

# A Study on Quality Management for Aerospace Product with Multilevel Suppliers

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**Abstract**—The quality management of aerospace product is related to multilevel suppliers and runs through its whole lifecycle. Considering the complexity of aerospace product, the quality management mode of aerospace product developing process is proposed. Three models including Product Quality Information Tree(PQIT), Product Quality Information Model of Lifecycle (PQIML) and Feature Model of Quality Problem (FMQP) are proposed to describe the all-sided quality information of the product in each period of the developing process. On the basis of these models, the systematic quality control method including the method of product quality prediction, process quality management, quality problem tracing and quality analysis and decision-making is presented to manage and control the aerospace product. At last, the application of this method is discussed in real quality management of rate gyroscope to demonstrate the efficiency of this method. The result showed the quality information of rate gyroscope in the whole lifecycle can be restored and utilized effectively using the method proposed.

**Keywords**—Multilevel Suppliers; Aerospace Product; Product Quality Information Tree; Product Quality Information Model of Lifecycle; Feature Model of Quality Problem of Lifecycle; Feature Model of Quality Problem.

## I. INTRODUCTION

Quality is the lifeline of the aerospace product. The quality of aerospace product is ensured by the strict quality management of aerospace product developing process, so the scientific and efficient quality management is the guarantee of aerospace product.

As a high-tech systemic program, the number of suppliers for aerospace product is quite large. For example, there are thousands of suppliers for “SHENZHOU” manned spaceship. So, how to control the products’ quality of these suppliers has become the most urgent problem for the aerospace product quality management. At the same time, the “Quality Problem Tracing” is becoming quite difficult because the information of product quality with multilevel

suppliers is absent or not enough. And with the tasks increasing, the “Draw Inferences about Other Cases from One Instance” become more and more difficult. These problems have become choke points in the quality management of aerospace product. So some methods and technology should be proposed to solve them.

Nowadays, the quality management and control of product is a research focus. Researchers often focus on the quality control of manufacturing process, quality problem diagnosing using IT technology and the establishment of quality information management system. However, there are fewer researches focusing on the quality management and control of product developing process with multi-suppliers. A systematic quality control method for product developing process is quite necessary to solve the problems which current aerospace product quality management is faced with.

According to the characteristic of aerospace product developing process, this paper proposes the quality management mode of aerospace product developing process with multi-suppliers. Then, PQIT is presented to describe the quality state of the aerospace product according to the BOM. PQIML is presented to describe quality state of the aerospace in each period of lifecycle. FMQP is presented to describe the feature of the quality problem. At last, a system of quality management method used for process control is studied based on the models of PQIT, PQIML and FMQP to manage and control the quality of aerospace product efficiently.

So, the content is arranged as follows. Firstly, the status of quality management for aerospace developing process is analyzed. Secondly, the quality management mode of aerospace developing process is proposed to solve the existent problems. Thirdly, the systematic quality management method is provided particularly. Fourthly, a case of quality management of rate gyroscope using this method is shown. At last, the conclusion of the research and the future work is presented.

## II. THE ANALYSIS OF AEROSPACE PRODUCT DEVELOPING PROCESS QUALITY MANAGEMENT

From the summary of 50 years practical experience in China’s space industry and the theory innovation of quality

management, the quality management kept to the principle of “Control from the start, Prevent is important, Control the whole period, Manage systemically” and the idea of “Zero Defect System Engineering Management”, and formed a scientific, advanced and effective control method system of aerospace product development.

According to the different developing state of the aerospace product, the quality management can be divided into four management periods: the quality prediction, developing process quality management and control, Quality Problem Tracing and the quality data analysis and decision. Then, the quality management will run through the whole process of prophase study, manufacturing, testing, delivering and using. So management can satisfy the requirement of whole lifecycle quality management and ensure the success of important aerospace programs, such as “The two missiles and one satellite”, “Lunar Exploration Program”, “Manned Space Engineering Program”.

In the practice of China aerospace product quality management, “Quality Problem Tracing” and “Draw Inferences about Other Cases from One Instance” are the main quality tracing and predicting method proposed creatively. In the fact, these two methods have become the most effective predicting and guarantying methods for aerospace products. “Quality Problem Tracing” is to ascertain the original cause by theoretical analysis and examination and to come back the phenomenon of quality problem by examination or other test methods, and then the original cause can be ascertained veracity. “Draw Inferences

about Other Cases from One Instance” is to examining other projects and other corporations according to the quality problem to prevent the same problem occurring.

