis, which results in many techniques being impractical due to computational complexity or lack of appropriately complex models for the manipulator. We consider the application of notions and techniques from fuzzy logic, fault trees, and Markov modeling to robot fault tolerance. Fuzzy logic lends itself to quantitative reliability calculations in robotics. The crisp failure rates which are usually used are not actually known, while fuzzy logic, due to its ability to work with the actual approximate (fuzzy) failure rates available during the design process, avoids making too many unwarranted assumptions. Fault trees are a standard reliability tool that can easily assimilate fuzzy logic. Markov modeling allows evaluation of multiple failure modes simultaneously, and is thus an appropriate method of modeling failures in redundant robotic systems. However, no method of applying fuzzy logic to Markov models was known to the authors. This opens up the possibility of new techniques for reliability using Markov modeling and fuzzy logic techniques, which are developed here.
Author (AIAA)
Fault Trees; Markov Processes; Robots; Fuzzy Systems; Reliability Analysis

19980120609
The use of fault trees for the design of robots for hazardous environments
Walker, Ian D., Rice Univ., USA; Cavallaro, Joseph R., Rice Univ., USA; 1996, pp. 229-235; In English
Contract(s)/Grant(s): NSF IRI-95-26363; NSF DDM-92-02639; DE-AC04-94AL-85000; NAG9-740; Copyright; Avail: Aeroplus Dispatch

This paper addresses the application of fault trees to the analysis of robot manipulator reliability and fault tolerance. Although a common and useful tool in other applications, fault trees have only recently been applied to robots. In addition, most of the fault tree analyses in robotics have focused on qualitative, rather than quantitative, analysis. Robotic manipulators present some special problems, due to the complex and strongly coupled nature of their subsystems, and also their wild response to subsystem failures. Additionally, there is a lack of reliability data for robots and their subsystems. There has traditionally been little emphasis on fault tolerance in the design of industrial robots, and data regarding operational robot failures are relatively scarce. However, at this time there is a new and critical need for safe and reliable robots for remote Environmental Restoration and Waste Management applications. This paper discusses aspects of the reliability problem in robotics, concentrating on the quantitative aspects of fault tree analysis for the design of robot manipulators.
Author (AIAA)
Fault Trees; Robots; Manipulators; Fault Tolerance; Robotics; Waste Disposal

19980160720
Basic fault-tree analysis
Koren, James, Science Applications International Corp., USA; Childs, Christopher, Science Applications International Corp., USA; 1994; In English; Copyright; Avail: Aeroplus Dispatch

Although based on some simple concepts, the application of fault trees to practical problems is fraught with pitfalls. This tutorial describes the basic techniques of synthesis and analysis and provides practical information so that their use can be cost-effective. There are nine important fault-tree construction issues. Basic-Event Naming Convention Component Boundaries Modularization Support-System Interface Common-Cause Events System Schematic Direction of Analysis Circular Logic System Notebooks. There are three general cautions. Set the goal of your analysis early and keep it in sight at all times. Each decision made concerning the fault-tree analysis must be made with this final goal in mind. Expand the fault tree only where it is needed. If a support system does not appreciably contribute to system failure, leaving it as an undeveloped event is acceptable. A fault tree that is harder to understand and comprehend than the system it represents is of little use to anyone.
Author (AIAA)
Fault Trees; Failure Analysis; Safety Management

19990085312
On the relations between intelligent backtracking and failure-driven explanation-based learning in constraint satisfaction and planning
Kambhampati, Subbarao, Arizona State Univ., USA; Artificial Intelligence; Oct, 1998; ISSN 0004-3702; Volume 105, no. 1-2, pp. 161-208; In English; Copyright; Avail: Issuing Activity

The ideas of intelligent backtracking (IB) and explanation-based learning (EBL) have developed independently in the constraint satisfaction, planning, machine learning and problem solving communities. The variety of approaches developed for IB and EBL in the various communities have hitherto been incomparable. In this paper, I formalize and unify these ideas under the task-independent framework of refinement search, which can model the search strategies used in both planning and constraint satisfaction problems (CSPs). I show that both IB and EBL depend upon the common theory of explanation analysis - which involves explaining search failures, and regressing them to higher levels of the search tree. My comprehensive analysis shows that most of the differences between the CSP and planning approaches to EBL and IB revolve around different solutions to: (a) how the failure explanations are computed; (b) how they are contextualized (contextualization involves deciding whether or not to keep the flaw description and the description of the violated problem constraints); and (c) how the storage of explanations is managed. The differences themselves can be understood in terms of the differences between planning and CSP problems as instantiations of refinement search. This unified understanding is expected to support a greater cross-fertilization of ideas among CSP, planning and EBL communities.
Author (EI)
Artificial Intelligence; Machine Learning; Computation

Includes iteration, differential and difference equations, and numerical approximation.

19700030987 Douglas United Nuclear, Inc., Richland, WA, USA
Commercial application of fault tree analysis
Bruce, R. A., Douglas United Nuclear, Inc., USA; Crosetti, P. A., Douglas United Nuclear, Inc., USA; Apr 7, 1970; 41p; In English; 9TH; RELIABILITY AND MAINTAINABILITY CONF., DETROIT
Contract(s)/Grant(s): AT/45-1/-1857
Report No.(s): DUN-SA-139; CONF-700702-1; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Fault tree analysis for reliability evaluation of commercial products
CASI
Products; Quality Control; Reliability Analysis; Trees (Mathematics)

19780020925 Sandia National Labs., Albuquerque, NM, USA
Common-cause analysis using sets
Worrell, R. B., Sandia National Labs., USA; Stack, D. W., Sandia National Labs., USA; Dec 1, 1977; 15p; In English
Contract(s)/Grant(s): EY-76-C-04-0789
Report No.(s): SAND-77-1832; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Common-cause analysis was developed for studying the behavior of a system that is affected by special conditions and secondary causes. Common-cause analysis is related to fault tree analysis. Common-cause candidates are minimal cut sets whose primary events are closely linked by a special condition or are susceptible to the same secondary cause. It is shown that common-cause candidates can be identified using the Set Equation Transformation System (SETS). A Boolean equation is used to establish the special conditions and secondary cause susceptibilities for each primary event in the fault tree. A transformation of variables (substituting equals for equals), executed on a minimal cut set equation, results in replacing each primary event by the right side of its special condition/secondary cause equation and leads to the identification of the common-cause candidates.
ERA
Boolean Algebra; Set Theory; Trees (Mathematics)

