

Research and Application of the "Five in One" Lean Management System for Electric Power Communication Network

Hao Feng*, Yong Zhang, Runhua Yang

State Grid Henan Information & Telecommunication company, China

*519271097@qq.com

Abstract

As the second largest physical entity network in the power system, the power communication network carries production and management operations such as power system scheduling, operation and maintenance, marketing, information, and safety supervision. The level of safe operation of the power communication network directly affects the overall safety and stability of the power system. With the rapid construction of the power grid and the continuous increase in grid business, the situation faced by the power communication network in scheduling, operation, maintenance, and management is becoming increasingly complex, and the pressure on scheduling and operation personnel is also increasing. State Grid Henan Provincial Electric Power Company Information and Communication Branch (hereinafter referred to as "State Grid Henan Information and Communication Company") has proposed a "Five-in-One" refined management system for power communication networks, starting from the five dimensions of "scheduling, planning, maintenance, safety, and emergency" to achieve seamless integration of communication professional management and scheduling operation management, forming a power communication management system that is "efficient in scheduling, strong in network structure, cooperative horizontally, linked vertically, and quick in response", effectively improving the safe operation level of the power communication network in the entire province.

Keywords

Power System; Entity Network; Communication Network.

1. Introduction

1.1 Basic Status

As the second largest physical entity network in the power system, the power communication network carries production and management operations such as power system scheduling, operation and maintenance, marketing, information, and safety supervision, and is an important foundation for the comprehensive construction of smart grids, continuous improvement of company efficiency and benefits, and guaranteeing safe production. The power communication network in Henan Province includes the headquarters of the provincial company and 53 500kV and above substations, 459 220kV substations, 33,571 kilometers of optical cables, 10,123 sets of communication equipment, and carries 48,480 business channels, including 26,400 production control channels. The existing scale of the power communication network is large, and the situation faced in scheduling, operation and maintenance, and management is becoming increasingly complex. The responsibilities and pressures of scheduling and operation personnel are also increasing. In addition, the existing communication network is formed along with the construction of the power grid, the network structure is not

optimized enough, the distribution of optical cable resources is unbalanced, and there is a high risk when optical cables malfunction, leading to many difficulties in operation and emergency repairs.

1.2 Main Research Content

In accordance with the overall requirements for the development of the power communication network of the Henan company, Henan Information and Communication Company starts from the five dimensions of “scheduling, planning, maintenance, safety, and emergency” to carry out full-process control. Clarify the influencing factors of each link, achieve “intensive construction and homogeneous operation” of communication scheduling, optimize network architecture, establish a multidimensional collaborative mechanism, implement business information disclosure, establish a synchronous assessment mechanism for communication network risks, improve the closed-loop management process for defects, innovate emergency drill mode, create a three-dimensional communication emergency system, strive to build a “detailed scheduling, strong network framework, horizontal collaboration, vertical linkage, and rapid response” power communication network control system and evaluation system, enhance the support capability of the power communication network in Henan, promote the construction of the company’s smart grid, and achieve the “dual-network” development of power.