The quality of aerospace product is not ensured by examination or statistic result but by the strict quality management and control of product developing process. Because of the complexity of the aerospace product, there are thousands of suppliers of materials, parts and systems, including the first level supplier supplying systems for the core enterprise directly, the second level supplier supplying parts for the first level supplier, and the third level supplier supplying parts for the second level supplier. For the aerospace product, the quality management and control of developing process is as important as the final quality. That is to say, the quality of materials, parts, components and systems supplied by the multilevel supplier are also the emphases of quality management.

### III. THE QUALITY MANAGEMENT MODE OF AEROSPACE PRODUCT DEVELOPING PROCESS

Quality management of the developing process for aerospace products with multilevel suppliers includes the four parts: the basic environment of quality management, the product quality transfer process, the quality management of aerospace product developing process and the object of quality management. As Figure 1 shown is the whole frame of quality management pattern for aerospace product developing process.

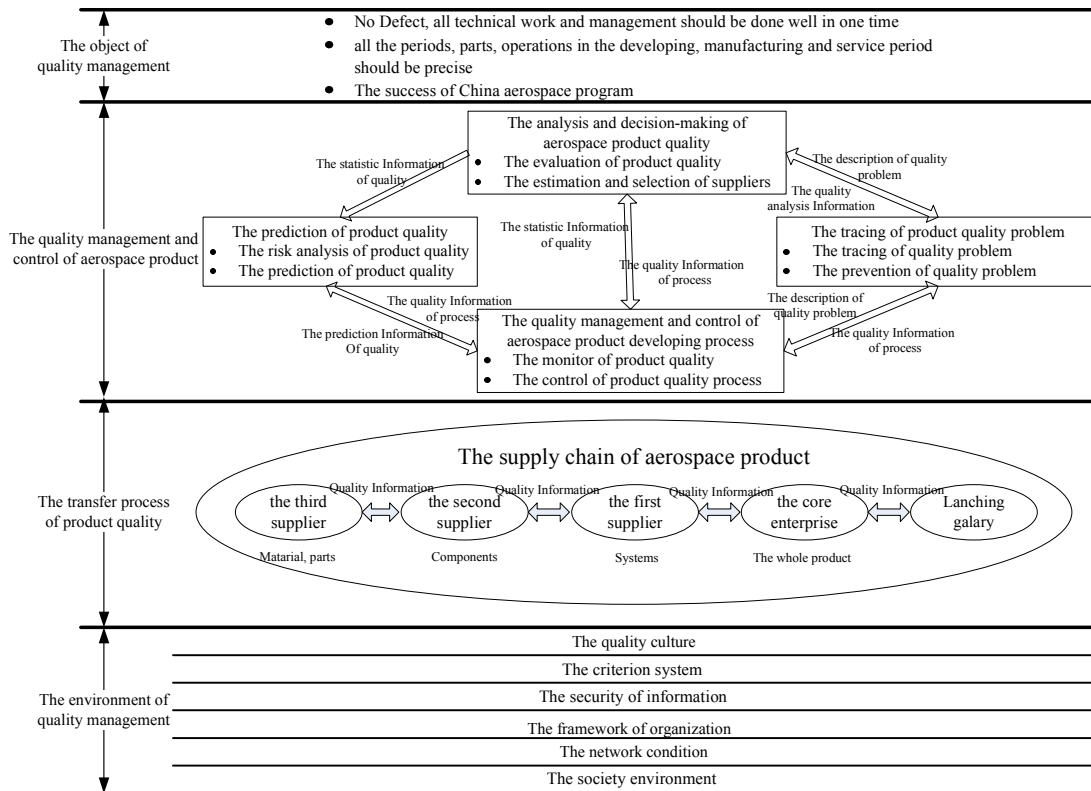


Figure 1. The quality management mode of aerospace product with multilevel suppliers

- The environment of quality management

The environment of multi-suppliers quality management for aerospace product includes the quality culture, the criterion system, the information security, the organization framework, the network condition and the society environment.