19790005623 Argonne National Lab., IL, USA
Introduction to fault tree synthesis using Lapp-Powers methodology
Lynch, E. P., Argonne National Lab., USA; Jan 1, 1978; 26p; In English; 1978 Symp. on Instrumentation and Control for Fossil Demonstration, 19-21 Jun. 1978, Newport Beach, CA, USA
Report No.(s): ANL/EES-CP-3; CONF-780656-1; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Fault tree analysis is a method of determining the possibility and/or probability that a specific designated failure will occur. A complete logic diagram is constructed that identifies the immediate precursor events leading to the failure, the precursors of these events, and so on until pyramid structure of tree is generated. A probability is assigned to each event in the tree, and the overall probability of the designated failure is calculated. The reader is shown how logic diagrams may be used in fault tree work, through the techniques developed by Lapp and Powers. Only simple systems are considered. Systems involving combinational logic only are discussed and, a sequential logic system in which one or more events cannot occur until one or more previous events are completed is examined.
DOE
Complex Systems; Failure Analysis; Logic Design; Probability Theory; Trees (Mathematics)

19800055379
Reliability analysis of an extreme ultraviolet spectrometer for space research
Chakrabarti, S., California, University, USA; Space Science Instrumentation; Jun 1, 1980; 5, pp. June 198; In English; p. 137-150
Contract(s)/Grant(s): DAAG29-77-C-0031; Copyright; Avail: Issuing Activity
    The method of fault tree analysis designed to assess the reliability of complex systems is applied to an extreme ultraviolet spectrometer for satellite-borne observations. A fault tree is a logic diagram describing critical occurrences which have relevance to the failure of a system. A critical occurrence is represented by an event (e.g., a component state), and a combination of several events is represented by a gate (e.g., AND, OR). The tree consists of primary events, secondary events, and logic gates. A major

goal of fault tree analysis is to calculate the probability of occurrence of the top event. A one-year lifetime has been predicted for the spectrometer on the basis of the analysis.
AIAA
Complex Systems; Reliability Analysis; Satellite Observation; Satellite-Borne Instruments; Systems Analysis; Ultraviolet Spectrometers

19830015988 Design Sciences, Inc., Sewickley, PA, USA
Fault tree analysis report
Powers, G. J., Design Sciences, Inc., USA; Lapp, S. A., Design Sciences, Inc., USA; Jun 1, 1982; 156p; In English
Contract(s)/Grant(s): DE-AC02-80CH-10047
Report No.(s): DE82-020754; DOE/CH-10047/4; Avail: CASI; A08, Hardcopy; A02, Microfiche
        Safety and reliability fault trees for the coal gasification process development unit (PDU) were constructed. Detailed fault trees with probability and failure rate calculations were generated for the events: fatality due to explosion, fire, toxic release or asphyxiation at the PDU coal gasification process; and loss of availability of the PDU. The trees were synthesized and subjected to multiple reviews. The steps involved in hazard identification and evaluation, fault tree generation, probability assessment, and design alteration are presented. The fault trees, cut sets, failure rate data and unavailability calculations are included.
DOE
Coal Gasification; Fault Trees; Pilot Plants

19830070167 Japan Atomic Energy Research Inst., Div. of Reactor Engineering., Ibaraki, Japan
Study on the scope of fault tree method applicability
Ito, T., Japan Atomic Energy Research Inst., Japan; Mar 1, 1980; 29p; In Japanese
Report No.(s): JAERI-M-8754; Avail: CASI; A03, Hardcopy; Avail: CASI HC A03/; A01, Microfiche; US Sales Only
        No abstract.
Fault Trees; Nuclear Reactors; Reactor Safety; Reliability Analysis

19980046696
Improved efficiency in qualitative fault tree analysis
Sinnamon, R. M., Loughborough Univ. of Technology, UK; Andrews, J. D.; Quality and Reliability Engineering International; September-October, 1997; ISSN 0748-8017; Volume 13, no. 5, pp. 293-298; In English; Copyright; Avail: Issuing Activity
        The fault tree diagram itself is an excellent way of deriving the failure logic for a system and representing it in a form is ideal for communication to managers, designers, operators, etc. Since the method was first conceived, algorithms to derive the minimal cut sets have worked directly with the fault tree diagram using either bottom-up or top-down approaches. These conventional techniques have several disadvantages when it comes to analyzing the fault tree. For complex systems an analysis may produce hundreds of thousands of minimal cut sets, the determination of which can be a very time-consuming process. Also, for large fault trees it may not be possible to evaluate all minimal cut sets, so methods to identify those event combinations which provide the most significant contributions to the system failure are evoked. Such methods include probabilistic or order culling to reduce the problem to a practical size, but they can also create considerable inaccuracies when it comes to evaluating top event probability parameters. This paper describes how the binary decision diagram method can be employed to evaluate the minimal cut sets of a fault tree efficiently and without the need to use approximations such as order culling.
Author (EI)
Fault Trees; Qualitative Analysis; Quantitative Analysis; Failure Analysis; Decision Theory; Reliability; Boolean Functions; Binary Codes

19980046697
Improved accuracy in quantitative fault tree analysis
Sinnamon, R. M., Loughborough Univ. of Technology, UK; Andrews, J. D.; Quality and Reliability Engineering International; September-October, 1997; ISSN 0748-8017; Volume 13, no. 5, pp. 285-292; In English; Copyright; Avail: Issuing Activity
        The fault tree diagram defines the causes of the system failure mode or 'top event' in terms of the component failures and human errors, represented by basic events. by providing information which enables the basic event probability to be calculated, the fault tree can then be quantified to yield reliability parameters for the system. Fault tree quantification enables the probability of the top event to be calculated and in addition its failure rate and expected number of occurrences. Importance measures which signify the contribution each basic event makes to system failure can also be determined. Owing to the large number of failure combinations (minimal cut sets) which generally result from a fault tree study, it is not possible using conventional techniques

to calculate these parameters exactly and approximations are required. The approximations usually rely on the basic events having a small likelihood of occurrence. When this condition is not met, it can result in large inaccuracies. These problems can be overcome by employing the binary decision diagram (BDD) approach. This method converts the fault tree diagram into a format which encodes Shannon's decomposition and allows the exact failure probability to be determined in a very efficient calculation procedure. This paper describes how the BDD method can be employed in fault tree quantification.
Author (EI)
Fault Trees; Quantitative Analysis; Failure Analysis; Decision Theory; Reliability; Boolean Functions; Binary Codes

