Construction Plan for Digital Cockpit of Quality Management

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Abstract. Quality management digital cockpit is a platform for display and operational analysis of quality data based on design, procurement, construction, commissioning and other businesses. The quality cockpit enables access, analysis, presentation, and the use of quality performance indicators and related quality business data. The quality cockpit can display the quality data concerned by the management in an intuitive way, and can drill down into multiple projects, multiple dimensions, different indicators, and different levels to improve the effectiveness, utilization, and standardization of quality data. And through intelligent analysis, it can predict and warn of possible quality problems in time. Realize the intelligent transformation of quality data from monitoring, early warning to prediction, and promote the high-quality development of the company.

Keywords: Quality management platform; cockpit quality; business data; quality performance indicators; data access; data analysis; data presentation

1   Introduction

With the rapid advancements in the nuclear industry, coupled with the pervasive digital revolution sweeping across society, quality management has undergone a profound transition from the traditional paradigm of total quality management to the era of digital intelligent quality management [1]. Simultaneously, the widespread application and deep integration of digital technology are significantly altering the management and operational modes across various sectors [2]. Against this backdrop, China Nuclear Engineering actively responded, began to gather resources, committed to establishing a digital quality management platform, and realized all-round digital management of major business processes such as R&D, design, procurement, construction, commissioning, and technical service projects [3]. Among them, the quality cockpit, as the core component of the platform, is not only the display window of quality business data, but also an important tool for operational analysis, providing a new perspective and means for quality management.

This study aims to delve deeply into the quality cockpit, analyze its application value within the context of digital intelligent quality management, and offer theoretical support and practical guidance for innovating quality management practices within the nuclear industry, and potentially, the entire manufacturing sector.

2   Cockpit Business Function Requirement Analysis

During the construction phase of a nuclear power project, each business segment within the company generates substantial volumes of business data throughout the business processes to facilitate the smooth progress of the project. The Quality Assurance Department, on the other hand, develops and implements a series of quality assurance processes. These encompass the establishment of quality standards, ongoing quality monitoring, the identification and treatment of quality issues, as well as the implementation of improvement measures. A series of processes are implemented to ensure the safe and stable operation of nuclear power construction and form an interactive cycle of quality and business, as shown in Figure 1.
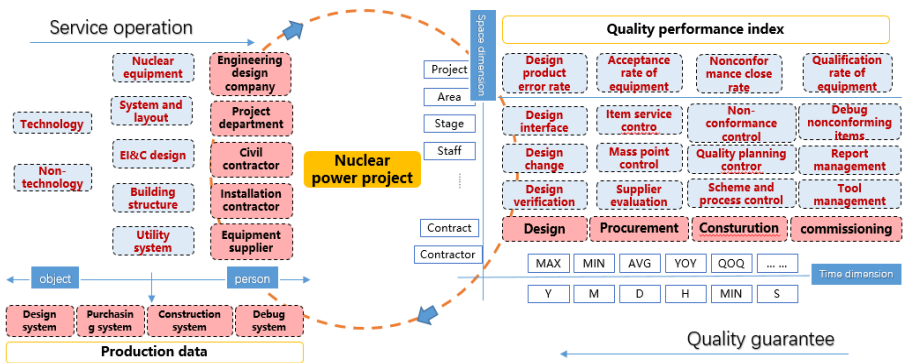

