IOP Conf. Series: Materials Science and Engineering **394** (2018) 032017 doi:10.1088/1757-899X/394/3/032017

Research on Model Driven Aerospace Product Quality Dataset Organization Method

Lu Wang[a], Han Zhao[b] and Yisu Gu[c]

Beijing Institute of Spacecraft System Engineering, Beijing, China

[a]wangl@cast.cn, [b]zhaohanboy@163.com, [c]guyisu@hotmail.com

Abstract. For satisfying the actual requirements of aerospace quality dataset organization, a model driven aerospace product quality dataset organization method is proposed. The method is based on quality dataset model and product structure model, related by attribute mapping, evolved through the whole lifecycle. As a result, product quality dataset can be obtained with completeness and traceability.

1. Introduction

On account of technical complexity, wide-range cooperation, high risks and etc., aerospace products exigently demand for high quality and reliability. Quality is the lifeline of aerospace products. To accurately, inextenso and traceably obtain quality data throughout product development life-cycle is the hardcore of quality management system. Nowadays, quality data management method of China aerospace is one dataset attached to one product, assisting with “quality trace-zero dual five rules”, which ensuring the quality and reliability of aerospace products for decades.

Though the management mode is still advanced, lack of effective technical methods makes procedures of quality dataset production encounter many difficulties.

Quality data severely depends on manual collection and clean-up. Except for some of them use computers, quite a lot quality data is input, collected by hands. Manual processing is easy to make mistakes, such as leave out and inconsistent, besides it is a hard work.

Quality data is stored in files and packed into different file folders according to product development life-cycle phase. This kind of organization has no relation to product structure, thus it’s hard to find out quality data through product structure.

Product datasets are always being generated at the stage of hand over, instead of during develop processes.

To deal with the problem, article [1] proposed an abstract expression infrastructure of lifecycle product quality dataset. Article [2] proposed a kind of quality model and its implementation method of products. Article [3] and [4] proposed an organization structure based upon product BOM (Bill of Material). However, those, focusing on large-scale manufacture industry, can hardly solve problems that aerospace products encountered when managing quality datasets.

This paper introduces a model driven quality dataset organization method. Firstly, based on relative research and analysis, the general strategy is proposed. Secondly, based upon quality dataset model, the overall process of collecting quality dataset is addressed. This method orderly binds key factors of quality dataset to different phase structural trees of product life-cycle. Thus accurate, consistent and traceable product quality dataset can be gradually formed.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

2. General Structure

Definition 1, Key Factors Collection of Product Quality Dataset: R represents the key factors collection of product quality dataset; R_i (i=1, 2, 3, …) represents a type of product quality datasets, including design quality dataset, manufacture quality dataset, experiment quality dataset and etc.; R_{ij} (i=1, 2, …; j=1, 2, …) represents a product quality data object. For example, manufacture quality dataset contends process quality data, working procedure quality data, frock quality data.

Definition 2, Attribute Relation Mapping: The attribute relation mapping is used to construct the relationships of node attributes of product structure to the key factors collection of product quality datasets. Along with product characteristics and phase characteristics being attached, the management structure of product quality datasets can be obtained.

In order to realize structural related quality data storage for entire production life-cycle of aerospace products, and in order to establish a sound base for later work, such as quality cast back, quality trace-zero and infer other things from one fact, the general structure of model driven quality dataset organization method of aerospace products is described as follows:

"Taking quality datasets as the bedrock, taking the product structure model as the carrier, taking the attribute relation mapping as the ligament, evolving throughout phases of the product lifecycle."

Model driven quality dataset organization method means to cover the entire lifecycle of product development, such as product design, process design, manufacture, examine, test and etc. This method syncretizes key factors of quality dataset to structural descriptions of product quality data. At first, build quality dataset model to provide a unique description rule when organizing quality data. Then, establish the mapping relationship between quality dataset model and nodes on product structure model. At last, instances of quality dataset model of different product development phases can be formed by using lifecycle penetrated product structures. Thereafter, key factors of quality dataset will run through whole product structure. Separating the work of quality dataset collection into different phases, organizing and recording quality data throughout product development lifecycle, tracing the quality cause and effect link, they should strongly support comprehensive application of consistent, related and traceable quality dataset.The organization method is shown as Figure 1.

