Research on project management methods for fusion engineering

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Abstract. The Comprehensive Research Facility for Fusion Technology (CRAFT) system is one of the major scientific engineering projects prioritized in China's 13th Five Year Plan for the Construction of National Major Science and Technology Infrastructure. Its construction purpose is to lay a scientific and technological foundation for the construction and operation of China Fusion Engineering Experimental Reactor (CFETR), and ensure the safety, reliability and progressiveness of China's fusion experimental reactor. This article mainly analyzes the project management methods for the research facilities of the key system of the fusion reactor host, including the establishment of the engineering project management system and the introduction of project management methods. It also provides reference for other major scientific engineering project management.

Keywords: CRAFT, CFETR, Project Management, Major Scientific Engineering, Nuclear Fusion

1 INTRODUCTION

Energy is the most important foundation for sustainable development of human society, and the development of green, renewable, and environmentally friendly energy is the only way forward. Nuclear fusion can have outstanding advantages such as rich resources, low carbon, safety and near pollution-free. It will become the ideal energy in the future of human society and one of the fundamental ways to solve human energy problems. The "Medium and Long Term Plan for the Construction of National Major Science and Technology Infrastructure (2012-2030)" issued by the China clearly proposes the strategic deployment of "timely launching the construction of efficient and safe fusion reactor research facilities, and accelerating the practical application process of fusion energy". Fusion research is a long-term and difficult great undertaking. With the joint efforts and unremitting efforts of the world's fusion community, significant progress has been made in various aspects such as high-temperature plasma physics and engineering, entering the stage of verifying combustion plasma physics and partial construction [1]. The ITER construction phase for the feasibility of major fusion countries in the world. Major fusion construction countries in the world

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have launched the design and research and development of fusion demonstration reactors, and China has also proposed its own "Fusion Engineering Test Reactor (CFETR)" research plan. Currently, it has entered the engineering design stage, but China's domestic research facilities are particularly scarce. The existing fusion research facilities in various aspects such as scale, systematization, and specialization cannot meet the needs of independent reactor construction, there is an urgent need to build relevant facilities. Based on this, China's fusion community has proposed the construction of an internationally leading national major scientific and technological infrastructure, the Comprehensive Research Facility for Fusion Technology (CRAFT), to provide engineering construction technology reserves and engineering technology verification platforms for fusion reactor construction research, and to lay the foundation for accelerating the application of fusion energy [2-3]. Taking the CRAFT power system as an example, the overall installation layout of the project is shown in the following Fig.1

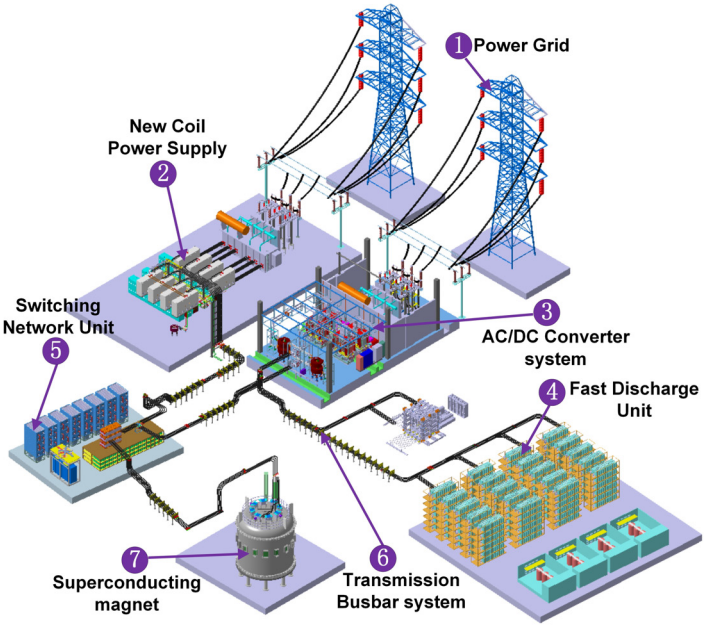

Fig. 1. CRAFT power system project

The entire project consists of two parts: park construction and facility main body. This article mainly discusses the project management methods and management system construction of facility main body construction.

2 CRAFT PROJECT MANAGEMENT SYSTEM

For the CRAFT project organization, establish a comprehensive research facility engineering command center and a scientific and technological committee for the fusion reactor host key system as shown in Fig.2.

