Research on the Improvement of Spacecraft Manufacturing Enterprise Quality Management System Audit Based on Process Method

Wei Liu*, Gang Sun, Kaimin Zhu, Bin Zhang
Beijing Institute of Spacecraft Environmental Engineering, Beijing, China

*Corresponding author e-mail: liuwei8321@126.com

Abstract. This article combines the spacecraft manufacturing enterprises that simultaneously build and operate ISO9001 and AS9100 quality management system. According to the process strengthening requirements of quality management system standards, research and improve the audit work with process method as the core. This article introduces the "turtle chart" process method audit management tool, summarizes the specific model and implementation points of the process method in the quality management system audit. This article analyzes the important role of this method in the internal audit of quality management system, in order to provide reference for spacecraft manufacturing enterprises to improve the audit of quality management system.

1. Introduction

《Quality Management System-Requirements for Aviation, Space and Defense Organization》 (AS9100) is a quality management system standard widely used in the international aerospace field. Among them, "Application of process method" is the basis of AS9100 standard import. "International Aerospace Quality Organization"(IAQG) believes that the application of process methods in quality management system in spacecraft manufacturing enterprises can promote enterprises to carry out more "value-added" management activities guided by customers. The introduction of horizontal management in process method can break through the boundaries between different functional departments in the vertical management of the organization, manage and control "the interaction between processes" and "the interface between processes and functional departments", and integrate the concerns of each department into the common goals of the organization.

In the key points of ISO9001:2015 standard, the process method is especially emphasized, which combines risk thinking and PDCA (planning, implementation, inspection and disposal) cycle. As an aerospace enterprise that simultaneously builds and operates ISO9001 and AS9100 quality management system, it should pay special attention to the coordination and targeting of the whole process. Combined with risk thinking and PDCA cycle, according to the strategic policy and direction of the organization, establish and maintain effective process management to produce the desired effect. Internal audit is the most commonly used method to evaluate the effectiveness of quality management system. The process method audit is concerned by the certification body and auditors. The requirements for understanding, implementing and auditing the quality management system have changed according to the process method."Audit requirements for aerospace and defense
organizations" (AS9101) has transformed the quality management system audit model into a process approach audit. Influenced by the traditional compliance audit method based on standard terms, the implementation of internal audit and effective continuous improvement of process methods still need continuous exploration and practice in management.

2. Analysis on the adaptability of traditional compliance audit

Based on the standard terms, the audit method by department belongs to the traditional audit method. That is, an auditor is responsible for auditing the responsibilities and activities of the quality management system performed by a department or several departments. Based on the definition of audit effectiveness, that is, the degree to which the planning content is completed and the planning result is obtained. The adaptability of traditional compliance audit includes the following aspects:

First, the audit continuity is constrained and the effectiveness measurement results cannot be obtained. As the activities of the quality management system process are often operated across departments. Therefore, when auditing by department, it is difficult for auditors to make a comprehensive judgment on the overall picture of the process and whether the process achieves the expected results. It is difficult to measure the effectiveness of processes and systems scientifically. The conclusions are often based on judgment rather than measurement results.

The second is to "cut" the process for audit, which is not conducive to focusing on the systematization of quality objectives and the interface between processes. If it is audited by functional departments or terms, it is easy to separate the process and only pay attention to the compliance of terms. There is a gap between departments and functions. It is not helpful to find out whether there is any inconsistency between department objectives and process objectives.

Third, it is not conducive to considering the process from the perspective of "value-added", and is not conducive to the improvement of the organization. Compliance audits often start with the description of the terms, focusing on the conformity of organizational documents and records. It is not conducive to research on the effectiveness of each process, so as to achieve the goal of the whole enterprise performance improvement and continuous improvement. Therefore, it is very important to explore the process method audit under the new mode.

3. Model and implementation of process method system audit

3.1. Management model of process method

Process method is a quality management system method based on process definition that is, inputting a group of interrelated or interactive activities to obtain expected results, systematically establishing and managing each process and interaction of quality management system, so as to enhance the overall performance of the organization.