- The quality transfer of aerospace product

As figure 1 shown, the whole product is composed of systems, the system is composed of components, and the component is composed of parts and material. As we can see, the quality information streams from the lower level supplier to the higher supplier in the product forming process.

- The quality management and control of the products developing process

Aimed at the particular aerospace product developing process, the quality management can be divided into four periods: the quality prediction, development process quality management and control, Quality Problem Tracing and the quality date analysis and decision as shown in Figure 1. The information stream of these four processes comes into being a closed loop. So, the quality management covers with the whole developing process of aerospace product.

- The object of quality management

“No Defect” is the object of aerospace product quality management, all technical work and management should be done well in one time. And all the periods, parts, operations in the developing, manufacturing and service period should be precise.

All the quality activities all work for the quality management object. The quality guarantee environment is the foundation of quality management. The quality transfer indicates the quality forming process of the products. The quality management and control activity can be divided into four periods according to the developing process. And it is the core of the quality management activity and the safeguard to ensure the product quality. The main quality management and control method will be introduced as follows.

#### IV. THE QUALITY CONTROL METHOD OF AEROSPACE PRODUCT DEVELOPING PROCESS

The systematic quality control method includes four main methods, which are the prediction method of aerospace product quality, the quality management of aerospace product developing process, the tracking method of aerospace product quality problem and the analysis and decision-making method of aerospace product quality.

##### A. The Prediction Method of Aerospace Product Quality

In order to avoid quality problems, the quality prediction is quite important to ensure the product quality. The quality prediction can be divided into two processes, one is the quality prediction before the developing activity starting, and the other is the quality prediction during the developing process. The object of first process is to predict potential problems in all the parts of the product. According to the prediction result, relevant actions can be taken to prevent the problem. It is the most efficient method to control the quality

of aerospace product. The object of second process is to provide decision reference to adjust the supply chain framework. In this process, the main work is predicting the product quality state, evaluating and predicting the quality ensure ability of suppliers. This object is achieved by collecting and analyzing the quality data of designing process, manufacturing process, servicing process and so on. The crucial technology is history quality information disposing method based on knowledge discovering, potential quality problem analysis and prediction method and the prediction and estimation method of quality current.

##### B. The Quality Management of Aerospace Product Developing Process

The emphasis of quality management for aerospace product developing process is to obtain the product state information in the product's whole lifecycle. So, noting and analyzing the quality information in real time is important. And also, there are two significant models to note the quality information effectively, which is Product Quality Information Tree (PQIT) based on BOM and Product Lifecycle Quality Information Model (PQIML) faced multi-suppliers.

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**Definition 1:** PQIT is the product quality information according to the BOM. In this model, the quality state information of the whole product is described by the quality information of every parts of product. The model is a static quality information model including the information of product's structure, parts' quality state and parts' suppliers. The node of PQIT can be described as follows:

QNode= (Name, FName, SN, Qstate, SName)

Name: the description of the name of component this model represents;

FName: the description of the name of the component's father component;

SN: SN is a gather (SN1, SN2,..., SNn), which describe components of this component;

QState: the description of the quality state of the component, which is “N(normal)” or “A(abnormal)”;

SName: the description of the information of the component's suppliers.

**Definition 2:** PQIML describes the different quality state of products' components and parts in different phase of all lifecycle. According to the whole variance process of aerospace product state, this model is used to describe the quality information from materials, parts, components to whole products. The basic model is described as follows:

Qinformation= (Name, Qstate, Pstate, T)

Name: the description of the name of component this model represents;

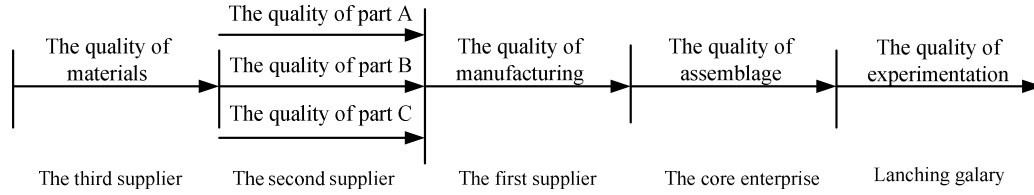


Figure 2. The transfer process of aerospace product quality state

Qstate: the description of the quality state of the component;

Pstate: the description of the developing state of the component;

T: is the time cycle of the phase which the component experienced, can be described as (Ts, Te), Ts is the start time of the phase, Te is the end time of the phase, and the format is "yymmdd".