2. Research and Application of Methods

2.1 Lean Management System of “Five-in-One”

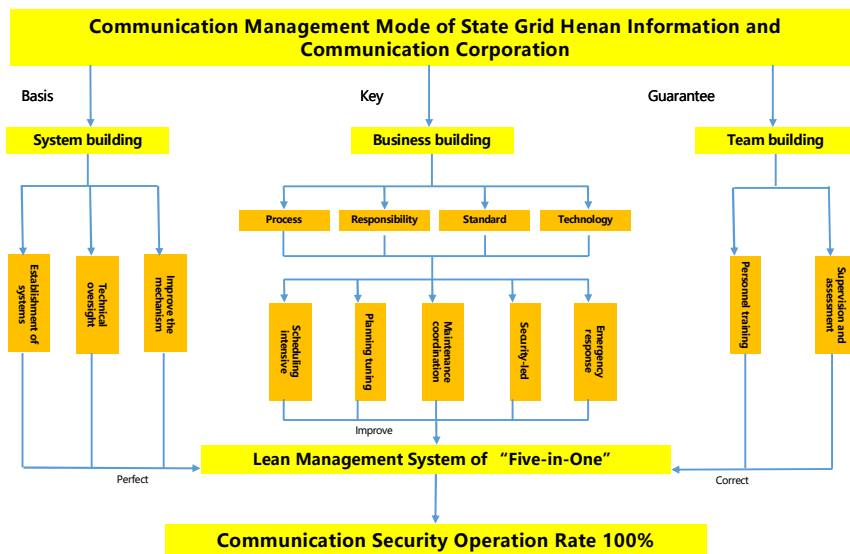


Figure 1. Lean Management System of “Five-in-One” flowchart

State Grid Henan Telecommunications Company has strengthened the top-level design of communication management mode, based on system construction, with business development as the key, and team building as the guarantee, to establish a full-process management system for communication operations, and implement a lean management system of “five-in-one” for the power communication network in the whole province, which includes “scheduling, planning, maintenance, safety, and emergency.” With intensive scheduling as the guidance, emphasis is placed on network planning and optimization, strict control of maintenance plans, multi-dimensional risk assessment and dynamic management of defect risks, rolling revision of large-scale power-outage emergency plans, and various special communication emergency plans, to achieve an overall improvement in the

safety of communication network operations. At the same time, key control points are added to the process, implementing a closed-loop management system, and combining communication network operation management with performance evaluation to ensure the proper implementation of the process.

2.2 Main Methods

2.2.1 Intensive Scheduling - Network Management Monitoring Centralized at the Provincial Level, and Full Coverage of Provincial and Local Communications

As of October 2023, the total number of communication transmission equipment in the Henan power system has reached 8707 sets, and more than 20 brands have been used for the construction of the third-level communication network of the provincial company and the fourth-level communication network of the local companies, which are each managed and monitored separately by the provincial and local companies. The decentralized communication network management system makes it difficult for the provincial communication scheduling to grasp the real-time operational status and network resource utilization of the entire provincial communication network, causing many difficulties and inconveniences promptly and accurately in scheduling, fault handling, network optimization, and so on.

In order to strengthen the unified management of the communication equipment in the entire province, State Grid Henan Telecommunications Company has transformed the transmission equipment of different brands separately managed by the local companies' transmission network management servers into being centrally managed by the provincial company's transmission network management server. For each brand of transmission equipment, a set of network management platforms is deployed in the provincial scheduling and backup scheduling in Luoyang, with hot standby at different locations. Each local company sets up two gateway network elements for primary and backup, and transmits to the provincial scheduling and backup scheduling in Luoyang. The centralized network management system of each brand is connected to the communication management system (TMS) through a northbound interface. Ultimately, achieving centralized network management construction at the provincial level with a monitoring coverage rate of 100% for the third and fourth-level communication networks lays a solid foundation for the provincial communication scheduling to be "intensively managed and homogeneously operated."

2.2.2 Scheduling "Optimization" - Defining Target Network Framework, Implementing Network Optimization

The Henan Power Communication Network relies on optical cable networking for primary line deployment. Due to limitations in optical cable resources, areas such as Nanyang, Xinyang, Zhumadian, and Zhoukou have single-point access to the backbone network structure, with poor reliability in inter-ring connections. Any malfunctions in this setup would result in massive regional service interruptions and poor network security reliability.

State Grid Henan Information and Communication Company has been consistently conducting network optimization work, guided by the principles of "foresight, unity, economy, and reliability," and oriented towards business needs. This optimization aims to achieve the "Four Optimizations, Four Eliminations, and Four Enhancements" objectives: optimizing network structure to eliminate "weak points" and enhance framework security; optimizing network traffic to eliminate "bottlenecks" and enhance bandwidth transmission capacity; optimizing network performance to eliminate "degraded points" and enhance network operation level; optimizing business channels to eliminate "potential hazards" and enhance business support level. This aims to achieve the goal of "One Transformation, Two Synchronizations": transitioning network optimization work from "passive acceptance" to "active optimization," with network optimization and communication project construction conducted "synchronously."

Through annual renovation proposals, the optical cable network architecture has been further optimized, forming the target network structure and eliminating bottleneck issues in the optical cable

network in southern Henan. As a result, the network’s resistance to risk has significantly improved, leading to a substantial reduction in major service interruption failures caused by optical cable malfunctions.