The complete description of the process should include six aspects: input, activity, output, owner, performance indicator and required resources, as shown in Figure 1. Among them, activity is a thing to achieve a specific purpose, and process is a series of things to achieve a specific result. Complex processes need to be decomposed into multi-level sub processes until specific activities. For example, the procurement process includes supplier management process, supplier management process includes supplier evaluation process, and supplier evaluation process includes specific audit and evaluation activities.
According to 《The concept of process method and its application guide in management system》 (ISO/TC176/SC2 N544R3), the application of process method includes planning, implementation, measurement, analysis, correction and improvement, as shown in Figure 2. Among them, process planning is the systematic work of identifying and defining the process elements for the purpose of value-added, and it is the basis of applying process methods to the organization's quality management system. Setting the key performance indicators (KPI) of each process of the organization is the status baseline for the subsequent monitoring and measurement process operation of the organization and obtaining improvement.

3.2. Management tool of Process method system audit

Process based audit method, which is a widely used management tool "turtle chart", is a very effective method of process analysis and audit. Take the supplier management process as an example, as shown in Figure 3.
Figure 3. Tortoise diagram of supplier management process.

From the diagram, the elements of the process can be defined, which is also the detailed planning of each process:
1) Who are the input provider and output receiver of the process?
2) What are the process requirements or process inputs?
3) What are the outputs of the process?
4) Who is responsible for this process? Who is the owner (centralized management department) of the process? Who is the executive department? What is their division of responsibilities?
5) What resources or support conditions are needed to meet the process requirements?
6) What are the process activities?
7) What are the process risks and control measures?
8) What are the documents and records of the process?
9) What is the process performance indicator setting?

3.3. Auditing ideas of Process method

Among the classic quality management methods, PDCA (Plan-Do-Check-Action) is the basic method to plan, implement and improve the quality management system and its process. The process method audit is carried out from the idea of "monitoring, measurement, improvement, planning and implementation" (CAPD). The audit ideas are shown in Table 1:
Table 1. Process method review ideas.

| Auditing ideas | Audit points |
|----------------|--------------|
| To examine:    |              |
| Process        | 1. Understand the process overview and main activities. |
| monitoring     | 2. Understand the KPI project and indicator setting of the process. |
| and           | 3. Understand KPI measurement method, cycle and frequency. |
| measurement    | 4. Understand the implementation and trend of process KPI. |
|                | 5. Pay special attention to customer related performance indicators. |
| To examine:    |              |
| Process        | 1. When the performance indicators or trends show bad, is the root cause analyzed and measures taken? |
| improvement    | 2. What is the effect of the measures taken? When the effect is not good, is the cause analysis and improvement repeated? |
|                | 3. When the performance indicators meet the expected requirements, are new objectives set? |
| To examine:    |              |
| Process        | 1. What procedures or operation documents does the process follow? |
| planning       | 2. Does the document meet the requirements of standards, applicable regulations and customers? |
|                | 3. Are process responsibilities and resources clearly defined? |
|                | 4. Operability and suitability specified in the document? Is there any planning problem that leads to the process result failing to achieve the expected goals and targets? |
| To examine:    |              |
| Implementation | 1. Does the process operate according to procedures or operation documents? |
| of the         | 2. Whether the input meets the planning requirements? |
| process        | 3. Whether the resources (manpower, equipment, tooling, information, etc.) meet the planning requirements? |
|                | 4. What are the problems in the process operation that cause the process results to fail to achieve the expected goals or targets? |

CAPD audit idea, that is, from the results of a process, to judge the planning of the process and the effectiveness of related activities to support the process, so as to improve the organization's process objectives. According to the results of the process, the auditor combines the human, machine, material, method, environment, measurement and other management factors that affect the process to find the audit focus. This method is helpful for auditors to quickly find the weak links in the organizational process and process activities, and even the interface problems between them.

