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Overall Design of Storage Reliability Evaluation System for Large Weaponry

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Abstract: Large weapon equipment has a long construction period, high construction cost, and the storage period occupies the whole life cycle. Therefore, storage reliability is an important tactical indicator of weapon systems. The storage reliability evaluation system is used for data acquisition, state detection, analysis and evaluation during the storage period of equipment, and has important application value for the evaluation of storage reliability. Firstly, the construction requirements of the storage reliability evaluation system are analyzed; Secondly, put forward the technical route and overall architecture of the system construction; Then, the key functional modules of the storage reliability evaluation system are determined. Finally, the full text is summarized.

1. Introduction

Storage reliability is an important tactical and technical index of weapon system, which is used to evaluate the ability of equipment to maintain specified functions within the specified storage period. The construction cycle of large-scale weapons and equipment is long and the construction cost is high. Except for normal training and task execution, the troops are in storage for the rest of the time. The storage period accounts for most of the whole life cycle of large-scale weapons and equipment. In the actual equipment development, the system level storage of large weapons and equipment is constantly checked and evaluated in actual use. Therefore, it is of great practical value to build a storage reliability evaluation system for large-scale weapons and equipment system in the army, evaluate the storage reliability of equipment and find the defects of equipment in storage reliability, so as to improve the comprehensive efficiency of weapons and equipment.

Hu Liangyong et al.[1] explored the storage reliability of armored vehicles and other equipment, and put forward the related problems of armored equipment storage. Liu Yan[2] and others focused on the analysis of the status quo of natural environment test for missile storage, and put forward targeted suggestions for the development of natural environment test technology. Wang Daka[3] and others studied the accelerated storage test and life assessment of electromechanical products and proposed corresponding solutions. Guo Yu[4] and others carried out research on evaluation method based on evidence fusion for storage life of solid rocket motor. In most storage reliability evaluation problems, the acquisition of failure data is a difficult problem. Therefore, the storage reliability evaluation and life evaluation of failure free data have become the key issues that researchers focus on and solve[5-10]. The research on missile storage reliability evaluation is the most extensive[11-12]. The main methods used include Bayesian model[13], degradation failure method[14], accelerated storage test[15,16], etc. The existing research results have a strong guiding significance for the storage reliability evaluation problem, but in practice, the storage reliability evaluation system is also needed as a basis for data collection, analysis, evaluation, etc. of the storage reliability of the equipment in the use phase, and this also needs to be bound with the specific model and composition of the equipment.Based on this, in view of the practical requirements of the storage reliability evaluation of large and complex equipment such as missiles and armored vehicles, this project first analyzes the construction requirements of the large storage reliability evaluation system, then proposes the overall architecture of the storage reliability evaluation system, and then elaborates on the key technologies and functional modules involved in the storage reliability evaluation system. Finally, the full text is summarized.

2. System construction demand analysis

The construction of the storage reliability evaluation system of large-scale weapons and equipment is mainly oriented to the army, which solves the practical problems of management, monitoring, maintenance, condition evaluation, etc. during the storage period of equipment. On the one hand, the construction of the system needs to solve the reliability evaluation problem and give the reliability index of the equipment, on the other hand, it also needs to record and assist decision-making on the maintenance, replacement and other specific work of the equipment during the storage period. Therefore, the requirements for the construction of the storage reliability evaluation system of large-scale weapons and equipment mainly include the following aspects:

(1) System wide condition monitoring data integration requirements. Under the condition of long-term storage, weapons and equipment will suffer from failures caused by fatigue, aging, wear and other factors, which will lead to partial or overall failure of weapons and equipment. The occurrence of equipment failure usually takes abnormal state parameters as a precursor, so it is necessary to establish real-time or regular monitoring of key state parameters of weapons and equipment, timely and accurately grasp the state and change rules of equipment, and find equipment parameters and abnormal state in advance.

