Wireless Transmitting Station Operation and Maintenance Management System Design Scheme (Postprint)

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Abstract

Based on the successful implementation of the ISO 9001 quality management system, this paper proposes the establishment of an effective operation and maintenance management system for wireless transmitting stations to address issues such as unclear processes, insufficient coordination, and fragmented management in technical maintenance operations. This system aims to promote the transformation of safe broadcasting management from results-based management to process-based management, thereby enhancing assurance capabilities.

Full Text

Design of an Operation and Maintenance Management System for Wireless Transmission Stations

Abstract: Building upon the successful implementation of the ISO 9001 quality management system, this paper proposes the development of an effective operation and maintenance management system for wireless transmission stations to address issues such as unclear processes, insufficient coordination, and decentralized management in technical maintenance work. The system aims to shift safety broadcast management from result-based management to process-based management, thereby enhancing overall assurance capabilities.

Keywords: transmission; operation and maintenance; management system

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1. System Design

The main functional modules are illustrated in Figure 2 [Figure 2: see original paper]. The establishment of a wireless operation and maintenance management system seeks to transform the current situation where equipment is emphasized while maintenance and management are neglected, thereby standardizing and elevating technical maintenance and management levels. This transformation will ultimately achieve a shift from result-based to process-based management of safety broadcasting and realize continuous improvement in broadcast quality.

Design Basis: The system is designed in accordance with the "Radio and Television Safety Broadcast Management Regulations" (SARFT Order No. 62), GY/T 179-2001 "Radio and Television Transmission Station Operation and Maintenance Procedures," and GB/T 19001-2015 "Quality Management Systems—Requirements."

Design Principles: The system design prioritizes service to safety broadcasting as its main thread, with equipment lifecycle management as a secondary thread, aiming to standardize operation and maintenance processes while reflecting staff value.

System Objectives: To standardize work processes and build standardized stations, while enhancing operation and maintenance skills and strengthening safety broadcast capabilities.

System Architecture: The system is designed to operate on the station's internal office network, with physical isolation gateways connecting the monitoring network. The software adopts a B/S architecture, as shown in Figure 1 [Figure 1: see original paper].

2.1 User Management

The system manages personnel by department, recording and querying duty and shift handover information while implementing comprehensive permission management, with each individual assigned a unique username and password. Based on established rules, the system automatically generates duty schedules for each period and supports personnel shift adjustments. It records shift handover information to enable process management of handovers, allowing incoming staff to review records from the previous shift. Permission management is granular down to each individual and every operation. The system also supports workload statistics by department and by individual.

2.2 Equipment Management

This module manages equipment throughout its complete lifecycle, divided into pre-management, usage management, and decommissioning, as shown in Figure 3 [Figure 3: see original paper]. Equipment is coded using an 11-digit system: equipment type (00) + department (00) + room (00) + cabinet (00) + serial number (000). This code remains unique throughout the equipment's entire

lifecycle, enabling queries for purchase information, maintenance records, spare parts replacement records, and other relevant data from the code alone. The code is converted into a QR code and affixed to a prominent location on the equipment panel, allowing staff to scan it with a mobile APP to instantly access all required equipment information.

The pre-management phase spans from submission of the procurement plan to equipment acceptance, managing documentation and information for each stage, including the equipment purchase plan, market research, procurement records (bidding materials, contracts), installation and commissioning records, acceptance records, and responsible personnel for each phase. The usage management phase covers the period from equipment commissioning to decommissioning, encompassing basic equipment information (code, asset code, name, specifications, classification, installation location, department, manufacturer, production date, factory code, commissioning date, equipment status, technical parameters) and linking to maintenance records and spare parts replacement history. The system includes preset expected service life for each equipment item and provides warnings for equipment approaching this limit, offering recommendations for replacement or extended use based on the health assessment function.

2.3 Spare Parts Management

This module comprises three functions: spare parts inbound, outbound, and replenishment planning, primarily for the categorized management of equipment and facility spare parts. Each spare part is directly associated with its corresponding equipment, enabling intuitive queries from equipment to spare parts. For spare equipment (standalone devices), differentiation is achieved through coding. The system supports spare parts inbound, storage location management, outbound, and inventory queries, and automatically generates replenishment plans when spare parts inventory falls below predefined thresholds.