3.4. Implementation of process method system audit

One is the planning of process system audit. Generally, it includes audit basis, audit scope, audit frequency, process audit method, qualification confirmation of process audit auditor, preparation of annual audit plan, etc. Among them, the process audit can be divided into centralized process audit and rolling process audit. The organization shall select appropriate and efficient audit methods according to internal and external conditions to avoid the trouble of "one person to the same department for many times" or "multiple persons to the same department for audit".

The second is the preparation of process system audit. Among them, the most important thing is to prepare appropriate audit plan. The process audit plan is fundamentally different from the traditional compliance audit plan. It should be designed on the basis of the process identified by the organization. Each process includes one or more standard terms. At the same time, a process often involves multiple functional departments. The responsible department and the executive department of the process should be audited. Generally, the preparation of audit plan includes the following steps:

(1) Identifying process of the organization

ISO 9001 standard clause "process method" puts forward that "in accordance with the quality policy and strategic direction of the organization, each process and its interaction system shall be regulated and managed". No matter how complex the quality management system process is within the organization, it can be generally classified into three types: customer-oriented process or core process
("P" means), support process ("s" means) and management process ("m" means). The organization shall analyze and determine the sequence and interaction of these processes, define process elements and form the process description of the organization, as shown in Table 2 quality management system process description sample table.

**Table 2. Sample table of quality management system process description.**

| Process number | Process name | Input | Process activity | Output | KPI and target value | Process owner | Monitoring method |
|----------------|--------------|-------|------------------|--------|----------------------|---------------|------------------|
| P1             | Operation planning and control | 1) Assignment, contract requirements, technical requirements 2) Applicable laws and regulations | 1) Identify products and objectives. 2) Determine product realization stage, etc. | 1) Project planning report. 2) Risk management plan. 3) Technical status management plan, etc. | Planning timelines rate = 100%, etc. | Responsible department | Every quarter. |

(2) Analysis process requirements and standard terms requirements
Comprehensively consider the requirements of process category, process requirements and standard terms to achieve the audit objective of covering process coverage terms. The comparison between process and standard elements can be represented by matrix diagram. Table 3 is an example of audit process requirements and terms correspondence table.

**Table 3. Requirements of audit process and corresponding relationship of terms.**

| Process number | Process name | Process requirements | AS9100D clause |
|----------------|--------------|----------------------|----------------|
| M1             | Management review | quality policy; Quality objectives; Process KPI; Data statistics and analysis; Management Review Report; Internal audit report; Corrective / preventive action report | 4.4 5.1 5.2 5.3 6.1 6.2 6.3 9.1 9.2 |
| M2             | Internal audit | | |
| M3             | Continuous improvement | Customer satisfaction questionnaire; Customer satisfaction improvement plan; Customer complaints and handling | 9.1 8.2.1 |
| M4             | Customer management | | |

(3) Prepare appropriate audit plan
Based on the process of organization identification, according to the analysis results of process requirements and clause requirements, a system audit plan based on the process method is prepared. The process system audit plan is operated across departments. Therefore, it is necessary to pay attention to the rationality and efficiency of department arrangement. Table 4 shows an example of internal audit plan of quality management system based on process method.
Table 4. Example of internal audit plan of quality management system based on process method.

| Audit time | 9:00-9:30 | 9:30-12:00 | 13:00-17:00 |
|------------|-----------|------------|-------------|
| First group|           |            |             |
|            | Planning of contract management and product realization (component test) P1-P2 | Design process (component test) P3 | Audited Department |
|            | Audited Department | Management process (interested parties, organizational environment, risk opportunities, process operation environment, etc.) | Audited Department |
| Second group| First meeting of internal audit | Management process - Leadership Communication Knowledge management S6 | Audited Department |
|            | | Audited Department | |
| Third group| Contract management, product realization planning, design process P1-P3 | Production process P5-P6 | Audited Department |
|            | Audited Department | | |
| Fourth group| Contract management, product realization planning, design process P1-P3 | Production process P5-P6 | Audited Department |
|            | Audited Department | | |

The audit plan shall be repeatedly discussed, approved and implemented by the leadership, technical experts and internal members of the audit team.

