Maintenance centered matrix-based universal quality characteristics analysis

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Abstract. Maintainability , as an important quality characteristic of the product, always been neglected during the design process, which lead to many problems around products' useage. The main purpose of the Maintenance centered matrix-based Universal quality characteristics analysis is, by determining the qualitative and quantitative relationship between the general quality features, to find the data flow, information flow between the common quality features and maintainability. Focusing on the maintenance process in a typical maintenance task model, the maintenance factors and general quality characteristics involved in the maintenance task model are analyzed, and the quantitative or qualitative correlation between the maintenance factors and the general quality characteristics is obtained. Finally, The maintenance matrix model integrated with maintenance-oriented, integrated maintenance elements, design specialties and design elements is available. By combining maintainability factors(observation, inspection, disassembly, replacement, installation, commissioning) with other related design discipline factors, correlating other design elements with maintainability elements, reaching a systematic trade-off centered on maintainability, which take maintenance of all elements into account, into the pre-design process.

1. Introduction

Maintenance is one of the quality characteristics that given to the product, determined in design stage. The main pursuit of today's product maintainability design is to obtaining high-quality products at the lowest cost. Maintainability is not only an economic indicator for the company, but also an urgent need of consumers.

Maintainability, as a formal concept, comes from the repairing problem of the equipment. The analysis of maintenance influencing factors and product maintenance practices show that the maintenance is convenient, fast, and economical, directly related to certain inherent design features of the product itself. As the complexity of equipment increase, reliability design can't always guarantee the stable operation of the product, and the convenient, fast, economic maintenance can make up for the lack of reliability, playing an important role in improving the integrity of the device

In the light of the existing maintenance design theory and methods, maintainability requirements on product design is still a challenging problem, maintenance requirements are difficult to produce a sufficient constraint on product design. Existing maintenance design theory and methods hardly fully meet the needs of device designers. The maintenance design work mode is passive, the development time lags behind, and it is inconsistent with the development of advanced design and manufacturing technologies. It is difficult to apply maintenance design to the current equipment design and development process and other issues.

At the same time, it is difficult to unify the design criteria due to the lack of communication between design departments, resulting in the lack of a more unified parameter standard transfer relationship during the design process. In the design process, little or no consideration is given to the constraints of other quality characteristics, leading to the insufficient of robustness in the design results and inability to obtain a mature and uniform design result.

International advanced aviation companies have established a similar RMS integrated integration system and have shown initial results, but they still need to improve the systematization, comprehensiveness, depth, and efficiency of the work. Parameter passing and shared mutual relationship between the design process, and the impact of factors such as the strength of the relationship still need to be clear.

In the rest of this paper, we fist review the state of maintenance analysis, we then introduce our model along with a few others for comparison. After presenting the results and discussion we conclude with direction for future research.

2. Related work

Maintenance analysis methods and other related analysis methods are widely developed since the advantage are well known. Some [1] proposed a virtual prototype simulation of maintenance activities, human factors and accessibility factor analysis. Some focu on failure mode analysis and maintainability simulation model, include[2],[3].

Some [4] start with the maintenance qualitative design factors, taking the interaction of universal quality factors into consideration, propose a maintenance model and maintenance assessment methods. Boeing's ISDP (In-Service Data Program) collects and collates aircraft reliability/maintenance data, monitors aircraft reliability information, analyzes positioning issues, and helps airlines share aircraft quality characteristic information.

In China, AVIC[5] proposed a RMSTS integration system platform combing the correlation between the RMSTS data, achieving the integration of design work, integration of data flow, and seamless integration of interfaces.

3. Methods

We introduce a maintenance-centered model and bring in a matrix to link other quality characteristics together.

3.1Maintenance task model analysis

By general maintenance task procedure analysis, we conclude a standard maintenance task model, including the correlation between maintainability and other quality characteristics.

Firstly, through the maintenance task input, we extract the maintenance information of a typical maintenance process and obtain the maintenance task model of the general equipment maintenance process. Then, by analyzing the maintenance tasks for the typical components, we make sure the maintenance information of the required maintenance level, maintenance tool requirements, maintenance operator level, and the number of maintenance operations in the maintenance process, so that the maintenance task are refined as a universal procedure.