As Figure 2 shown is the different phase which aerospace product span different suppliers. Every product has a forming process, and every process can be divided into several different phases. In this way, the developing process of aerospace product can be divided into minimal cell to note the particular quality state information in every phase.

PQIT and PQIML have a common element: Name. For a product described in the PQIT, the quality state of every phase can be backdated through the PQIML. And the structure information of the product represented by the PQIML can be obtained by the PQIT. Using these two models, the quality information of aerospace product for the lifestyle can be noted and managed.

### C. The Tracking Method of Aerospace Product Quality Problem

Based on the successful experience of aerospace product quality management, there are two core methods to trace and predict the quality problem: "Quality Problem Tracing method" and "Draw Inferences about Other Cases from One Instance". Before introducing the two methods, we will establish the Quality Problem Feature Model (FMQP).

**Definition 3:** FMQP is the mathematics model to describe the whole quality problem information of product, including the character of material, structure, function, matter description and the cause. It is shown as follows:

Qcharacter= (QMaterial, Structure, Function, Matter, Cause)

QMaterial: the description of material character of the product;

Structure: the description of structure character of the product, which can be shown in the product structure tree;

Function: the description of function of the product;

Matter: the description of abnormal character of the product;

Cause: the description of cause to the quality problem.

FMQP is especially important for the quality problem tracing method of aerospace product. The quality character of quality problem can be picked up using the method of "Quality Problem Tracing" (QPT). In this way, FMQP can be constructed to match and find the same problems in other projects. Then, the problems can be avoided. The method is

called as "Draw Inferences about Other Cases from One Instance" (DIOCOI).

(1) The QPT method for aerospace product with the multilevel suppliers

The key of QPT is to find the root of the quality problem. So, first go through the whole product quality information tree according to the topology frame of the quality tree, and then the PQIML of different parts can be constructed. Then, the PQIML is exhaustively searched to ascertain the quality problem by matching the FMQP. At last, where and why the quality problem occurred can be known.

(2) The DIOCOI method for multi-project

To realize the DIOCOI of quality problem, first should construct the FMQP according to the result of "Quality Problem Tracing". Based on the FMQP, knowledge discovery methods such as Association Rules, Rough Set Theory, and Clustering Method should be used to find and prevent the same problems in other projects and other products in the same project.

### D. The Analysis and Decision-making Method of Aerospace Product Quality

The collection and analysis of ago product quality information is an important work in the aerospace product quality management. It is helpful for the decision-making in the continuous product quality management. There are two aspects, one is the analysis of product quality used for the evaluation of product quality, and the other is the analysis of multi-suppliers used for the evaluation and selection of suppliers.

The evaluation of aerospace product quality is carried out in two steps. First, the ago quality information of product should be analyzed to detect the existent problems and confirm the emphasis of product quality control. Then the product quality object will be adjusted according to the result. This will provide references for the quality management and control of new product. The normal method adopted is to evaluate the product quality by constructing the proper quality evaluation system according to the actual condition.

The quality of components supplied by suppliers will influence the final quality of products. The evaluation and selection of suppliers is important to ensure the product quality in the supply chain quality management. So the management and control of suppliers should be strengthened and the quality guarantee ability of suppliers should be evaluated and predicted precisely and reasonably. Then the prediction result can provide references to adjust the frame and constituent of the supply chain. There are many researches focusing on the evaluation and selection of

suppliers. The normal method is to evaluate the product quality by constructing the proper evaluation system according to the actual condition, and then the Analytic Hierarchy Process, Fuzzy Theory, and Neural Network are also used to evaluate the ability of suppliers.

## V. CASE STUDY: THE QUALITY MANAGEMENT OF RATE GYROSCOPE

The method proposed in this paper has been used in the quality management of rate gyroscope. The rate gyroscope is the indispensable component in the control system of rocket. It is used to control the flight gesture of rocket, especially in the new type rocket which is slightness. The low frequency phase margin is mainly supplied by the rate gyroscope. So the quality of the rate gyroscope will determine the balance of rocket and influence the success of the launch of the rocket.