Fig. 1. Nuclear power business and quality management

At present, the quality information of China Nuclear Engineering is mainly concentrated in four parts: design, procurement, construction and commissioning. Each plate needs to extract a large amount of quality data for quality management. The quality assurance department then carries out statistical analysis on the quality information, and finally obtains the overall quality trend of the company [4][5]. Through quality control, the production practice is guided, as shown in Figure 2. In order to intuitively reflect the quality of each plate, the quality assurance Department adopts the reliability analysis method to sort out the quality indicators required by the four plates, and conducts modeling and analysis of the quality big data in stages through intuitive and accurate real-time data[6]. The comprehensive score obtained by each index can be used to quantify the status quo of quality management, as shown in Figure 3.
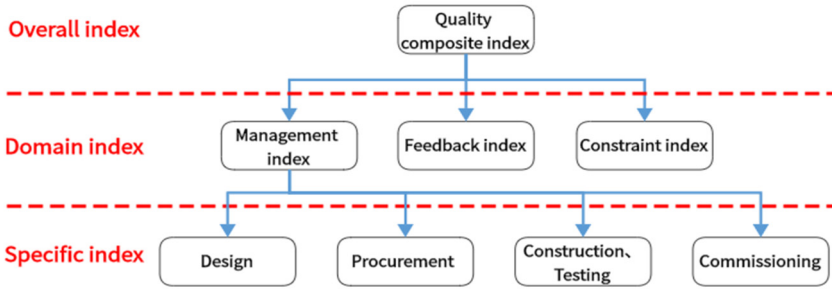
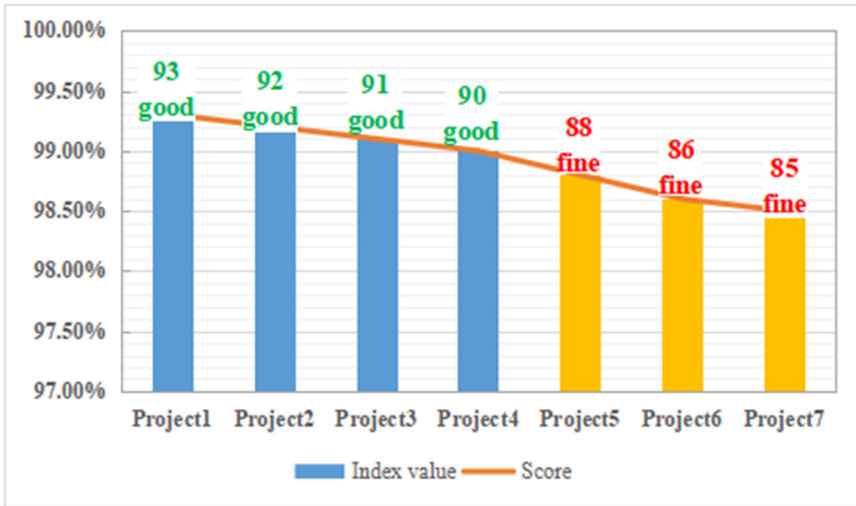**Fig. 2.** Quality performance indicators

Fig. 3. Quality performance evaluation

3   Cockpit Design Framework

Quality management cockpit will deeply integrate quality information and business, based on "data +AI", bring together existing data and business assets, promote the formation of data-driven, platform support, knowledge sharing, data collaboration, intelligence-led new digital system [7][8], and facilitate the high-quality transformation and development of digital quality management. The overall architecture is shown in Figure 4.
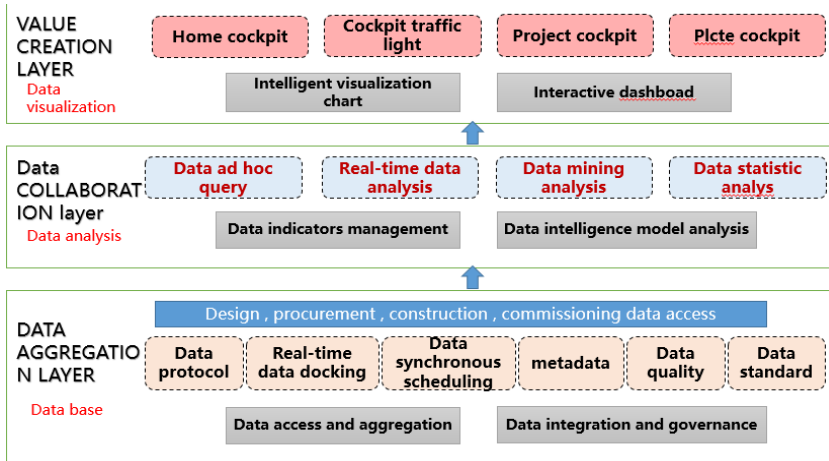
Fig. 4. Quality cockpit design framework

3.1 Data Aggregation Layer

The data aggregation layer plays a crucial role in the cockpit system. It is not only the main source of the cockpit data, but also responsible for integrating the data of each generation link and realizing the access and summary of the data. Through automatic acquisition, real-time acquisition, analysis and aggregation, and multiple sharing functions, the data aggregation layer ensures the comprehensiveness and real-time performance of the data, providing accurate and reliable data support for the cockpit

3.1.1 Quality Data Access and Aggregation

In the construction process of quality cockpit, data access is undoubtedly a core and complex link. In order to ensure the effective use and accurate analysis of data, it is necessary to conduct comprehensive combing, evaluation, interface establishment and standardized processing of data [9].