2.4 Daily Maintenance

Based on maintenance plans defined in ISO procedure documents, the system pre-configures annual, quarterly, monthly, weekly, and daily maintenance schedules and automatically generates weekly and daily maintenance plans. On-duty personnel conduct equipment inspections according to these plans, with execution results reviewed by department leadership. Maintenance is categorized as either routine maintenance (such as dust cleaning, replacement of wear parts, and index testing) or preventive maintenance (referring to special inspections, such as additional line and index testing due to weather conditions, or pre-inspections before important broadcast periods). The system supports customized maintenance plans for different equipment types, allows pre-scheduling of annual maintenance plans at the beginning of the year, and enables automatic generation of weekly and daily plans based on these pre-schedules with corresponding manual adjustments. It also supports special maintenance arrangements for important broadcast periods, records each maintenance item with clear responsible per-

sonnel, and supports workload statistics and audit workflows for maintenance results, with department heads accountable for their department's maintenance outcomes.

2.5 Fault Repair

This module encompasses accident handling, accident reporting, and record query functions, completing full-process management of fault inspection and repair while incorporating data mining capabilities for intelligent analysis. Faults are classified as either emergency repairs (reactive) or routine maintenance (proactive). Accidents are categorized by nature, responsibility, technology, sabotage, or disaster, with causes including human operation errors, inadequate maintenance, equipment failure, switching issues, technical quality problems, malicious sabotage, accidents, natural disasters, fire, or other factors.

The system provides comprehensive fault repair information recording and management, documenting each fault's phenomena, occurrence time, emergency measures taken, repair records, recovery time, post-incident cause analysis, participating maintenance personnel, and workload statistics. Based on fault repair records, the system can automatically generate accident reports with approval workflows (data entry → report generation → department head review → chief engineer approval). It supports intelligent fuzzy matching of historical repair records, enabling rapid searches for similar fault phenomena and providing previous disposal processes as references for maintenance personnel. The system can also generate fault trajectory maps and provide predictions and warnings for future similar faults. With data mining capabilities, it enables intelligent analysis of processing records for staff training and provides valuable prompts to maintenance personnel during repairs, transforming the previous phenomenon where repair records were shelved after completion.

2.6 Health Assessment

Through data mining and analysis of equipment repair records, spare parts consumption, monitoring data, index testing, field strength measurements, stop-broadcast rates, and failure rates, the system establishes a self-assessment and prediction model for system health. It visually displays the health status of equipment throughout its lifecycle using data tables and charts, generating equipment operation assessment reports where the weight of each data component can be configured. The health assessment primarily establishes a scientific and standardized evaluation model, referencing the 2017 provincial wireless transmission station inspection checklist issued by the State Administration of Radio and Television. It comprehensively evaluates technical aspects, operation and maintenance systems, and coverage effectiveness by assessing system scientificity, equipment reliability, environmental safety, disaster recovery effectiveness, operation and maintenance efficiency, and coverage continuity.

2.7 Safety Broadcast Management

This module manages safety broadcast by frequency, extracting data from the system to generate accident reports and stop-broadcast rate reports. It manages emergency plan drills and execution and provides special management for important broadcast periods. The system pre-sets scheduled broadcast time and extracts corresponding stop-broadcast time from fault repair records to generate safety broadcast reports, including internal stop-broadcast rate, external stop-broadcast rate, and stop-broadcast rate per 100 hours. It records drill questions, operations, and scores for each emergency plan exercise, incorporating them into individual capability assessments. The system also records the start and end times, assurance requirements, execution personnel, and clear responsible persons for each important broadcast period, supporting workload statistics and maintenance plan arrangements.

2.8 Wireless Terminal

The system supports mobile terminals including Android and iOS, with two-way data encryption and login accounts bound to specific mobile phones and SIM cards. It enables real-time alarm reception and status viewing. Different information is provided to users based on their permission levels, including real-time viewing of transmitter operating status and data, auxiliary equipment operating parameters, and environmental parameters.

Note: Figure translations are in progress. See original paper for figures.