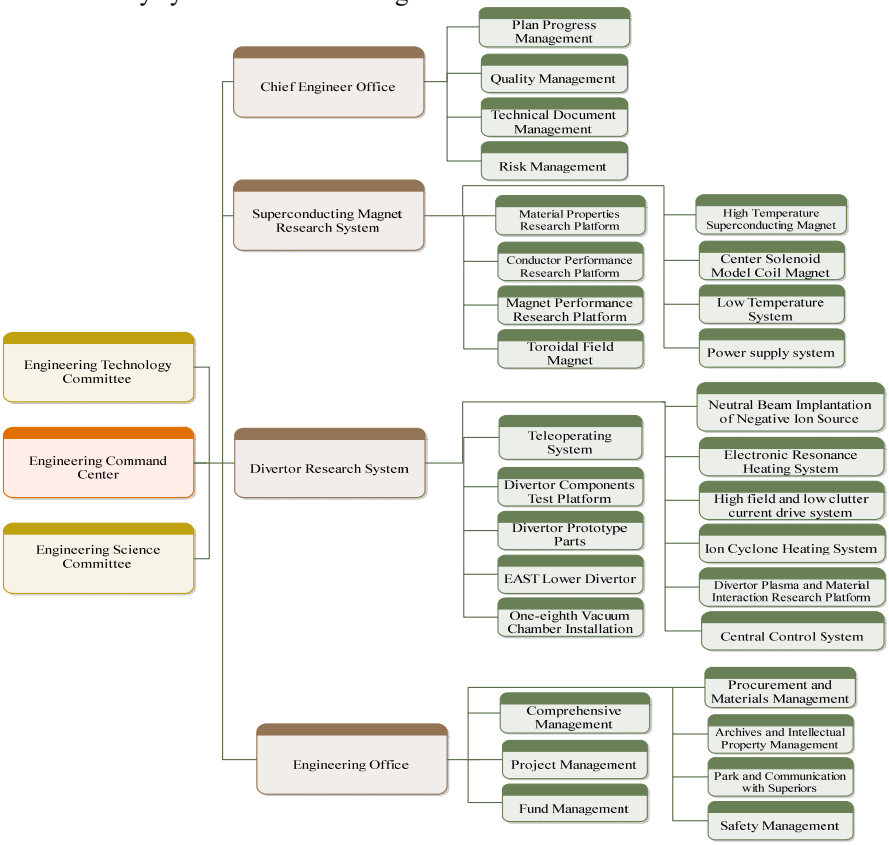

Fig. 2. CRAFT Project Organizational Structure

The engineering command center includes the chief commander, deputy chief commander, chief scientist, chief engineer, chief craftsman, and chief economist, providing top-level design and decision-making for the project. The Science and Technology Committee is composed of experts and scientists from the same field who provide guidance and constructive opinions for the project, guiding the smooth progress of the project. At the same time, an engineering technical committee will be established to provide technical support during the project execution period [4-5].

The main body of the facility consists of a superconducting magnet research system and a divertor research system. The research system of superconducting magnet includes eight systems: research platform of material comprehensive performance, research platform of conductor performance, research platform of magnet perfor-

mance, toroidal field magnet (TF), central solenoid coil magnet (CSMC), high temperature superconducting magnet, cryogenic system and power supply system. The divertor research system mainly comprises a divertor plasma and material interaction research platform, a divertor component engineering test platform, divertor prototype components, an EAST lower divertor, a 1/8 empty chamber and an overall installation system, a negative ion source neutral beam injection system (N-NBI), an electron resonance heating system (ECRH),There are 11 systems such as high field lower hybrid current drive (LHCD), remote control system (RH) and master control system[6].

3 CRAFT PROJECT MANAGEMENT METHODS

3.1 Management Mode

In terms of CRAFT project management mode, the project headquarters is the starting point, and the fine management mode is put forward. The person in charge of the plate and the functional departments work together, report in time, and establish a technical support system and a comprehensive support system in the process of project construction, installation, commissioning and operation [7]. At the same time, CRAFT adopts collaborative management mode, which integrates all project-related contents such as project management, document management, design management and resource management into the online collaborative management platform to achieve unified centralized management and integrated collaborative process of project, structure/electronic design and simulation. With the WBS work package as the framework, the standard engineering design process as the basic work plan, and the output documents as the basis for work acceptance, the three are combined with the project classification plan, and the critical path and key milestone management system are used to manage the plan and track the whole process of the project execution cycle. Management mode is showing as Fig.3.