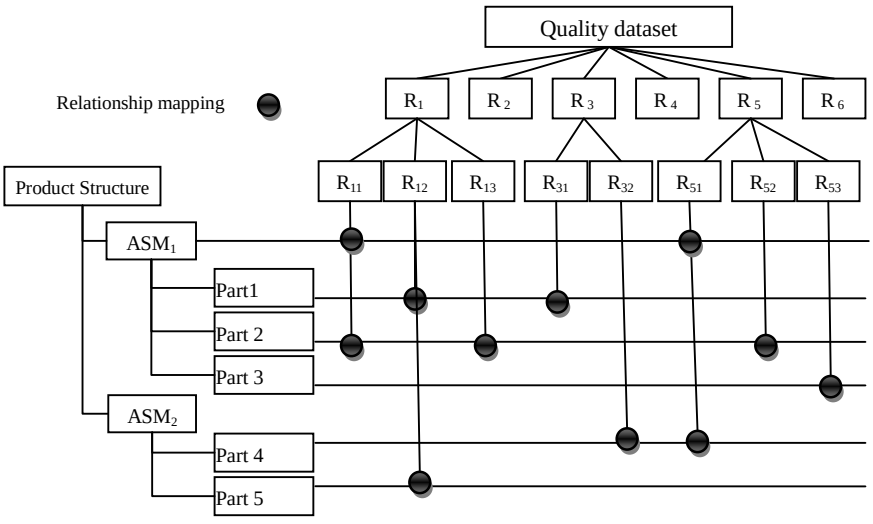


Figure 1. General Structure of Model Driven Quality Dataset Organization Method

3. Quality Dataset Model

Definition 3, Product Quality Data Model (PQDM): can be described as the following tuple:

PQDM = (Basic Factor Model, Product Structure Model, F_R)

① Basic Factor Model

Basic factor model is the basic element for describing and organizing quality dataset. It has to include all quality data objects forming throughout product development process. Basic factor model has to conform active aerospace quality dataset management methods.

Definition 4, Basic Factor Model: the collection of quality factors that related to product development processes all about. Structural description of quality data factor orientated to product development phases is described as follows.

BasicFactorModel= (*Design, Manufacture, Assemble, Test, Other*)

Design means the key factors collection of product quality dataset in design phase, including bill of design files, component checklist, bill of key parts, bill of important parts, electric component checklist, material checklist, material checklist without flying verification, reliability and safety analysis report, test coverage analysis report, special design verification test report, detail rules of machine debug & test, product accept outline, review & double check report, and any other related documents.

Manufacture means the key factors collection of product quality dataset in manufacture phase, including process design checklist, process checklist without flying verification, key process checklist, certifications of new processes, product process modification summary statement, quality tracking card of processing procedure, material review certificate, loading list of electric elements, component certificate, out-sourcing component quality certificate, accept certificate, key parts over-tolerance summary sheet, inspection record, compulsory inspection point checklist, key parts quality control process record, installation accuracy, product repair record and etc.

Assemble means the key factors collection of product quality dataset in assemble phase, including quality trace card during assembling, debugging and testing, debugging record, inspection record, in-process test record, component replace record and etc.

Test means the key factors collection of product quality dataset in test phase, including test record or test report, environment test certificate, environment test report, special test report, check result of test coverage, transportation record, product storage record, usage record of finite lifetime products and etc.

Other means the key factors collection of product quality dataset spending multi-phases, including technique notification, technique problem disposal document, unqualified product disposal document, faults and their disposal document, quality problem trace-zero information (quality problem statement, trace-zero report), electric coupler plug-in and pull-up record, failure electric components summary, failure electric component analysis report, product resume and etc.