19990004494
New approaches to evaluating fault trees
Sinnamon, R. M., Loughborough Univ. of Technology, UK; Andrews, J. D.; Reliability Engineering & System Safety; Nov, 1997; ISSN 0951-8320; Volume 58, no. 2, pp. 89-96; In English; 1995 ESREL Conference, Jun., 1995, Bounemouth, UK; Copyright; Avail: Issuing Activity

Fault Tree Analysis is now a widely accepted technique to assess the probability and frequency of system failure in many industries. For complex systems an analysis may produce hundreds of thousands of combinations of events which can cause system failure (minimal cut sets). The determination of these cut sets can be a very time consuming process even on modern high speed digital computers. Computerised methods, such as bottom-up or top-down approaches, to conduct this analysis are now so well developed that further refinement is unlikely to result in vast reductions in computer time. It is felt that substantial improvement in computer utilisation will only result from a completely new approach. This paper describes the use of a Binary Decision Diagram for Fault Tree Analysis and some ways in which it can be efficiently implemented on a computer. In particular, attention is given to the production of a minimum form of the Binary Decision Diagram by considering the ordering that has to be given to the basic events of the fault tree.
Author (EI)
Fault Trees; Failure Analysis; Probability Theory; Digital Computers; Decision Theory; Binary Data; Sequencing

19990074565
Failure fundamentals
Mostia, William L.; Control (Chicago, Ill); Oct, 1998; ISSN 1049-5541; Volume 11, no. 10; 4p; In English; Copyright; Avail: Issuing Activity

This article is the third in a series of three that discuss failures of measurement, automation, and process control equipment and systems (herein referred to as instruments). In August, Part I covered types of failures and failure phases in the instrument lifecycle. In September, Part II explained random, systematic, and common cause failures.
Author (EI)
Errors; Process Control (Industry); Random Processes

65
STATISTICS AND PROBABILITY

Includes data sampling and smoothing; Monte Carlo method; time series and analysis; and stochastic processes.

19680072678 University of Southern California, Aerospace Safety Div., Los Angeles, CA, USA
Observations relative to fault tree analysis
Miller, C. O., University of Southern California, USA; Oct 1, 1965; 11p; In English; Avail: CASI; A03, Hardcopy, Unavail. Microfiche
No abstract.
Accident Prevention; Safety Factors; System Failures; Systems Analysis

19690072936 Boeing Co., Airplane Group., Seattle, WA, USA
Introduction to fault tree analysis
Feutz, R. J., Boeing Co., USA; Tracy, J. P., Boeing Co., USA; Sep 1, 1965; 32p; In English
Report No.(s): D6-16182; Avail: CASI; A03, Hardcopy, Unavail. Microfiche
No abstract.
Aircraft Industry; Error Analysis; Trees (Mathematics); Utilization

19790031380
Fault tree analysis with probability evaluation
Proctor, C. L.; Kothari, A. M., Western Michigan University, USA; Proctor, C. L., II, Purdue University, USA; Jan 1, 1978; 6p; In English; Annual Reliability and Maintainability Symposium, January 17-19, 1978, Los Angeles, CA; See also A79-15351 04-38; Copyright; Avail: Issuing Activity

This paper presents the fault tree analysis with probability evaluation by use of Boolean logic. It provides an all inclusive, versatile mathematical tree for analyzing gate and/or gate operations. The construction criteria and the probability evaluation methods of fault trees are briefly discussed. The reliability equations of the basic logic units of the tree are presented. The probability evaluation by use of Boolean logic has been discussed for generating the minimal cut sets of a fault tree containing repetitions of basic events and is illustrated by means of a sample fault tree. The MTBF (mean time between failure) evaluation with use of the reliability approach are illustrated by means of simple example. The paper treats the simple series structure and the parallel structure. For each, the probability of success and probability of failure are derived.
AIAA
Boolean Functions; Logical Elements; Probability Theory; Reliability Analysis; Set Theory

19800037900
Inverting and minimizing Boolean functions, minimal paths and minimal cuts - Noncoherent system analysis
Locks, M. O., Oklahoma State University, USA; IEEE Transactions on Reliability; Dec 1, 1979; R-28, pp. Dec. 197; In English; p. 373-375; Copyright; Avail: Issuing Activity
No abstract.
Boolean Functions; Computer Aided Design; Fault Trees; Reliability Analysis; Systems Analysis

19800064633
Uncertainty propagation in fault-tree analysis
Colombo, A. G., Commission of the European Communities, Joint Research Centre, Italy; Jan 1, 1980; 9p; In English; Synthesis and analysis methods for safety and reliability studies, July 3-14, 1978, Urbino, Italy; Sponsored by In: Synthesis and analysis methods for safety and reliability studies; Proceedings of the Advanced Study Institute; See also A80-48801 21-38; Copyright; Avail: Issuing Activity

Various methods for investigating the propagation of uncertainty from the lower level (primary event) to the higher level of a complex system in a fault-tree analysis are discussed with reference to a sample 750 failure mode fault-tree. It is shown that the problem of uncertainty analysis requires further research, particularly in the nuclear field where the error factor of failure parameter distribution is large. A numerical code which systematically combines random variables is found to be an efficient tool in this task, at least for numerical calculations.
AIAA
Complex Systems; Fault Trees; Probability Theory; Reliability Analysis; Stochastic Processes

19860037128
Confidence intervals for top event unavailability - A problem of Bayesian statistics
Clarotti, C. A., Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative, Italy; Contini, S., SYRECO, Italy; Jan 1, 1984; 4p; In English; See also A86-21851; Avail: Issuing Activity