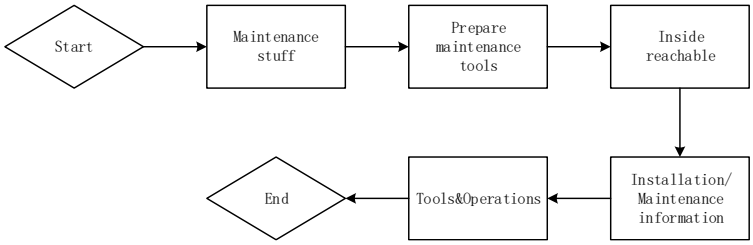

Figure 1. A standard maintenance task model that contains basic maintenance tasks.

These system or component universal maintenance procedure can generally show the operations that maintenance personnel must take at each step. And maintenance motions always involve in some maintenance elements, though the research on the maintenance elements, we can associate maintenance operations with related design disciplines in the design department, shown in table 1. Further more, combining with analysis tools, we can conduct maintenance centered correlation analysis on universal quality characteristics.

Table 1. The specific design departments that are related to the specific maintenance tasks.

Maintenance tasks	Maintenance elements	Design departments
Use of test points, test holes and adjustments	Visibility reachability	Testability
Demolition of fasteners.	Maintenance tools, Detachability	Feature design & distribution design
Use of lifting equipment.	Visibility, Reachability	Maintainability
Demolition of maintenance parts.	Maintenance tools, Detachability, Visibility, Reachability	Maintainability
Movement and replacement of maintenance parts.	Mobility	Feature design
Movement and use of maintenance tools.	Mobility, Interchangeability	Supportability

3.2Maintenance centered correlation analysis on universal quality characteristics

Each step of the maintenance motion in maintenance operation is related to the product's general quality characteristics design results. Whether the product can be quickly, conveniently, accurately maintained, or whether maintenance personnel can perform maintenance operations safely and conveniently is closely related to the constraint relationship between maintainability and other general quality characteristics at the design stage.

Combining the characteristics of universal quality characteristics of typical system components and the correlations between maintainability, using the principle of maintenance and the correlation data flow between the universal quality characteristics, we can get the design constraint relationship between maintainability and universal quality characteristics.

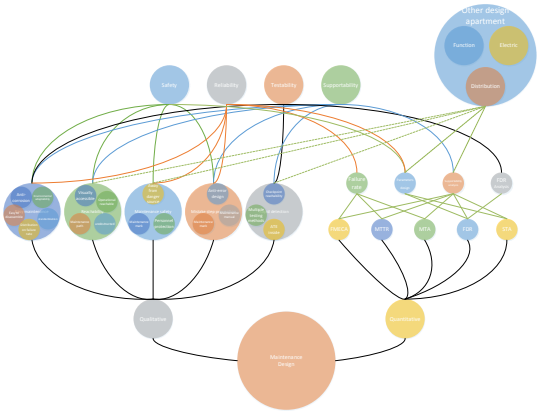

Figure 2. Maintenance centered correlation analysis on universal quality characteristics.

Maintainability is linked to design apartments and universal quality characteristics through qualitative and quantitative factors in Figure 2. The quantitative correlation factors include FMECA, MTTR, FDR, STA, etc. Qualitative factors include easy maintenance, reachability, maintenance safety, mistake operation prevention, rapid detection, etc. Each also contains three to five more detailed items.

3.3Maintenance centered correlation design matrix

By linking maintenance elements (observation, inspection, disassembly, replacement, installation, commissioning) with related majors in other design fields, we can figure out the correlation between them. Let the maintenance elements as an axis of the 3D correlation matrix, the equipment design elements and the design professions as the other two axes, forming the maintenance centered 3D matrix. We use this kind of matrix to associate professional design elements with maintainability elements to achieve maintainability centered system balance.

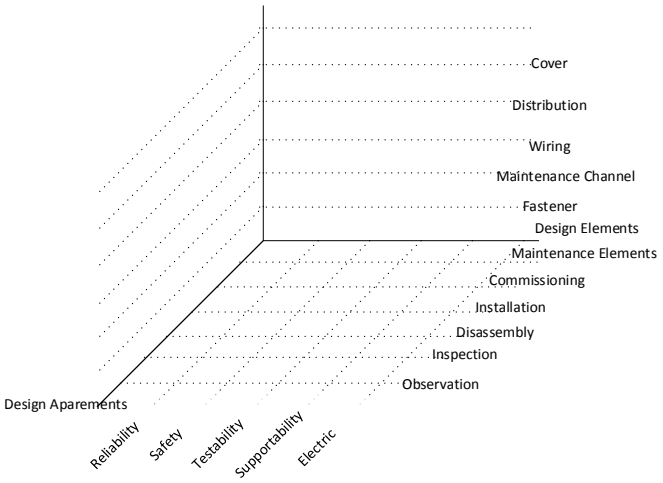

Figure 3. Maintenance centered correlation design matrix, it's a three-dimensional matrix.