We need to have a deep understanding of the current state of data from each system source. This includes the format of the data, how it is stored, how often it is updated, and so on. And at the same time, we also need to assess the availability of quality data, which means whether the data is complete, accurate, reliable, and can meet the analytical needs of the quality cockpit.

In the process of data access, the most important thing is to establish different data interfaces. Given the diversity of data sources, we need to design and develop corresponding data interfaces according to the characteristics of each system. These interfaces need to be able to automatically access existing business system data and be scalable to accommodate new platforms and other quality data access requirements in the future.

3.1.2 Metadata Standard Development

The Quality cockpit has developed standardized metadata [10], combed and cleaned the data, and improved the relevant data governance norms and processes. Through the development and implementation of these specifications, the accuracy, integrity and consistency of data are ensured, thus effectively promoting the improvement of data quality.

Standardized metadata provides clear guidance and specifications for data access and aggregation, so that data from different sources and different formats can be processed and integrated according to a unified standard. This greatly improves the comparability and availability of data, and provides strong support for subsequent data analysis and decision-making.

In addition, the Quality cockpit also considers the orderly management of quality data assets. Through comprehensive sorting and classification of data assets, a perfect data management system has been established to ensure the security and accessibility of data assets. This not only helps to improve the efficiency of data use, but also avoids risks such as data leakage and abuse.

3.2   Data Collaboration Layer

The data collaboration layer of the quality cockpit, with the data center and the quality warehouse as the core, is the concentrated embodiment of the digital capability of the enterprise. The data center integrates data from various business systems and ensures data quality by standardizing metadata to provide a solid foundation for analysis [11]. The quality warehouse focuses on data storage and processing to realize real-time classification and sorting of data [12]. The combination of the two realizes comprehensive collaborative data processing and provides strong data support for cockpit functions. Through the visual display of the cockpit display board, data in various fields can be used and displayed, providing accurate data support for business decisions. The construction of this data collaboration layer not only improves the level of enterprise data governance, but also promotes the process of digital transformation. It makes full use of data resources, fully explore the value of data, and inject new impetus into the development of enterprises. The construction of this data collaboration layer can not only improve the level of enterprise data governance, but also promote the process of enterprise digital transformation.

3.2.1 Quality Data Analysis

The quality data analysis module can implement the collection, processing and presentation of quality data, and the comprehensive integration of quality data. Data mining, machine learning, AI processing and other technologies are used to conduct in-depth data analysis, form a comprehensive and unified view of quality data, save the analysis results to the personal data portal, and generate a comprehensive quality report for users to export and use.

3.2.2 Quality Data Assets

All kinds of structured data and non-structured data such as document information in the quality data warehouse can be opened to quality management personnel with corresponding permissions for independent inquiry [13]. Users can visualize the status of data assets. At the same time, it can also seamlessly connect with the quality data analysis function, and directly use the queried data for quality data analysis, and write the results into the quality document.

The multidimensional analysis of data in the quality cockpit provides an important basis and tool for decision support, which helps the company realize the functions of problem diagnosis, trend prediction, resource optimization and performance evaluation in quality management, so as to make more scientific and reasonable decisions. Collaborative management of quality data can improve the effectiveness, timeliness and collaboration of company data management and archiving.

3.3   Value Creation Layer

The value creation layer is the business display layer of the cockpit, which is the key to the quality of the cockpit. Quality managers manage and make decisions through the data and results displayed in the cockpit [14]. The core of the value creation layer is "one image imaging". Through the display of quality performance indicators, the quality of engineering projects of each project and each section of the company can be painted, and the scoring results can be displayed with intuitive and accurate real-time data for users at all levels.

3.3.1 Quality Data Visualization

Data visualization in the cockpit can transform complex data into an intuitive and understandable graphical interface. In the cockpit (as shown in Figure 5), there are the overall quality trend of the company, the score of the overall quality trend of each section and each project, the comparison of the score and the historical trend, and other key content such as the abnormal quality of each project; Quality performance traffic light interface, quantitative scoring results of all items and indicators, through the visual display of traffic lights; The project quality perception cockpit corresponds the actual construction progress of the project to the quality inspection node of the Nuclear Safety Administration, the project milestone node and the occurrence time of quality accidents, and intuitively reflects the current key work and main quality risks of the project; Plate quality perception cockpit, through in-depth mining of various index data of each plate, multi-level data drilling, through multi-dimensional analysis and comparison, detailed display of the scores of each quality performance evaluation index, quality information collection and reporting analysis.