The problem of propagating uncertainties through a fault tree is framed into a Bayesian statistics context and in that view pre-existing approaches are analyzed and criticized. The question is examined of the relationship between uncertainty propagation and the probabilistics cut-off.
AIAA
Availability; Bayes Theorem; Confidence Limits; Fault Trees; Reliability Analysis

19880014137 Technische Hogeschool, Delft, Netherlands
Fault tree analysis and synthesis
Bossche, Adrianus, Technische Hogeschool, Netherlands; Jan 1, 1987; 176p; In English; Avail: CASI; A09, Hardcopy; A02, Microfiche

The Top-Event's Frequency Algorithm for evaluating the top-event's failure frequency of fault trees containing mutually exclusive failure modes of multi-state components is derived. The System Interstate Frequency Algorithm to evaluate the state probabilities and interstate frequencies of a (sub)system from which the (sub)system's transition rates can be found easily is introduced. This latter algorithm allows a recursive calculation of system state frequencies and transition rates, i.e., the probability

and frequency data of subsystem performance are calculated prior to the evaluation of the probability and frequency data of the system using the same algorithm for all steps. Component models that show all fault propagation through the components and fault initiation by the components in both directions (upstream and downstream) are outlined. It is shown how to create system models that interconnect system components and environmental variables. A fault tree construction algorithm to generate fault trees from the given system and component models is presented. A real-time fault location algorithm to extract all faults and fault combinations that are most consistent with the set of measured variables, even when sensor circuits provide faulty information, is shown.
ESA
Failure Analysis; Fault Trees; Systems Analysis

19920051717 NASA Lewis Research Center, Cleveland, OH, USA
Structural system reliability calculation using a probabilistic fault tree analysis method
Torng, T. Y., NASA Lewis Research Center, USA; Wu, Y.-T., NASA Lewis Research Center, USA; Millwater, H. R., Southwest Research Institute, USA; Jan 1, 1992; 11p; In English; 33rd; AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Apr. 13-15, 1992, Dallas, TX, USA; See also A92-34332
Contract(s)/Grant(s): NAS3-24389
Report No.(s): AIAA PAPER 92-2410; Copyright; Avail: Issuing Activity
    The development of a new probabilistic fault tree analysis (PFTA) method for calculating structural system reliability is summarized. The proposed PFTA procedure includes: developing a fault tree to represent the complex structural system, constructing an approximation function for each bottom event, determining a dominant sampling sequence for all bottom events, and calculating the system reliability using an adaptive importance sampling method. PFTA is suitable for complicated structural problems that require computer-intensive computer calculations. A computer program has been developed to implement the PFTA.
AIAA
Fault Trees; Probability Density Functions; Reliability Analysis; Structural Failure; Structural Stability

19950042913
MetaPrime: An interactive fault-tree analyzer
Coudert, Olivier, DEC Paris Research Lab, USA; Madre, Jean Christophe; IEEE Transactions on Reliability; March 1994; ISSN 0018-9529; 43, 1, pp. 121-127; In English; Copyright; Avail: Issuing Activity
    The performances of almost all available fault-tree analysis tools are limited by the performance of their prime-implicant computation procedure. All these procedures manipulate the prime implicants of the fault-trees in extension, so that the analysis costs are directly related to the number of prime implicants to be generated, which in practice makes these tools difficult to apply on fault-trees with more than 20 000 prime implicants. This paper introduces an analysis method of coherent as well as noncoherent fault-trees that overcomes this limitation because its computational cost is related to neither the number of basic events, nor the number of gates, nor the number of prime implicants of these trees. We present the concepts underlying the prototype tool MetaPrime, and the experimental results obtained with this tool on real fault-trees. These results show that these concepts provide complete analysis in seconds on fault-trees that no previously available technique could ever even partially analyze, for instance noncoherent fault-trees with more than 10(exp 20) prime implicants. These concepts can also be used to analyze event-trees because such trees denote Boolean functions on which these concepts can be applied. Prime implicant computation is also critical in many other domains, in particular in expert-system applications such as reasoning maintenance and multiple fault diagnosis. The application of the concepts underlying MetaPrime to the resolution of these problems is under study.
Author (EI)
Boolean Functions; Computation; Costs; Domains; Error Analysis; Fault Trees; Maintenance; Prototypes

19980060345
Hierarchical analysis of fault trees with dependencies, using decomposition
Anand, Anju, Boeing Co., USA; Somani, Arun K., Iowa State Univ., Ames; 1998, pp. 69-75; In English; Copyright; Avail: Aeroplus Dispatch
    We demonstrate a decomposition scheme where independent subtrees of a fault tree are detected and solved hierarchically; a subtree is replaced by a single event in the parent tree whose probability of occurrence represents the probability of the

occurrence of the subtree. The decomposition and hierarchical solution can be more useful in case of fault trees with dependences. Instead of solving the whole system as a Markov model, only the appropriate subsystem needs to be analyzed as a Markov model.
Author (AIAA)
Fault Trees; Markov Chains; Reliability Analysis; Probability Theory

19980228485 Research Inst. of National Defence, Avd. foer Vapen och Skydd, Tumba, Sweden
Assessment of Effect and Vulnerability Vaerdering av Verkan och Sarbarhet
Wijk, G., Research Inst. of National Defence, Sweden; Mar. 1998; 50p; In Swedish
Report No.(s): PB98-171002; FOA-R-97-00594-310-SE; No Copyright; Avail: Issuing Activity (Natl Technical Information Service (NTIS)), Microfiche
    The Computer programs APAS, LMP3 and VERKSAM/VERANA are described in principle. The report is the documentation of a course held at the Swedish Defense Academy in spring 1997.
NTIS
Vulnerability; Computer Programs; Damage Assessment; Computerized Simulation

19990067887
Constrained mathematics evaluation in probabilistic logic analysis
Arlin Cooper, J., Sandia Natl. Lab., USA; Reliability Engineering & System Safety; Jun, 1998; ISSN 0951-8320; Volume 60, no. 3, pp. 199-203; In English; Copyright; Avail: Issuing Activity
    A challenging problem in mathematically processing uncertain operands is that constraints inherent in the problem definition can require computations that are difficult to implement. Examples of possible constraints are that the sum of the probabilities of partitioned possible outcomes must be one, and repeated appearances of the same variable must all have the identical value. The latter, called the 'repeated variable problem', will be addressed in this paper in order to show how interval-based probabilistic evaluation of Boolean logic expressions, such as those describing the outcomes of fault trees and event trees, can be facilitated in a way that can be readily implemented in software. We will illustrate techniques that can be used to transform complex constrained problems into trivial problems in most tree logic expressions, and into tractable problems in most other cases.
Author (EI)
Boolean Algebra; Reliability