The rate gyroscope (RG) is consisted of gyro motor-driven (GM), magnetic moment (MM), in-phase sensor (IS), temperature compensator (TC), axletree (AT), damper (DP), the equipment of transmit electricity (ETE) and the dobber (DB). So the PQIT can be constructed as the Figure 3 shown. For some reason, the suppliers are anonymous and just replaced them by the letters A, B, C.

In the whole lifecycle of the rate gyroscope, there are some special and important periods, such as designing, manufacturing, debugging, experiment, matching with other systems, cell test, level test and the launching test. The quality information of the rate gyroscope will change with the quality state in the different period. And the PLQIM of every component in the rate gyroscope will be constructed, so the quality information of the whole lifecycle can be remembered and restored.

Here, the lifecycle can be predigested into three periods: designing period, manufacturing period and experiment period. So the PLQIM of the rate gyroscope can be described as the Figure 4 shown. In the figure, the quality state of the rate gyroscope is shown in the three periods. Take the magnetic moment (MM) for example, as we can see, the quality state is "N" (normal) in the designing period and the time cycle of this phase is from September 10, 2007 to October 25, 2007.

In this way, the quality information of the rate gyroscope can be restored. When there are some quality problems, the QPSM can be constructed according to the practical problem. The factor of this model can be described in text, such as the matter and the cause of the problems. So, we can affirm the part with problems using the QPSM and the PQIT. Then, using the PLQIM, we can confirm the actual phase when the problem happening. In this way, the QPT and the DIOCOI can be realized. These three models is the important basis for the QPT and the DIOCOI. And in the actual practice, the quality management method is quite effective.

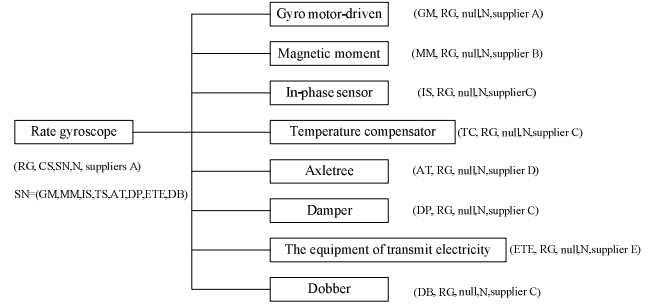


Figure 3. The PQIT of the rate gyroscope

## VI. CONCLUSION AND FUTURE WORK

According to the character of quality management for aerospace product, this paper proposed the quality management mode of aerospace product with multi-suppliers. To manage the quality of developing process for aerospace product efficiently, three models including PQIT, PQIML and FMQP are provided. Using these models, the quality information and the quality problem can be described for the lifecycle. On the basis of PQIT, PQIML and FMQP, the method system of quality control is provided to solve the problems efficiently. And the research has been used to guarantee the quality of a rate gyroscope in the rocket. The future research will study and perfect these methods continuously in the actual work.

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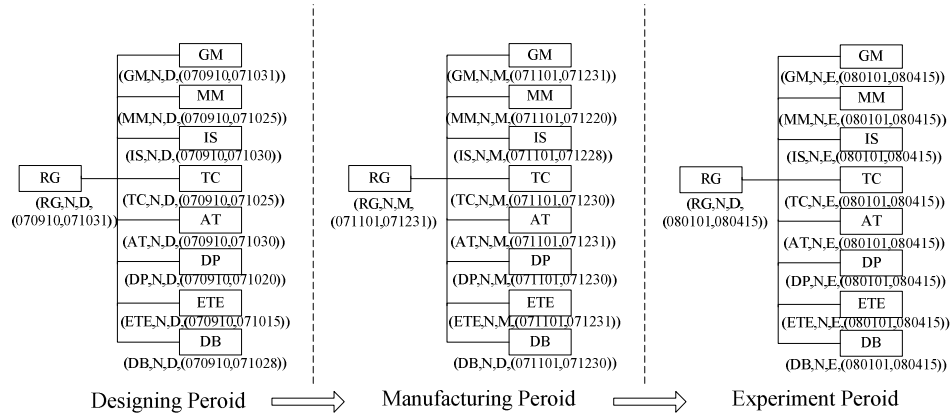


Figure 4. The PLQIM of the rate gyroscope