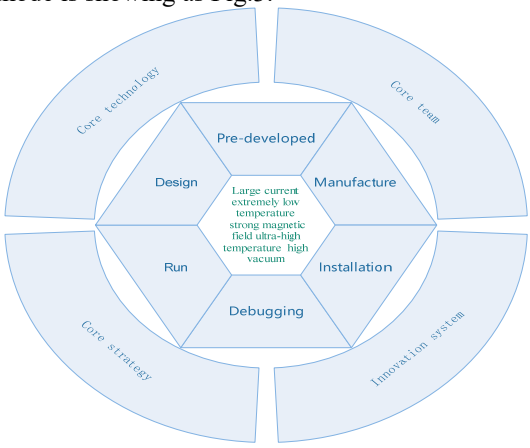

Fig. 3. CRAFT Project Management Model

Designate and improve the "Engineering Implementation and Management Plan" and "Project Assessment Management Measures" in project management, where the "Engineering Implementation and Management Plan" serves as the guiding principle and benchmark for project engineering, completing institutional management methods such as fund management methods, procurement and asset management methods, project management methods, archive management methods, and other comprehensive management methods. Establish them in accordance with regulations, making project management institutionalized and standardized Standardization. The "Management Measures for Project Assessment" mainly focuses on project assessment and management, including the issuance and review of project task books, the execution of project funds, process supervision of archives and quality, and selection and recognition of projects.

3.2 Project Quality Management

Drawing on the successful EAST and ITER implementation management experience of high-quality component delivery, based on PDCA cycle theory, through the implementation of system construction and operation planning, standardized quality control of the whole process, key links witness and pass, regular quality status evaluation and analysis to achieve continuous improvement. Construct the ISO 9001 quality management system for the whole life cycle to ensure that the project achieves the expected performance and fully meets the design indicators. Determine the detailed quality policy, establish rules and regulations, determine "top-level document-management system-implementation rules-record template" as the four levels of system documents, issue the Project Quality Assurance Program and a number of quality control documents, complete the establishment of the overall quality system of the project, and ensure the institutionalization, standardization and standardization of project implementation.

The CRAFT project platform, support and system construction take QP-MIF-MIP as the specific implementation path to plan and promote quality work, determine the resources and management basis required for quality, and analyze the implementation process in advance based on the process method, and set up different quality control methods. Based on the key quality characteristics, multiple types of quality control points are scientifically preset for multiple topics that have entered the component pre-research and core process research. Before the implementation of each quality control point, system management control procedures such as technical verification, process control and test acceptance requirements should be established. During the implementation, each quality control point should operate in accordance with the safety regulations and keep a complete process record, which should be released after confirmation by a special person. Important key quality control points must be released after the authenticity and validity are witnessed by the Chief Engineer Office and the Engineering Command. Various special trainings on quality management shall be carried out flexibly at different levels, and qualification certification and quality training for relevant personnel shall be completed according to project requirements. Through continuously improving the quality management skills and level of

scientific research personnel. Through the implementation of management review, internal audit, subject exchange and discussion, we seek opportunities for management improvement and continuously improve the operation level of the quality system.

3.3 Project Schedule Management

Implement the requirements of project engineering headquarters and progress management measures, compile the CRAFT Annual Key Milestones, and set up milestone points for monitoring and inspection during the implementation of the plan. In order to ensure that the milestone completion witness review work can be carried out in a standardized manner, the milestone description document template, milestone self-inspection report template, milestone review flow chart and milestone deviation application form have been prepared and improved successively to guide the first-level research groups to prepare the relevant work of milestone review in time according to the requirements. At the same time, evaluate and determine the key milestones in the later stage of the project as the key management and control objectives to ensure that the project passes the acceptance on schedule. According to the project schedule management method, taking the overall project schedule as the core, using the principle of WBS work breakdown structure, and adopting the strategy of short-term detailed long-term summary, a three-level schedule framework is set up. Assist each first-level research group to prepare the benchmark progress plan of the project by using the progress management software, and put forward rectification suggestions for the current problems of the progress plan and help to carry out optimization work, so as to ensure that the project progress plan can be smoothly tracked and updated regularly and the overall linkage calculation. Complete the preparation of the preliminary progress plan for each first-level subject of the CRAFT project, and complete the rectification work of all the recommended optimization items of the subject progress plan as planned. The project schedule is showing as Fig.4.