19990108384
Fault tree developed by an object-based method improves requirements specification for safety-related systems
Cepin, Marko, Jozef Stefan Inst., Slovenia; Mavko, Borut; Reliability Engineering & System Safety; Feb, 1999; ISSN 0951-8320; Volume 63, no. 2, pp. 111-125; In English; Copyright; Avail: Issuing Activity
    Fault tree analysis is frequently used to improve system reliability and safety. to be suitable for analysis of software in computerised safety-related systems, it has to be modified accordingly. This paper presents a new application: the fault trees developed by an object-based method. The object-based method integrates structural and behavioral models of a system. The developed fault tree includes information on structure and the failure behaviors of classes of the system. Away from traditional use of the fault tree, which for traditional systems emphasises qualitative and quantitative results, the result of the new application emphasises the process of fault tree development and its qualitative results. Such fault tree application reduces the probability of failures in the requirements specification phase within the software life cycle, which increases the reliability of its product; however, it does not confirm this in a quantitative manner.
Author (EI)
Accident Prevention; Standards; Reliability; Computer Programs

19990109070
Design of reliable systems using static & dynamic fault trees
Ren, Yansong, Univ. of Virginia, USA; Dugan, Joanne Bechta; IEEE Transactions on Reliability; Sep, 1998; ISSN 0018-9529; Volume 47, no. 3 pt 1, pp. 234-244; In English; Copyright; Avail: Issuing Activity
    A genetic algorithm (GA) is embedded into a fault tree method to determine the heuristic optimal design configuration of a reliable system. For optimization, a fault tree which can represent the failure causes of potential designs is used. Several techniques to accelerate the optimization process are implemented which appreciably reduce the calculation time.
EI
Reliability; Genetic Algorithms; Heuristic Methods; Optimization

Includes mathematical modeling of systems; network analysis; mathematical programming; decision theory; and game theory.

19750024786 California Univ., Operations Research Center., Berkeley, CA, USA
Computerized fault tree analysis: TREEL and MICSUP
Pande, P. K., California Univ., USA; Spector, M. E., California Univ., USA; Chatterjee, P., California Univ., USA; Apr 1, 1975; 57p; In English
Contract(s)/Grant(s): N00014-69-A-0200-1070; NR PROJ. 042-238
Report No.(s): AD-A010146; ORC-75-3; Avail: CASI; A04, Hardcopy; A01, Microfiche

Fault tree analysis has proven to be extremely useful in studying large scale systems in both industry and research. Due to the size and complexity of most trees, it has been necessary to develop computer programs for efficient analysis. Vessely and Narum developed a computer package called PREP and KITT in 1970. In 1974, Fussell, Henry and Marshall produced a program called MOCUS. The computer programs presented in this paper perform functions similar to the PREP and MOCUS codes, though the methodology and efficiency are greatly advanced. In addition, this paper provides a basic understanding of the terminology and concepts of fault trees, discusses planned objectives, and gives some insight into a topic called Tree Trimming. All concepts and explanations are illustrated by example.
DTIC
Computer Programs; Systems Analysis; Trees (Mathematics)

19770033878
Fault tree graphics - Application to system safety
Wynholds, H. W.; Porterfield, W. R.; Bass, L., Lockheed Missiles and Space Co., Inc., USA; Jan 1, 1976; 14p; In English; 2nd; International System Safety Conference, July 21-25, 1975, San Diego, CA; See also A77-16726 05-31; Avail: Issuing Activity

Fault tree analysis is an engineering modeling and evaluation technique. Its primary use has been in the areas of system safety and reliability, although its application is conceptually much broader. Fault Tree Graphics is an operational system that enables the user, through an interactive graphics terminal, to construct, modify, analyze and store fault trees. Included is a discussion of how this technique can be applied to System Safety.
AIAA
Computer Graphics; Design Analysis; Failure Analysis; Reliability Analysis; Safety Management; Trees (Mathematics)

19820029589
Performance evaluation of systems that include fault diagnostics
Walker, B. K., Case Western Reserve University, USA; Jan 1, 1981; 5p; In English; In: Joint Automatic Control Conference, June 17-19, 1981, Charlottesville, VA; See also A82-13076 03-63; Copyright; Avail: Issuing Activity

The development of numerous methods for automatically diagnosing faults in complex systems leads naturally to the design problem of choosing the best method and the best design parameters for a particular system. This paper addresses the problem of efficiently evaluating the performance of systems which include automatic fault diagnostics. The analytical methods discussed rely on the construction of generalized Markovian models for the evolution of the status of the system. Emphasis is placed on evaluating the standard reliability measure of the system, but other performance measures that can be generated are also suggested.
AIAA
Complex Systems; Failure Analysis; Fault Trees; Markov Processes; Performance Prediction; Reliability Analysis; System Failures

19830041492
An analytic method for uncertainty analysis of nonlinear output functions, with applications to fault-tree analysis
Cox, D. C., Battelle Columbus Laboratories, USA; IEEE Transactions on Reliability; Dec 1, 1982; R-31, pp. Dec. 198; In English; p. 465-468
Contract(s)/Grant(s): NRC-04-76-293-08; Copyright; Avail: Issuing Activity

An analytic method is developed for the uncertainty analysis of the output of a complex model. The inputs of the model are assumed to be s-independent random variables and the model output is given as an analytic though possibly nonlinear function of the inputs. A method is formulated for partitioning the variance of the output among contributing causes. The most important contributors to the output uncertainty are identified by such a partitioning and therefore it provides an effective way of reducing that uncertainty. An example of the use of this method is given by applying it to the uncertainty analysis of fault trees. In addition,

it is suggested that this method could be applied to large computer codes where output cannot be represented as an analytic function of output, although considerable computation would likely be required in such cases for the evaluation of the conditional s-expectations.
AIAA
Complex Systems; Fault Trees; Nonlinear Systems; Probability Theory