(2) Requirements for system wide fault diagnosis and prediction. During the storage period of weapons and equipment, under the influence of storage environment, working stress, use and maintenance methods and other factors, the internal material performance will change, and the failure modes and mechanisms are complex and diverse, which will seriously affect the combat readiness, operation safety and effectiveness sustainability of the entire system. Therefore, when the key components of the weapon system fail or have fault symptoms, it should be able to carry out fault diagnosis according to the state parameters of the equipment, and make fault prediction according to the change law of the state parameters and the fault law, so as to provide a basis for subsequent operation and maintenance decisions.

(3) Requirements for precision maintenance of the whole system. During the actual storage period of weapons and equipment, the equipment management personnel are generally required to conduct regular maintenance and repair, especially to ensure the integrity of the equipment, the faulty parts and vulnerable parts need to be regularly updated and maintained. Therefore, during the construction of the system, it is necessary to customize relevant functions in combination with the specific work such as equipment maintenance.

(4) Requirements for system wide reliability assessment. There will be integrity and other index

requirements for weapons and equipment during the period, so it is extremely important to evaluate the storage reliability of equipment. The storage reliability evaluation system needs to collect the condition monitoring data of the whole system, evaluate the reliability of key components, and then build the reliability evaluation model of the whole system to realize the reliability evaluation of the equipment system.

3. Overall design scheme of the system

3.1. Technical route of system construction

The construction of the long storage reliability evaluation system for large weapon equipment systems requires the design of equipment management, state monitoring, data preprocessing, model construction, auxiliary decision-making optimization and other technologies. It is a very complex system with high technical requirements. Therefore, the technical route of system construction is determined according to the actual needs of storage reliability evaluation and the actual work.

Firstly, the system structure function decomposition and system task profile division are carried out, and the system structure composition tree is constructed to identify the key equipment that affects the storage reliability; For these equipment, failure mechanism analysis is conducted respectively to determine the reliability evaluation data requirements; Data acquisition methods include collecting on-site monitoring data, reliability test data, digital simulation data, etc; For the reliability information from various sources, data preprocessing is carried out to convert the original information into data available for equipment reliability evaluation.

According to the failure mechanism and data characteristics of various types of equipment, the equipment level storage reliability evaluation is realized by using failure data evaluation model, degradation trajectory evaluation model, model and data mixture model, multi-source information fusion model, storage reliability evaluation model considering maintenance, etc.

According to the reliability relationship between the system and equipment, the logic diagram model of weapon equipment reliability is constructed. Based on the equipment level storage reliability model, the idea of system reliability synthesis is adopted to realize the storage reliability evaluation of weapon equipment, and at the same time, the maintenance strategy formulation during the system storage period is assisted in decision-making.

3.2. System architecture

The system architecture consists of basic environment layer, data interface layer, data management layer, technical support layer and system function layer

(1) Basic environment layer. The basic environment layer refers to the basic software and hardware environment required for building the system. The system includes: database, operating system, server, etc.

(2) Data interface layer. The data interface layer refers to the interface of the system for data interaction. The system includes two types of data interfaces: simulation data interface and real-time data interface. The simulation data interface receives the simulation data generated by the system simulation, and the real-time data interface receives the real-time data generated through sensors, etc.

(3) Data management. The data management layer is used to manage all data of the system. The system data is divided into basic data, dynamic data and decision data.

(4) Technical support layer. The technology support layer includes various technologies required to support the system functions, such as: equipment logic identification, model calculation, data preprocessing, data visualization, etc.

(5) System function layer. The system function layer includes various functions that can be realized by the system. The system includes system management, reliability modeling, failure process simulation, equipment reliability evaluation, system reliability evaluation and other functional modules.

4. Detailed design of system functions

The storage reliability system needs to manage the data of equipment components, and then build a component level reliability analysis model for components, and then build a system level reliability model. It also needs to consider user management issues. Therefore, the main functional modules of the system include: system management, equipment management, component level reliability evaluation, and equipment reliability evaluation.

(1) System management

The system management function is the basis for configuring the basic software configuration, user permissions, user interfaces, system functions, etc. Specifically, it includes system configuration, menu management, user management, role management, authority management, etc.