The maintenance centered design matrix expresses the relationship between design majors, maintenance elements, design elements, and the correlation of design professions and maintenance elements in a three-dimensional table. As for some specific design element or design professions, it's a two-dimensional table in particular. In this two-dimensional table, what is obtained is an integrated table on specific design elements and maintenance, and the relationship between each design element, design specialty, and maintenance element can be clearly expressed. In the table, strong and weak relationships can be expressed by scores. The score is divided into 1/3/5/7/9. The lower the score, the weaker the correlation, and vice versa.

Table 2. Maintenance centered two-dimensional table.

Design elements / Maintenance elements / Design apartments	Observation	Inspection	Disassembly	Replacement	Installation	commissioning
Reliability						
Testability						
Safety						
Supportability						
Electric						
Function						
Distribution						
……						

After the expert's rating, the score can be assigned to design departments as constraints to guide product design.

4. Verification

The proposed model has been implemented, a case study on armored vehicle power compartment has been carried out.

First is to establish the standard maintenance task model that contains basic maintenance tasks. After maintenance information collection, the maintenance task model is shown in Figure 4.

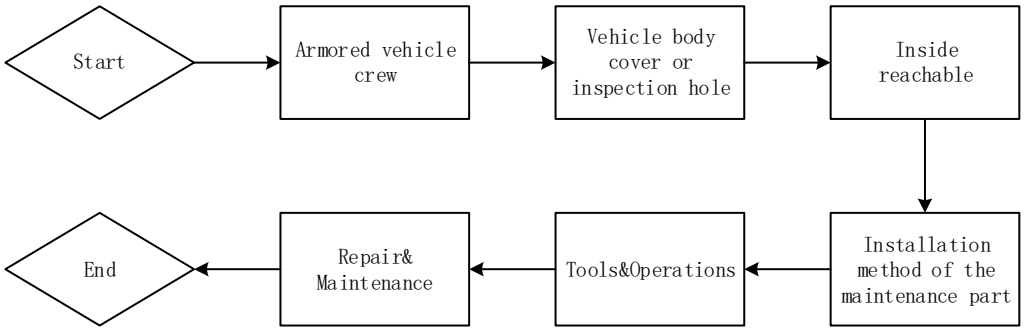

Figure 4. A standard maintenance task model that contains basic maintenance tasks of the armored vehicle.

As different parts of the equipment has the same correlation on the maintenance centered correlation analysis on universal quality characteristics, The result of this step is the same as 3.2 in this paper, so no more discussion here.

The last step is the maintenance centered analysis. By linking maintenance factors (observation, inspection, disassembly, replacement, installation, and commissioning) with related majors in other design fields, other professional design elements are associated with maintainability elements to achieve system balance based on maintainability. Take into account the full range of factors that influence maintenance design and incorporate maintenance design into the preliminary design work.

Table 3. Maintenance centered analysis two-dimensional table.

Maintenance elements / Cover / Design apartments	Observation	Inspection	Disassembly	Replacement	Installation	Commissioning
Reliability	3	5	3	3	3	5
Testability	9	9	7	3	3	9
Safety	3	3	5	7	7	5
Supportability	7	3	5	7	5	5
Electric	5	7	3	3	5	7
Function	7	5	3	3	5	5
Distribution	9	7	9	7	7	5

After the rating, we use normalization analysis to evaluating the importance of maintenance elements to design apartments under design element ‘cover element’.

It shows that to get better design for cover element, Observation, Commissioning and Inspection are important maintenance elements, and for the design apartments, reliability apartment should mind the design for inspection and commissioning; testability apartment should mind the design for observation, inspection, commissioning; safety apartment should mind the design for commissioning; supportability apartment should mind the design for observation; electric apartment should mind the design for inspection and commissioning; For function apartment inspection and disassembly should take more attention; For distribution apartment is observation. The results are in line with actual situation.

5. Conclusion

This study has shown that maintenance-centered model can help to linking all the design departments together in the early design phase, providing a passable parameter system for the design apartments, products are strong enough and functional healthy.

In future work the model will be extended to an visualization software, and a more intuitive scoring method is necessary for the model.

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