19850050429
Boolean difference techniques for time-sequence and common-cause analysis of fault-trees
Moret, B. M. E., New Mexico, University, USA; Thomason, M. G., Tennessee, University, USA; IEEE Transactions on Reliability; Dec 1, 1984; ISSN 0018-9529; R-33, pp. 399-405; In English
Contract(s)/Grant(s): N0014-78-C-0311; Copyright; Avail: Issuing Activity

Fault trees are a major model for the analysis of system reliability. In particular, Boolean difference methods applied to fault trees provide a widely used measure of subsystem criticality. This paper generalizes the fault-tree model to time-varying systems and uses time-dependent Boolean differences to analyze such systems. In particular, suitable partial Boolean differences provide maximal and minimal solution sets for sensitization conditions. A method of common-cause failure analysis based on partial time-dependent Boolean differences allows the study of failures due to repeated occurrences, at different times, of the same phenomenon. Such methods generalize to systems with repair, and under certain assumptions of independence, steady-state distributions can be used for the analysis of system faults. These methods are generally useful in reliability and sensitivity analysis.
AIAA
Boolean Algebra; Differences; Failure Analysis; Fault Trees; Reliability Analysis

19900019826 Draper (Charles Stark) Lab., Inc., Cambridge, MA, USA
Model authoring system for fail safe analysis
Sikora, Scott E., Draper (Charles Stark) Lab., Inc., USA; Aug 1, 1990; 65p; In English
Contract(s)/Grant(s): NAS2-12451; RTOP 505-68-27
Report No.(s): NASA-CR-4317; H-1620; NAS 1.26:4317; Avail: CASI; A04, Hardcopy; A01, Microfiche

The Model Authoring System is a prototype software application for generating fault tree analyses and failure mode and effects analyses for circuit designs. Utilizing established artificial intelligence and expert system techniques, the circuits are modeled as a frame-based knowledge base in an expert system shell, which allows the use of object oriented programming and an inference engine. The behavior of the circuit is then captured through IF-THEN rules, which then are searched to generate either a graphical fault tree analysis or failure modes and effects analysis. Sophisticated authoring techniques allow the circuit to be easily modeled, permit its behavior to be quickly defined, and provide abstraction features to deal with complexity.
CASI
Artificial Intelligence; Computer Programs; Expert Systems; Fail-Safe Systems; Failure Modes; Flight Control; Knowledge Bases (Artificial Intelligence); Object-Oriented Programming

19980120605
Fault tree analysis and binary decision diagrams
Sinnamon, Roslyn M., Loughborough Univ. of Technology, UK; Andrews, John D., Loughborough Univ. of Technology, UK; 1996, pp. 215-222; In English; Copyright; Avail: Aeroplus Dispatch

The paper describes the use of a binary decision diagram for fault tree analysis and ways in which it can be efficiently implemented on a computer. Results to date show a substantial improvement in computational effort for large complex fault trees analyzed by this method in comparison with the traditional approach. The binary decision diagram method has the additional advantage that approximations are not required and that exact calculations for the top event parameters can be performed.
Author (AIAA)
Fault Trees; Reliability; Industrial Plants; Decision Theory

19980120607
Facilitating fault tree preparation and review by applying complementary event logic
Burkett, Michael A., Allison Engine Co., USA; 1996, pp. 223-228; In English; Copyright; Avail: Aeroplus Dispatch

This paper describes a simple analysis and documentation procedure which can help ensure the completeness and accuracy of fault tree analysis and thus help assure the safety of the corresponding product or system. With this procedure, each layer of the fault tree which feeds into an OR gate is structured to comprise a complete theoretical set. This is done, generally, by first including the most significant or most obvious failure contributor, and then using complementary event logic to define a second

failure contributor which includes all possibilities except the one already covered. Fault trees prepared in this way are inherently complete and more amenable for review.
Author (AIAA)
Fault Trees; Logical Elements; Software Development Tools; Gates (Circuits)

19980229866
Redundancy killers
Yellman, Ted W., Boeing Commercial Airplane Group, USA; 1998, pp. 33-43; In English
Report No.(s): SAE Paper 981204; Copyright; Avail: Aeroplus Dispatch

This paper clarifies the concepts of unrelated, related (both cascading/consequential and common-external-cause), independent, and dependent, failure pairs, and their connections and their differences. It shows how the possibility of occurrence of a related failure pair in a real-life system results in a dependent failure pair in an analysis, and why and how much system safety can be degraded as a result. Methods are presented to help assess the degree of safety degradation which the possibility of related failure pairs can introduce into a system, so that their impacts can be reduced or even eliminated. The event-sequence analysis method is used to illustrate the principles discussed. The paper finishes up with some observations and cautions about using fault-tree analysis to assess the safety of systems in which related failure pairs can occur.
Author (AIAA)
Safety; Redundancy; System Failures; Fault Trees; Systems Analysis

19980236501 Army Research Lab., Human Research and Engineering Directorate, Aberdeen Proving Ground, MD USA
Fault Tree Analysis of Bradley Linebacker *Final Report, Jun. - Sep. 1996*
Jul. 1998; 47p; In English
Report No.(s): AD-A352536; ARL-TR-1716; No Copyright; Avail: CASI; A03, Hardcopy; A01, Microfiche

This report presents a version of the degraded states (DS) methodology, concentrating on the logic used within fault trees. This methodology was the basis for the system analysis conducted on the Bradley Linebacker. This methodology and analysis were documented within the System Analysis Report (SAR) of J. F. Meyers, B. G. Ruth, and R. W. Kunkel entitled, "Survivability/Lethality Analysis Report for the Bradley Linebacker," from the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD in October 1996, in support of the U.S. Army Operational Evaluation Command (OEC) in the preparation of the System Evaluation Report (SER). The Bradley Linebacker is an enhancement to the Bradley Fighting Vehicle (M2A2) with the ability to select targets, automatically track targets, and launch Stinger missiles. This is the first integrated system performed on any system where synergy of different battlefield threats was considered.
DTIC
Guidance (Motion); Missiles; Automatic Test Equipment; Combat; Rocket Vehicles; Trees (Mathematics); Fault Trees