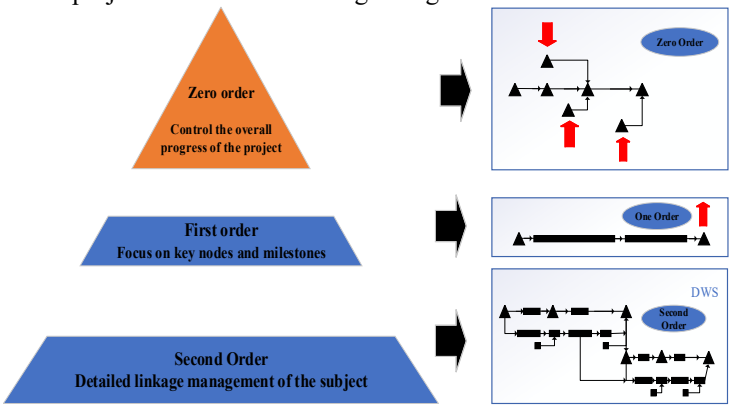

Fig. 4. CRAFT Project Schedule Structure Partition Diagram

Implement the hierarchical management system of monthly report, organize the first-level project to record the implementation of progress plan, existing problems, solutions and follow-up plans in the monthly report on a monthly basis, submit the monthly report of the second-level project to the first-level project for review, and summarize the evaluation report from the progress, progress implementation and key milestone warning by the chief engineer office to form the overall monthly progress evaluation report of the project. In addition, during the implementation of the monthly report, the template was optimized and upgraded, including the implementation of progress, document management and evaluation of secondary topics, to ensure that the project moves forward as planned. In order to continuously and effectively promote the operation of the progress management system and improve the software operation proficiency of the progress management personnel of the research group, P6 software training for project progress management is provided. Starting from the knowledge of project management, grasping the idea of progress control, combining actual combat with theory, this paper interprets the various functional modules of P6 software, the process of schedule preparation and the tracking and updating of schedule, and at the same time, with the help of excellent cases in the industry, makes the schedule personnel have a further understanding of the project schedule management system, and helps to continuously improve and enhance it.

3.4 Project Risk and Funding Management

With the management idea of "risk identification-risk assessment-risk response", the CRAFT Risk Management Measures are formulated, the project is organized to complete risk identification and risk assessment, refine risk response plans, continuously carry out dynamic assessment and monitoring of risks, regularly update and dynamically assess risks, focus on the management of medium and high risks, and optimize risk response. The SMART risk response principles can be showing as Fig.5.The risk can be controlled and identified. Complete risk awareness training for technicians and project managers to enhance risk prevention and control awareness and ability.

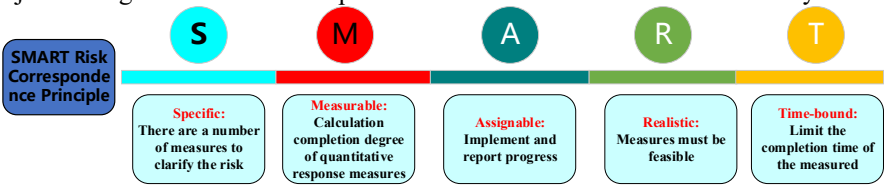

Fig. 5. CARFT Risk Response Principles

To formulate the Measures for the Management of Project Funds, and strive to formulate and complete the annual investment plan, fund declaration and other materials. In strict accordance with the relevant provisions of the state and research institutes, special funds, legal compliance, ARP system project funds management, real-time monitoring of expenditure, standardized reimbursement process and file management, ensure physical review and procurement data filing, formulate detailed rules for the use of funds such as approval of funds, budget changes, business reimburse-

ment, and so on. Ensure the reasonable, legal and efficient completion of the implementation of funds and the examination and approval of economic business.