The system configuration function can manage the version, change, audit, report, etc. of the storage reliability evaluation system. Role management is mainly used to configure the role types of users. Configurable users include system administrators, equipment support personnel, upper level decision makers, etc.. Permission management enables equipment support personnel to authorize by professional system. Different professionals can only see their own professional equipment data, while system administrators, decision makers and engineering designers can see all data. Menu management can create menus for authorized users according to their needs. User management mainly supports adding, modifying, and deleting system users.

(2) Equipment management

Equipment management is the management of basic information such as equipment composition and parameters. It is the most basic function to realize system storage reliability evaluation, including product type management, equipment strength management, equipment monitoring data management, and document management.

Product type management is mainly aimed at the situation that there are many parts of the same type of equipment and multiple equipment are stored at the same time. It abstracts the equipment strength, customizes the abstract classes of equipment parts, and establishes the association relationship for the same type of parts in equipment. Equipment strength management is the materialization of product types and the specific object of equipment management, maintenance, analysis and evaluation. There is a hierarchical relationship among equipment, such as system, subsystem, component, and component. It is necessary to build a tree representation of this relationship. Equipment monitoring data management is mainly based on the parameter configuration in equipment strength management to manage the actual monitoring data of equipment. In this module, it is necessary to combine the actual data acquisition mode, build a data receiving mode matching the data acquisition interface, and realize the online collection, display and storage of equipment monitoring data. The document management mainly realizes the management of various types of documents such as equipment supporting pictures, user manuals, maintenance manuals, etc. The main purpose is to support specific work such as maintenance and use in the storage stage.

(3) Component level reliability assessment

The component level reliability evaluation mainly uses various analysis models and methods to simulate, preprocess, analyze and evaluate the component data. The specific functions include fault data simulation, performance data simulation, data preprocessing, reliability model management and monitoring data analysis.

Fault data simulation is mainly aimed at components that cannot deploy sensors and can only be evaluated by relying on experimental and actual life data. It can simulate the failure data of components, test the reliability evaluation model based on failure data, and provide support for the reliability evaluation of related components. Performance data simulation is mainly based on prior experience simulation to generate performance degradation data of equipment, and verify the reliability evaluation model based on performance degradation data. Data pre-processing is mainly aimed at the possible situation that the sensor will be affected by external random factors, resulting in disturbance or error in the measurement results. A real-time monitoring data pre-processing method is proposed to ensure that the data can truly reflect the status of the equipment. Reliability model management is mainly designed for the actual situation that components of the same type and similar failure process may adopt the same analysis model. Users can select models more independently for different types of components and gradually expand the model. Monitoring data analysis mainly constructs models for monitoring data and usage data of various sensors to analyze and predict the change trend of data.

(4) System level reliability evaluation and maintenance decision

The system level reliability evaluation and maintenance decision-making are mainly oriented to the entire equipment system. Based on the component level reliability evaluation, the reliability model of the entire system is constructed, and then the system is evaluated, including system reliability modeling and system maintenance decision-making.

The system reliability modeling mainly constructs the system level reliability model through the visual mode, including series, parallel, and mixed connection. The system reliability evaluation is mainly based on the component level reliability evaluation results and reliability block diagram to build the system level reliability model and realize the system level storage reliability evaluation.

The system maintenance decision is mainly based on the reliability evaluation results of the system and the reliability evaluation results of the component level to build an opportunity maintenance decision model for the entire system. On the one hand, it needs to replace the failed components, and on the other hand, it needs to carry out joint maintenance for other components with low reliability related to the failed components.

5. Conclusion

Combined with the actual requirements of storage period management of large weapons and equipment, this article analyzes the requirements of the storage reliability evaluation system, puts forward the realization technical route and overall functional architecture of the system construction, and then discusses the design of key core functional modules, which can provide a reference for the construction of the storage reliability evaluation system. As the construction of the system needs to be closely related to the specific equipment and storage process, it is suggested that further in-depth research should be carried out in the future.

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