

# **2022 13th International Conference on Reliability, Maintainability, and Safety (ICRMS 2022)**

**Kowloon, Hong Kong  
21-24 August 2022**



**IEEE Catalog Number: CFP2262H-POD  
ISBN: 978-1-6654-8691-0**

**Copyright © 2022 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP2262H-POD
ISBN (Print-On-Demand):	978-1-6654-8691-0
ISBN (Online):	978-1-6654-8690-3
ISSN:	2334-0878

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

## Table of Contents

### O - Warranty Models and Analysis

Warranty Cost Models for Products Protected by Lemon Laws Considering Mutual Failure Interaction <i>Fakhri I. ALIFIN, Bermawi P. ISKANDAR, Hennie HUSNIAH</i>	1
Automobile MTBF Evaluation Method Based on Two-dimensional Warranty Data <i>Huan PANG, Dongyang SHI, Zheng GONG</i>	7
Maintenance Decision System Design Based on Equipment Support Data System <i>Chenning LIU, Chang ZHOU, Siyuan CHEN, Hao LI, Xin KONG</i>	12

### A1 - Artificial Intelligence in Reliability and Safety

Research on Feature Selection Method Based on Bayesian Network and Importance Measures <i>Zhiqiang CAI, Chen CHEN, Yuhan WU, Shubin SI, Zhimin GENG, Jingwei ZHANG</i>	18
AtFP: Attention-based Failure Predictor for Extreme-scale Computing <i>Longhao LI, Taieb ZNATI</i>	23
Deployable Lightweight ANN-Based Approach for Wind Turbine Fault Detection <i>Yuewei ZHANG, Qize LIU, Wenxuan LIU, Wenqiang ZHENG</i>	28

### J - Resilience Analysis, Assessment, and Management

Optimal Redundancy Strategy of Defense Resource Allocation for Power Grid System Based on Game Theory Analysis <i>Wei WANG, Yinguo YANG, Jin XING, Zhen YU, Li LI, Yang LIU, Shuangxi WU, Yu ZHU</i>	35
Sensitivity Analysis-based Multi-modal Transportation Network Vulnerability Assessment with Weibit Choice Models <i>Yu GU, Anthony CHEN, Guoyuan LI</i>	40
Accessibility and Vulnerability Analysis of the Integrated Road, High-speed Rail and Airline System in China <i>Wenjing SUN, Hui ZHANG, Min OUYANG</i>	45

### A2 - Artificial Intelligence in Reliability and Safety

Reliability Analysis for Mixture Weibull Distribution with Progressively Censored Data Based on Stochastic Expectation-maximization Method <i>Zhong LU, Yuting WU, Haijing SONG, Jia ZHOU</i>	50
GWO-LSSVM-based Strain Prediction and Importance Analysis for Full-scale Static Testing of Composite Wind Turbine Blades <i>Zheng LIU, Yongjie LI, Zhenfeng HE, Liang TU, Xin LIU</i>	55
Intelligent PHM Based Condition Monitoring in Nuclear Energy Systems <i>Yuantaoyao YAO, Daochuan GE, Jie YU</i>	60

## **L - Statistical Methods for Reliability Prediction**

- An Exploration into the Monitoring Methods for Key Parameters of Servo Drive Unit Based on Control Chart Method 65  
*Libin XIE, Chong PENG, Wenwei LIU*
- An Efficient Metamodel-based Method for Integrating Low-fidelity and High-fidelity Data on Reliability Evaluation 70  
*Bowen LI, Bingyi LI, Xiang JIA, Zhijun CHENG, Bo GUO*

## **K - Software Reliability and Security**

- A Selection Method of Effective Metamorphic Relations 75  
*Dafei HUANG, Meng LI, Shiyu YAN, Helin GONG, Jie HONG, Jie ZHANG*
- A Dynamic Recognition Method of Metamorphic Relation Identification 81  
*Jie HONG, Jie ZHANG, Qi QIU, Meng LI, Angang MA, Shiyu YAN, Helin GONG*
- A Systematic Method for Identifying Safety-related Faults in Formal Specifications Using FTA 87  
*Wen JIANG, Shaoying LIU, Ai LIU*