3.5 Procurement and Records Management

Complete and revise the procurement and outsourcing business management measures, and establish a scientific and applicable procurement internal control management and supervision system. Following the principle of "first application, then procurement", actively carry out the whole cycle process management of procurement review, bidding procurement and performance acceptance, sign and approve step by step according to the procurement amount, realize the process and specialization of procurement management, and gradually achieve the effect of cost reduction. With the working goal of "reducing costs and increasing efficiency, and increasing the share of domestic equipment in the project", the technical evaluation system of purchasing items is established, and the "CRAFT Technical Evaluation Specification for Purchasing Items (Trial Implementation)" is formulated to carry out different purchasing processes and purchasing evaluation systems according to different purchasing amounts from necessity, feasibility, rationality of funds and whether it can be replaced domestically. The procurement team evaluated and accounted for the purchased items, enhanced the rationality of the procurement plan, improved the procurement efficiency, and comprehensively promoted the domestic procurement of equipment; it realized the sharing of resources within the Institute, gave full play to the professional ability of the subject, and increased the proportion of domestic equipment procurement. In view of the problem of "emphasizing bidding and neglecting acceptance" in the past, the procurement team improved and innovated the acceptance mechanism. In terms of acceptance organization, the strategy of separation of procurement and acceptance is adopted, which clearly stipulates that the procurement personnel and the implementation of acceptance personnel have different positions and subject personnel, and invites the superior departments, such as the centralized management department and the supervision department, to participate in the acceptance, so as to supervise the whole process of acceptance. In the form of acceptance, according to the characteristics of different projects, the acceptance methods and methods are clearly defined, and different types of acceptance methods and processes, such as standard goods, testing and processing, services, are formulated respectively. For complex procurement projects, try to invite third-party professional organizations and experts to participate in acceptance. In the process of acceptance, we should stop going through the motions, simplify the procedures, strictly check the bidding documents and contract requirements, collect all the acceptance data and do a good job of archiving. Complete the equipment procurement work efficiently, and realize the complete and systematic process equipment and asset management.

Complete and formulate the CRAFT Project Archives Filing Specification and other detailed rules for archives management, and clarify the responsibilities of archives management, filing principles, filing scope, quality requirements for filing documents, and specific filing requirements. The archives management meeting shall be held in time, and the relevant archivists shall be trained. The EDM document management

system is established, and the document management framework of the whole life cycle centered on the construction object is created, which realizes the functions of graded use, classified storage and online review of electronic documents in CRAFT project. It also establishes a CRAFT project document management team with the chief engineer office and the responsible person for the document management of each subject. Document management specifications shall be formulated to determine the numbering rules, naming rules and approval rules of CRAFT documents. The document management is regularly reviewed and spot checked to supervise the implementation of rectification. The CRAFT project number and project document classification method are shown in Fig.6.

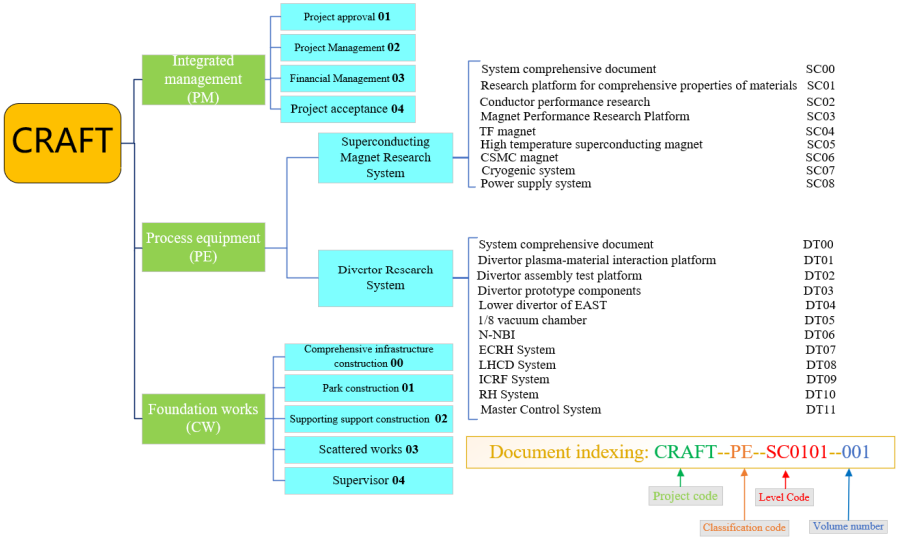

Fig. 6. CRAFT Project Document Classification

4 CONCLUSION

The construction of CRAFT project facilities is to break through a series of major technical bottlenecks in the construction of fusion reactor main engine, solve and verify the core scientific and technical problems related to the construction of fusion reactor main engine, build two research systems of superconducting magnet and divertor with international leading level, and provide extreme experimental conditions such as particle flow, electricity, magnetism, heat and force for the research of key systems of fusion reactor host. The whole project includes a number of major issues and a large amount of project funds, so the project management is complex and unique. This paper makes a systematic analysis and explanation of the project from the aspects of CRAFT project management framework, fund management, quality management, risk management and schedule management, and summarizes the experience of CRAFT project management. It provides reference and reference for the management mode of large scientific engineering projects of the same category.

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