② Product Structure Model

Nowadays, product structure has being the kernel of many product data management systems. It is coming to be the most suitable carrier of product information organization. The organization of quality data, as an important constituent part of product information, has native and close relation with the product structure.

Definition 5, Product Structure Model: By means of the adoption to product structure, entire quality status of products can be described with the attribute mapping and objects in basic key factors model. Product structure model can be described as the following tuple:

Product Structure Model = *(ID, ProductTree, Qitem)*

ID: product structure indicator;

ProductTree: product structure tree that referenced;

Qitem: a tuple ($qitem_1$, $qitem_2$… $qitem_n$), represents quality attribute of a node, extracted from the basic factor model of product quality dataset.

③ Attribute Mapping Function F_R

Basic factor model of quality dataset is the abstract collection of related quality data factors. As long as mapping basic factor model to product structure of all product lifecycle phases, a meaningful quality dataset organization structure can be obtained.

At a given lifecycle time *t*, relationship between *factor* ∈*Basic Factor Model* and *Qitem* ∈*Product Structure Mode* can be described as the following tuple:

$$PQDM_t = [\mathrm{Pr}oductStructureModel_t, (Factor \xrightarrow{F_R} Qitem)_t]$$

Where, t is a given lifecycle time, $PQDM_t$ is the quality dataset instance on time t, *Product Structure Model* is the product structure model on time t.

The evolvement throughout product lifecycle can theoretically generate a quality dataset model instance for any timeline. From the point view of aerospace products development, important lifecycle moments, such as conceptual design, prototype design, and detail design, processing design, manufacture and test are chosen to form quality dataset model instances, and those are able to fully describe the changing progress of product status.

4. Organization Process of Model Driven Quality Dataset

The organization process of model-driven quality dataset is shown as Figure 2.

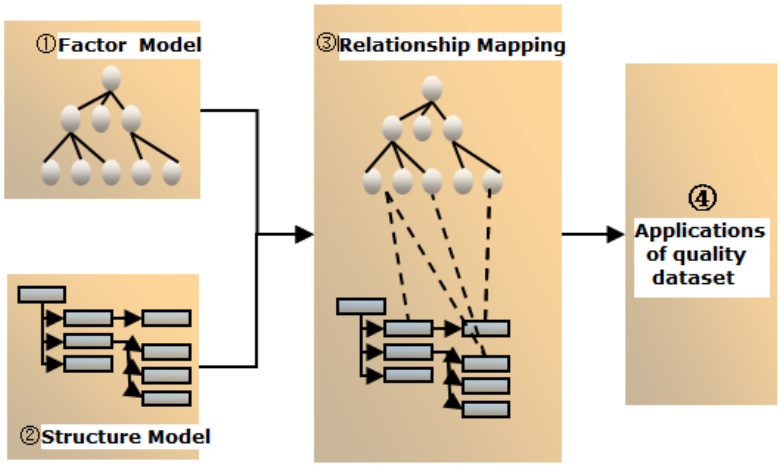


Figure 2. The organization process of model-driven quality dataset

Build basic key factor model. According to definition 4, the conformation of basic key factor model needs to observer standing quality dataset regulations of spacecraft development. So the first step is to transform tabular formed quality documentation checklists into scalable and reusable model express style, such as relational model, UML model and ontology model. Obviously, the transformation must be an iterative, revisable and evolving procedure, and needs to suit for new quality dataset management regulations of spacecrafts.

Build product structure model. Taking into account of current status of aerospace institutes, the product structure can be obtained from the AVIDM (Aerospace Vehicles Integrated Design and Manufacturing) system through system integration.

Build attribute relation mapping. After the product structure is determined, related factors can be selected from the basic key factor model, and then taken as attribute links to the structure model. Because quality key factors that taken into consideration are various, product structures in different phases of product lifecycle have their unique characteristics. It's impossible for one attribute mapping suitable for all phases of product lifecycle. By means of attribute mapping relation, the quality dataset organization model will be formed out, which is carried by product structure and for various phases of product development. Actually, an instance of quality dataset model it is. An example is shown as Figure 3.