## **F - Maintenance Models and Analysis**

- Mission Reliability Driven Risk-based Maintenance Approach of Multi-state Intelligent Manufacturing System 93  
*Ruoyu LIAO, Yihai HE, Xin ZHENG, Yuqing ZHANG*
- Joint Predictive Replacement Management and Spare Part Planning of High-speed Railway Bearing Under Bayesian Framework 99  
*Ruoran HAN, Zirong WANG, Longyan TAN, Xiaobing MA, Li YANG, Miaomiao WANG*
- Fuel Cell Stochastic Deterioration Modeling for Energy Management in a Multi-stack System 104  
*Jian ZUO, Christophe BERENQUER, Catherine CADET, Zhongliang LI, Rachid OUTBIB*
- Optimal Ordering and Replacement Scheduling for a Deteriorating System Subject to Shocks 109  
*Wenjie DONG, Min LIU, Sifeng LIU*

## **C1 - Degradation Modeling and Analysis**

- Battery Remaining Useful Life Prediction Based on a Combination of ARMA and Degradation Model 115  
*Ruihua JIAO, Jiping XIAO, L. LI, Xin MA*
- A Mode-based Approach for Lognormal Parameter Estimation on Heavily Censored Data 120  
*Faqun QI, Renyan JIANG, Yu CAO*
- Dynamics Modeling and Simulation of Multi-rotor UAV based on the Composite Wind Field Model 127  
*Jingru WANG, Yang JIANFENG, Yang ZHONGQING*
- Degradation Mechanism and Failure Analysis of Planar Type SiC MOSFETs Under Cyclic Stress of Surge Current 135  
*Yihang LIN, Yiqiang CHEN, Kuiwei GENG, Bo HOU*

A New Method for Deriving Reliability Qualification Test Plans <i>Ping JIANG, Bo WANG, Dian ZHANG, Jianjun QI</i>	140
--	-----

## **C2 - Degradation Modeling and Analysis**

Model and Application of Intelligent Equipment Health Monitoring and Intelligent Warning Based on the Interaction of Virtual Reality <i>Yaohua DENG, Zilin ZHANG, Xiali LIU, Guanhao CHEN, Yujian LU, Qiwen LU</i>	144
---	-----

An Improved FMEA Method Based on Performance Degradation Analysis for Offshore Wind Turbine Blade Trailing Edge <i>Conggui CHEN, Zheng LIU, Zhenfeng HE, Yongjie LI, Liang TU</i>	149
--	-----

A Computationally Efficient Link Criticality Ranking with Perception Error and Route Overlapping for Road Transport Networks <i>Daniyar KURMANKHOJAYEV, Guoyuan LI, Anthony CHEN</i>	154
---	-----

## **D - Failure Analysis and Physics of Failures**

Reliability Analysis for Aero Engine Gear Considering Dependence of Multiple Failure Modes Based on Copula <i>Ning LU, Yan-Feng LI, Tudi HUANG, Hong-Zhong HUANG</i>	159
---	-----

Failure Mode, Mechanism, and Effect Analysis of Visible Light Camera in an Optoelectronic Pod <i>Ying ZENG, Ruishu HUANG</i>	164
---	-----

Utilisation of Fuzzy Fault Tree Analysis for Risk Assessment of Offshore Wind Farm Construction <i>Junhui ZHANG, Yanjie WANG, Ziming SHI, Yongqiang SUN</i>	169
--	-----

A Research of a Modified Bearing Fault Diagnosis Model Based on Deformable Atrous Convolution and Squeeze-and-Excitation Aggregation <i>Yang YU, Ziyi CHEN, Xia FANG, DingCheng ZHANG, Zhe WANG</i>	174
--	-----

## **G3 - Prognostics and Health Management**

A Hybrid Model for Detecting Satellite Telemetry Data Anomalies <i>Zhaoping XU, Zhijun CHENG, Jiahui HE, Bo GUO</i>	180
--	-----

A Hybrid Approach for Surface Roughness Prediction Based on Multi-domain Feature Fusion and Deep Learning <i>Xiaofeng WANG, Jihong YAN</i>	185
---	-----

Research on Fault Prognostic of Photovoltaic System Based on LSTM-SA <i>Yujie HUANG, Shunong ZHANG, Xin XU</i>	190
---	-----

Sensitive Features Extraction of Wear Monitoring Signals Based on Wavelet Packet Energy Spectrum <i>Weiwei DUAN, Wei DAI, Shi GUO, Wei SHI, Tong LI</i>	196
--	-----