Third, the implementation of internal audit of process methods. According to the audit plan and audit checklist, combined with CAPD audit ideas, find the process data, and evaluate the compliance and effectiveness of the process.

Fourth, verification of audit report and corrective measures. According to the audit findings, a "process effectiveness evaluation report" is formed. Different from the compliance audit report, the process effectiveness evaluation should comprehensively evaluate whether the implementation of the process is good, whether the performance of the process reaches the planning results, and whether the organization has taken appropriate measures if the performance indicators are not achieved. Generally, the evaluation conclusions are as follows:

1. The process implementation has reached the result of organization planning.
2. When the process implementation fails to reach the results planned by the organization, appropriate measures are taken.
3. The implementation of the process did not reach the planning results of the organization, nor did appropriate measures be taken.
4. The process is not implemented and fails to achieve the results planned by the organization.

4. Advantages of process method system audit
The advantages of comprehensive analysis process method system audit mainly include the following aspects:

First, the audit main line is in line with the actual operation process to ensure the integrity of the audit process. The process audit method breaks the traditional "department limitation" and "space limitation", and audit the process step by step along the process route. The actual operation process involves multiple departments and different sites, and the process method matches with it to ensure the complete audit of a process.

Second, the clauses require the return to process management to achieve efficient audit results. Process method audit, return the terms and requirements to the activities (process)
management of the audit, pay attention to the systematicness of the process, judge whether the activities of the process meet the standard requirements, which is conducive to finding out the inconsistency between the department objectives and the process objectives, and obtain high-efficiency audit results.

The third is to provide efficiency for the improvement of organizational management mode. The process method audit finds out the weak links in the process operation, directly enters the key links in the process from the management elements, and ensures that the establishment, implementation and improvement of the quality management system are closely combined with the performance, which can effectively promote the organization to continuously optimize the process, so as to improve the management mode.

5. Some suggestions and Enlightenment

Based on the improvement of process method system audit, the following suggestions are put forward for the application of process method and the implementation of process method system audit:

Understand and consistently meet requirements. Every process needs to be analyzed and designed in depth. Who is the customer, what is the customer's requirements, what information and resources are inputs, and what are the risks affecting the process output. Only the process design that constantly meets the requirements is effective.

Consider the process from a value-added perspective. Design process performance indicators based on the principle of "more, faster, better, and less" in order to continuously improve the process, delete, merge or transform unnecessary processes or activities, and achieve value-added purpose.

Strengthen the evaluation of data and information, and improve the process with quantitative indicators. The monitoring and measurement system is used to collect data, analyze and compare the objective measurement data with the planned objectives, find out the differences, and promote the continuous improvement of the process. The quantitative evaluation method is used to analyze the process audit results, evaluate the audit differences and the trend of process changes, and provide data support for process improvement.

6. Conclusion

Process method is a new standard and new situation, which is a new requirement for the organization to establish, implement and improve the quality management system. It is the trend of quality management system audit faced by enterprises. The quality management system audit with process method as the core can take the performance of the organization as the main clue, pay more attention to customer requirements, value-added process and continuous improvement. In order to improve the quality management system continuously, the systematic problems of the process are grasped from the macro view.

References
[1] Li Shuangming. Research on methods to improve quality management of weapon equipment [J]. Electronic design engineering, 2014, 8: 26-27
[2] Sheng Jianyou. PDCA cycle in equipment development [J]. Electronic quality 2012, 11: 45-48
[3] Wu Guilin. On the application of process method and system method to military software quality management [J]. Standard science, 2010, 11: 64-68
[4] Wang Peixun, Zhou Yong. Main characteristics of process method audit [J]. Certification technology, 2012 (1): 34-35
[5] Meng Bo, quality management system auditor, standard conversion training textbook 2015 [M], edited by China Certification and Accreditation Association, Beijing: China Quality Inspection press, China Standards Press, 2015