19990064882
Implicit method for incorporating common-cause failures in system analysis
Vaurio, Jussi K., Lappeenranta Univ. of Technology, Finland; IEEE Transactions on Reliability; Jun, 1998; ISSN 0018-9529; Volume 47, no. 2, pp. 173-180; In English; Copyright; Avail: Issuing Activity

A general procedure incorporates common-cause (CC) failures into system analysis by an implicit method; ie, after first solving the system probability equation without CC failures. Components of subsets are assumed to be equally vulnerable to CC of any particular multiplicity. The method allows for age-dependent hazard rates, repairable & non-repairable components, systems with multiple CC groups, and systems where not all components are statistically-identical or subject to CC failures. Key equations are given both for reliability block-diagrams and fault-trees (success and failure models), considering the system reliability, availability, and failure intensity functions. Initial failures and certain human errors are included, mainly for standby-system applications. The implicit method can dramatically simplify the Boolean manipulation and quantification of fault trees. Possible limitations & extensions are discussed.
Author (EI)
Systems Analysis; Probability Theory; Computation; Statistical Analysis

Includes atomic and molecular structure, electron properties, and atomic and molecular spectra. For elementary particle physics see 73 Nuclear Physics.

19690026587 Douglas United Nuclear, Inc., Richland, WA, USA
Computer program for fault tree analysis
Crosetti, P. A., Douglas United Nuclear, Inc., USA; Apr 1, 1969; 29p; In English
Report No.(s): DUN-5508; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Computer program for fault tree analysis on critical reactor systems
CASI
Computer Programs; Critical Mass; Failure Analysis; Reactor Safety

19990101080
FuzzyFTA: A fuzzy fault tree system for uncertainty analysis
Guimarees, Antonio C. F., Nuclear Energy Natl. Commission, Brazil; Ebecken, Nelson F. F.; Annals of Nuclear Energy; Apr, 1999; ISSN 0306-4549; Volume 26, no. 6, pp. 523-532; In English; Copyright; Avail: Issuing Activity
    This paper describes a new approach and new computational system, FuzzyFTA, for reliability analysis using fault tree and fuzzy logic. Some measures are defined to determine critical components and the uncertainty contribution of each one to the system. The FuzzyFTA system includes algorithms to consider the minimal cut set approach for the top event calculation. After that, these algorithms are used to determine importance measures. The computer code application is the Auxiliary Feedwater System (AFWS) analysis, a recent study made for Angra-I, Brazilian NPP.
Author (EI)
Fuzzy Sets; Reliability; Algorithms

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NUCLEAR PHYSICS

Includes nuclear particles; and reactor theory. For space radiation see 93 Space Radiation. For atomic and molecular physics see 72 Atomic and Molecular Physics. For elementary particle physics see 77 Physics of Elementary Particles and Fields. For nuclear astrophysics see 90 Astrophysics.

19780017927 Addis Translations International, Portola Valley, CA, USA
Evaluation of the safety of storing radioactive wastes in geological formations: A preliminary application of the fault tree analysis to salt formations
Bertozzi, G., Addis Translations International, USA; Dalessandro, M., Addis Translations International, USA; Girardi, F., Addis Translations International, USA; Vanossi, M., Addis Translations International, USA; Oct 24, 1977; 23p; Transl. into ENGLISH from French Report; In English; Workshop on Risk Analysis and Geol. Modelling, 23 May 1977, Ispra, Italy
Report No.(s): BNWL-TR-272; CONF-770565-2; Avail: CASI; A03, Hardcopy; A01, Microfiche
    Two imaginary formations were selected: salt bed and salt dome. Hypotheses on their stratigraphic, hydrologic, and geomorphologic conditions were made. Fault tree analysis was used on the various groups of phenomena which could cause the geological barrier to fail. The types of failures and their probabilities were evaluated on the basis of four time periods (103, 104, 105, 106 years).
ERA
Failure Analysis; Geochemistry; Landforms; Radioactive Wastes; Safety Factors; Sodium Chlorides; Structural Properties (Geology); Waste Disposal

19990010531
Fault-tree analysis of criticality in a pulsed column of a typical reprocessing facility
Nomura, Yasushi, Japan Atomic Energy Research Inst., Japan; Naito, Yoshitaka; Nuclear Technology; Jan, 1998; ISSN 0029-5450; Volume 121, no. 1, pp. 3-13; In English; Copyright; Avail: Issuing Activity
    Scenario identification, preparation of reliability data, and fault-tree construction were conducted for a criticality in a pulsed column of a typical model of a reprocessing facility to find a weak link in the system. The plant system data, the basic reliability data with the fault-tree analysis code FTL, were supplied from NUKEM GmbH, Germany. In this exercise, a low nitric acid concentration in the scrub flow to the pulsed column is initiated by failures of the reagent preparation system of the primary separation

cycle, triggering plutonium accumulation, eventually exceeding the safety limit of the scrub column, and thus a criticality accident occurs. The occurrence frequency was evaluated to be 2.2 x 10(sup -5)/yr for this most conservative case of the accident scenario. The main contributor was investigated by the fault-tree branch analysis and identified to be human error relating to the sampling measurement for fresh nitric acid scrub feed. Because 2.2 x 10(sup -5)/yr is quite a high value in comparison with the generally accepted 10(sup -6)/yr, Monte Carlo uncertainty analysis assuming an error factor of 5 for each of the reliability data was conducted to predict a 90% confidence range of 1.9 x 10(sup -6)/yr to 8.25 x 10(sup -5)/yr. In addition, there might be unforeseen equipment failures related to the same criticality scenario. The additional analysis and discussion lead to the recommendation to adopt shape and dimension control in the design stage for the whole range of plutonium concentrations from a criticality safety point of view.
Author (EI)
Fault Trees; Nuclear Fission; Nuclear Reactors; Nuclear Fuel Reprocessing; Failure Analysis; Accidents