## **B1 - Complex System Reliability**

Reliability Modeling of Bi-directional Circular Multi-State Sliding Window System for Sequential Tasks <i>Wei WANG, Siyuan ZHANG, Peng SI, Mingqiang LIN, Bin MA, Jianfeng LUO</i>	201
---	-----

Study on Standby Hydraulic of Single-heat-source Single-looped District Heating Network 206  
*Ding MAO, Zhizhao HE, Peng WANG, Long NI*

A Specification for Phased-mission System with Redundancy Based on SysML 212  
*Zhengyin YAO, Xinyang WU, Xiaoyue WU*

A Multi-objective Optimization Based Safety Requirement Assignment for Aircraft Systems by Using NSGA-II 218  
*Zhong LU, Lu ZHUANG, Haijing SONG, Jia ZHOU*

### **C3 - Degradation Modeling and Analysis**

Research on Reliability Modeling of Bivariate Correlation Degradation Based on Nonlinear Wiener Process 223  
*Hanrui LI, Guangyan ZHAO, Huimei YAO*

Operational Risk Modeling of CNC Machine Tool Considering Workpiece Quality 228  
*Xin ZHENG, Yihai HE, Ruoyu LIAO, Yuqing ZHANG*

Photovoltaic Systems Degradation Modeling Under Dynamic Environmental Profiles 233  
*Qifang LIU, Qingpei HU, Dan YU*

Reliability Modeling and Analysis of Satellite-based Phased Array Antenna 238  
*Zi-Chen ZHAO, Wen-Bin CHEN, Xiao-Yang LI*

### **H - Reliability and Maintenance Optimization**

Robust Redundancy Allocation by the Min-max Regret Framework and Sequential Two-stage Approach 243  
*Chunyan LING, Jingzhe LEI, Kangzhe HE*

### **B2 - Complex System Reliability**

Reliability Classification Assessment of Logistics Service Capability Based on Universal Generating Function 248  
*Xiaoyue WANG, Ruoxi ZHOU, Ru NING*

Research on Smart Meter Prognostics and Health Management Model Based on Virtual Measurement 253  
*Zhou YANG, Juntao PAN, Xinqiu WEI*

Reliability Evaluation Method of Motorized Spindle Based on Dual-source Data 260  
*Chuanhai CHEN, Zhifeng LIU, Junqi LONG, Jinyan GUO, Baobao QI, Wei LUO, RongHan HU*

### **G1 - Prognostics and Health Management**

Degradation Prognostics of Lithium-ion Batteries Based on Partial Features and Long Short-term Memory Network 265  
*Huixing MENG, Mengyao GENG, Xu AN, Jinduo XING*

A Remaining Useful Life Prediction Framework for Aero-engine Using Information Entropy-based Criterion and PCA-RVM 270  
*Lechang YANG, Xuan LI, Xingchen LIU, Feng ZHU*

Dictionary Based Three-phase Driver MOSFET Cascading Fault Diagnosis 275  
*Chengzhi SUN, Cen CHEN, Xuerong YE, Guofu ZHAI, Dong ZHANG*

Research on Circuit Fault Diagnosis Method Based on Multi-feature Information Fusion 280  
*Xulan ZHU, Weiwei HU, Hui FAN*

### **A3 - Artificial Intelligence in Reliability and Safety**

Reliability Assessment Scheme for Intelligent Autonomous System 285  
*Bin SHANG, Xiaobing LI, Ya MENG, Wenfei WAN, Shuang RONG, Bing MO*

A Semi-supervised Deep Learning Model with Consistency Regularization of Augmented Samples for Imbalanced Fault Detection 290  
*Hao CHEN, Junhua HAN, Xiaomeng LV, Zhenyu WU, Hui Feng GUO, Zhiqiang ZHAN*

Data Augmentation to Improve the Performance of Ensemble Learning for System Failure Prediction with Limited Observations 296  
*Guo SHI, Bin LIU, Lesley WALLS*

### **G2 - Prognostics and Health Management**

A Knowledge Graph-based Link Prediction for Interpretable Maintenance Planning in Complex Equipment 301  
*Liqiao XIA, Pai ZHENG, Shufei LI, Carman LEE, Pin LYU, Jialiang ZHOU, Kaiye WANG*

Mission-oriented Prioritization Method for Health Management Objects of Complex Equipment 306  
*Hao LI, Haotian ZHOU, Chenming LIU, Yang NA, Huixiong WANG, Zeqing LIU*

**Author Index 311**