Fig. 5. Cockpit page display

3.3.2 Quality Real-Time Monitoring and Early Warning

Performance scores for key indicators and eye-catching identification of quality performance traffic lights, as well as changes in quality trends, can quickly identify potential problems and risks to the project (as shown in Figure 6). By setting the early warning threshold of quality performance and early warning of possible risks, such as the red light of quality performance, quality accidents and abnormalities, the company management can respond quickly to problems and deal with them in time.

Fig. 6. Quality Performance Traffic Light

3.3.3 Auxiliary Decision Making

Relying on real-time data collection, update and display of various types of data, the company's management can be clear about the core data, and can help managers timely grasp the construction dynamics and internal operations. By relying on the monitoring and utilization of the entire data process, it can assist managers in providing end-to-end tracking of all production data. Relying on the computational analysis of intelligent algorithms, machine algorithms and deep learning models, the cockpit can conduct comprehensive data analysis, monitoring and business insight on project data, enabling managers to carry out targeted quality control. The cockpit helps the relevant leaders to efficiently manage the normal operation of the project from different management paths such as project dimension and unit dimension, achieve decision support based on quality data, and improve management ability.

3.4   Technical difficulties in cockpit implementation

In the construction process of the quality cockpit, the following technical difficulties need to be considered:

(1) The system interface involved is complex

In the four plates of design, procurement, construction and commissioning, each plate has different business logic, different systems used, different degrees of digitalization, and different ways of data storage and interaction. Therefore, it is necessary to analyze the data and system of each plate respectively, and coordinate various departments to establish different interface access methods. However, the data must be imported into the cockpit to form a unified data format and data assets.

(2) Complex data sources

There are many sources of quality data collection, including manually filled reports, paper documents, imported files using excel, word, pdf, etc., and result data extracted from business data of other platforms. The frequency of the report is varied (day, week, month, quarter, year, etc.); The collection methods are complex, some are full collection, some are incremental collection. Indicators need to be analyzed in different dimensions according to different data analysis methods.

(3) The complexity of performance index evaluation

Owing to the intricate nature of data sources and the multifaceted character of index evaluation dimensions, some indicators are designated as quarterly while others are monthly. Certain indicators reflect statistical accumulations over time, whereas others reflect the specific performance of a given month or quarter. Some indicators are integral to the process of performance evaluation, whereas others serve solely as monitoring metrics. Furthermore, as the digitization dimension of data expands, some indicators may afford additional analytical dimensions, thereby enriching the scope of potential analysis. Consequently, in the computation and presentation of these indicators, it is imperative to conduct classification analysis and ensure the accurate display of information.

(4) The graphical display of the cockpit is intricate

Some previous indicators are presented solely in the form of data and text, which cannot be adequately represented by the current charting methods. Additionally, Some

of the metrics are so complex that they need to be broken down and simplified in the cockpit. Therefore, it is imperative to meticulously consider these indicators, disaggregate the data information contained within them, and extract the intention they aim to communicate. Grasping the commonalities in the expressive content of indicators allows for intuitive, clear, and comprehensive display.

4   Conclusion

The cockpit system has revolutionized the traditional approach to quality management. The cockpit system not only enables online processing of critical quality issues and facilitates network collaboration, significantly enhancing work efficiency, but also propels a profound transformation of the company across multiple dimensions.

1. The quality database is formed

The quality cockpit has built two major calculation models, quality performance evaluation model and quality index calculation model, which have been widely valued by various projects and sectors in the implementation process.

2. The data penetration is realized

The quality cockpit connects eight projects in four sections, and realizes the up-down linkage and integration of the five links of raw data and quality data access in each section of the project, quality data processing and calculation, quality index analysis, and quality performance evaluation, forming two dimensions of data and analysis. It provides a solid data foundation for the analysis of the quality sector of the company, and makes the connection and utilization of the data of the quality sector and various systems, so that the decision has more comprehensive data support and more accurate data basis, and the subsequent extraction and control of quality data will be more convenient.

3. Promote quality management improvement

The quality performance evaluation method realizes the quantitative evaluation and management of various projects, and each general contract project can fully grasp the operating data information of each section through the cockpit. The red and yellow indicators of each plate have been rapidly processed and improved, and the management of each project has been optimized. For the blue light item, each plate is also thinking of countermeasures to improve, and promote the quality management of each project. Promote the quality management work to achieve more scientific, more perfect, more effective, more mature leapfrog improvement.

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