19990100587
Application of fault detection and identification (FDI) techniques in power regulating systems of nuclear reactors
Roy, K., Bhabha Atomic Research Cent., India; Banavar, R. N.; Thangasamy, S.; IEEE Transactions on Nuclear Science; Dec, 1998; ISSN 0018-9499; Volume 45, no. 6 pt 3, pp. 3184-3201; In English; Copyright; Avail: Issuing Activity
    Application of failure detection and identification (FDI) algorithms have essentially been limited to identification of a global fault in the system, and no further attempts have been made to locate subcomponent faults for root cause analysis. This paper presents Kalman filter-based methods for FDI in power regulating systems of nuclear reactors. The attempt here is to explain how the behavior of the states, residues, and covariances can be interpreted to identify subcomponent faults. An alternative to the Kalman filter - the risk-sensitive filter - is also introduced. Comparison of its performance with the Kalman filter-based FDI algorithms is studied. All simulation studies have been carried out on postulated faults in the power regulating system of heavy water moderated, low pressure vertical tank-type research reactors.
Author (EI)
Algorithms; Kalman Filters; Assessments; Risk; Safety; Valves

81
ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

19790030391
Problems in contracting for system safety
Rackley, L. E.; Lemon, G. H., General Dynamics Corp., USA; Jan 1, 1977; 4p; In English; 15th; SAFE Association, Annual Symposium, December 5-8, 1977, Las Vegas, NV; See also A79-14401 03-03; Copyright; Avail: Issuing Activity
    Fault tree analysis is the method used for system hazard analysis, for assessing the safety level of the development aircraft and for predicting the safety level of the production aircraft at maturity. Source data for the fault tree logic diagrams are accumulated with the Subsystem Hazard Analysis (SSHA) program. Hazard analysis data are purchased from subcontractors. The Preliminary Hazard Analysis (PHA) identifies hazards in equipment and the Operating Hazard Analysis (OHA) identifies hazards in software and written instructions. One of the problems encountered in contracting for system safety is related to the failure of some subcontractors to properly identify 'command' failures. Another problem is connected with the failure to identify all part failure modes.
AIAA
Aircraft Safety; Contract Management; Flight Hazards; Safety Management

89
ASTRONOMY

Includes observations of celestial bodies, astronomical instruments and techniques; radio, gamma-ray, x-ray, ultraviolet, and infrared astronomy; and astrometry.

19920008654 NASA, Washington, DC, USA
Hubble Space Telescope: SRM/QA observations and lessons learned
Rodney, George A., NASA, USA; Jan 1, 1990; 27p; In English
Report No.(s): NASA-TM-105505; NAS 1.15:105505; Avail: CASI; A03, Hardcopy; A01, Microfiche
    The Hubble Space Telescope (HST) Optical Systems Board of Investigation was established on July 2, 1990 to review,

analyze, and evaluate the facts and circumstances regarding the manufacture, development, and testing of the HST Optical Telescope Assembly (OTA). Specifically, the board was tasked to ascertain what caused the spherical aberration and how it escaped notice until on-orbit operation. The error that caused the on-orbit spherical aberration in the primary mirror was traced to the assembly process of the Reflective Null Corrector, one of the three Null Correctors developed as special test equipment (STE) to measure and test the primary mirror. Therefore, the safety, reliability, maintainability, and quality assurance (SRM&QA) investigation covers the events and the overall product assurance environment during the manufacturing phase of the primary mirror and Null Correctors (from 1978 through 1981). The SRM&QA issues that were identified during the HST investigation are summarized. The crucial product assurance requirements (including nonconformance processing) for the HST are examined. The history of Quality Assurance (QA) practices at Perkin-Elmer (P-E) for the period under investigation are reviewed. The importance of the information management function is discussed relative to data retention/control issues. Metrology and other critical technical issues also are discussed. The SRM&QA lessons learned from the investigation are presented along with specific recommendations. Appendix A provides the MSFC SRM&QA report. Appendix B provides supplemental reference materials. Appendix C presents the findings of the independent optical consultants, Optical Research Associates (ORA). Appendix D provides further details of the fault-tree analysis portion of the investigation process.
CASI
Aberration; Error Analysis; Hubble Space Telescope; Manufacturing; Mirrors; Quality Control

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GENERAL

Includes aeronautical, astronautical, and space science related histories, biographies, and pertinent reports too broad for categorization; histories or broad overviews of NASA programs such as Apollo, Gemini, and Mercury spacecraft, Earth Resources Technology Satellite (ERTS), and Skylab; NASA appropriations hearings.

19710052620
Status of failure /hazard/ mode and effect analysis, fault tree analysis, and prediction, apportionment and assessment
Grose, V. L.; Jan 1, 1971; 9p; In English; 10TH; RELIABILITY AND MAINTAINABILITY CONFERENCE, JUN. 27-30, 1971, ANAHEIM, CA; CONFERENCE SPONSORED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, THE SOCIETY OF AUTOMOTIVE ENGINEERS, AND THE AMERICAN INST. OF AERONAUTICS AND ASTRONAUTICS.; Copyright; Avail: Issuing Activity
        Fault tree, failure mode and effect analysis, prediction apportionment and assessment, discussing system effectiveness
AIAA
Failure Analysis; Failure Modes; Performance Prediction; System Effectiveness; Trees (Mathematics)

19720065841 Texas A&M Univ., Dept. of Industrial Engineering., College Station, TX, USA
A computer algorithm for fault-tree analysis *Final*
Cannon, J. A., Texas A&M Univ., USA; Dec 1, 1970; 72p; In English
Report No.(s): AD-738977; Avail: CASI; A04, Hardcopy, Microfiche
        No abstract.
Algorithms; Error Analysis; Trees (Mathematics)

19740076158 Picatinny Arsenal, Dover, NJ, USA
Fault tree analysis
Larsen, W. F., Picatinny Arsenal, USA; Jan 1, 1974; 73p; In English
Report No.(s): AD-774843; PA-TR-4556; Avail: CASI; A04, Hardcopy, Microfiche
        No abstract.
Boolean Algebra; Failure Analysis; Ordnance; Probability Theory; Systems Analysis

19770068969 California Univ., Berkeley. Lawrence Berkeley Lab, CA, USA
Fault tree analysis programs available on the 7600/6600 computers
Mcgibbon, A., California Univ., USA; Feb 7, 1973; 40p; In English; Sponsored by ERDA
Report No.(s): TID-26994; Avail: CASI; A03, Hardcopy, Microfiche
        No abstract.
CDC 6600 Computer; CDC 7600 Computer; Trees (Mathematics)

Subject Terms Index

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