Applications of quality dataset. Above steps fulfill the organization of related factors of quality dataset for lifecycle phases in the manner of product structure. Because models are evolving throughout the lifecycle of product development, it is possible to trace all quality data from any node of the product structure. Thanks to the realization of structural and relational quality data storage throughout lifecycle of product development, activities, such as dataset based quality trace back,

quality problem trace-zero and infer other things from one fact, can be implemented more effectively and conveniently.

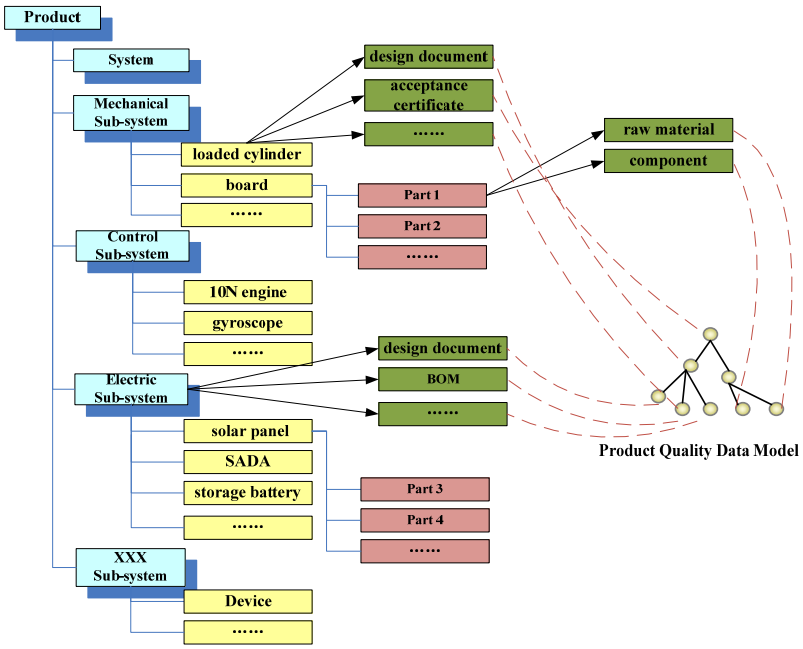


Figure 3. Attribute Relation Mapping

5. Conclusion

The model driven organization method of quality dataset, taking quality dataset model as the foundation, taking product structure as the carrier, taking attribute relation mapping as the ligament, evolving throughout different product lifecycle phases, orderly binding key factors in quality datasets to product structure trees of different product lifecycle phases, make the quality dataset gradually formed during the process of product development.

As the requirement for the quality and reliability of aerospace products becoming more and more rigorous, the model driven organization method of quality dataset of aerospace products could support the management of product quality dataset of aerospace institutes from the technique point of view. On one hand, it would save designers and project managers out from manually collecting quality data. On the other hand, it would ensure the integrality, consistency, traceability of quality dataset, in order to meet the quality and reliability requirements better.

References

[1] LU Yu-feng TANG Ting-ting WANG Lu-yuan LU Yao, The Management Information System of Aeroengine Quality Review Based on PDM, Manufacturing Information Engineering of China, 2011, 40 (23): 31-35.

[2] LI Juan LIANG Gong-qian, Classification of quality information on remanufacturing production process providing Bill of Material, MANUFACTURING AUTOMATION, 2011, 33 (14): 1-4.

[3] Cheng Hui Zhang Jian Wu Qinghua Liu Kuan. Aerospace Discrete Manufacturing Total Quality Management System based on XQBOM. Aerospace Manufacturing Technology, 2014 (3): 31- 35.

[4] Tang Xiaoqing, Hu Yun, Evolution process of quality BOM for product process, JOURNAL OF BEIJING UNIVERSITY OF AERONAUTICS AND ASTRONAUTICS, 2009, 35 (2): 209-214.