2.2.3 Maintenance “Coordination” - Strengthening Planning Management, Improving Internal Control Mechanisms

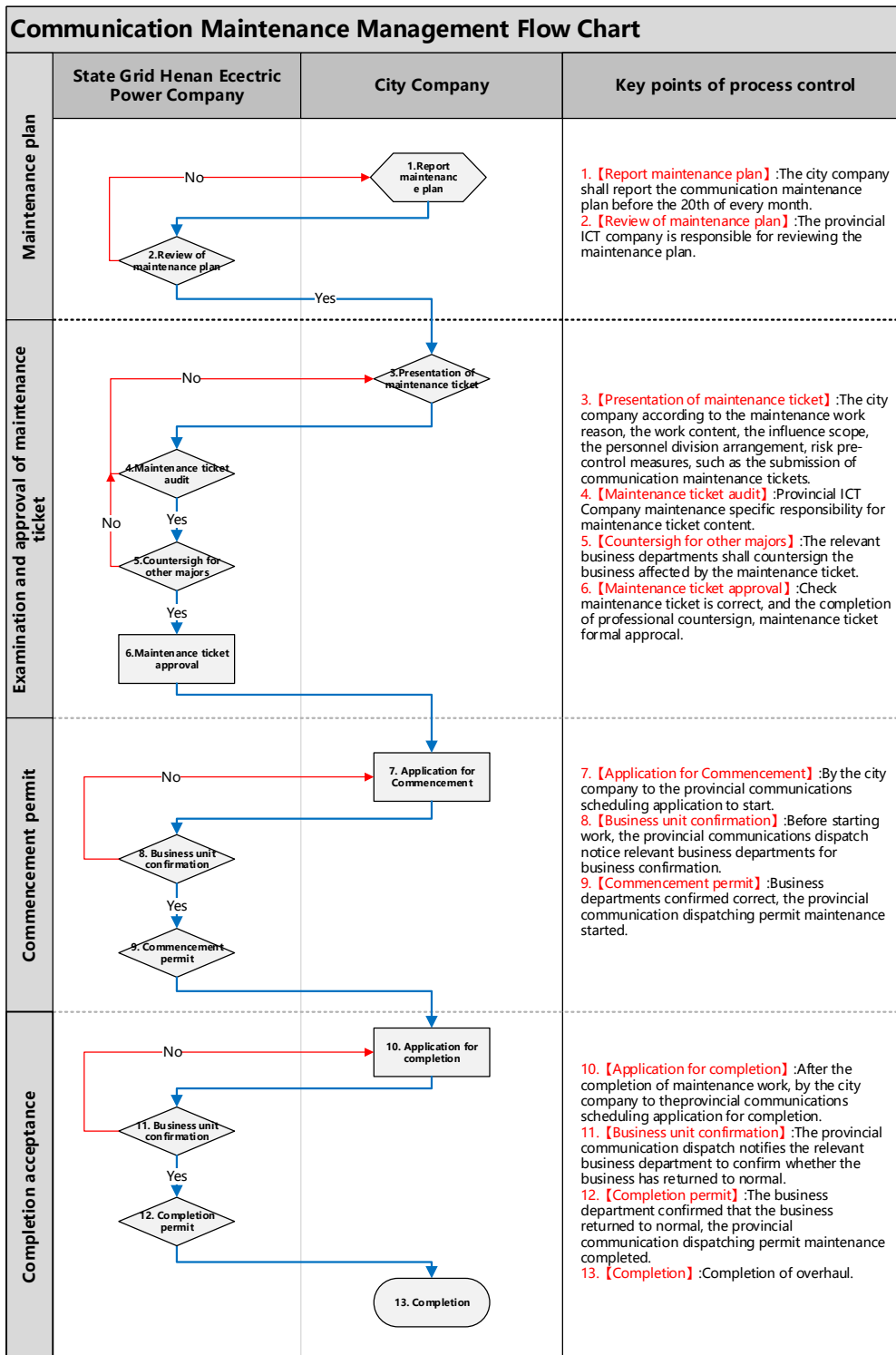


Figure 2. Communication maintenance management flowchart

State Grid Henan Information and Communication Company has formulated communication maintenance management standards, communication maintenance technical work standards,

communication maintenance standardized process guidance manuals, and typical communication maintenance work manuals. It has also participated in the formulation of power grid power outage planning management standards, comprehensively carried out business identification, and achieved full coverage of technical standards for all business systems, management standards for all processes, and work standards for all positions. This further strengthens communication management and improves the safety internal control mechanisms for communication business support. It has standardized the management and work processes related to power grid dispatch production communication maintenance, new equipment startup, business acceptance, fault handling, communication support, and hazard elimination, clarifying the work responsibilities and interfaces between the Information and Communication Company and the power dispatch center, emphasizing professional coordination, voltage level coordination, top-down coordination, supply-use coordination, and overall coordination to improve work efficiency and form a standardized safety coordination and supervision system.

Under the strict implementation of the “Four Coordination” principle and in combination with the unique characteristics of communication maintenance, a “Five Parties Mutual Sign-off” system has been established for the maintenance plan with the power dispatch center, enhancing communication and coordination with the power grid control department to ensure the smooth implementation of the communication maintenance plan, thereby reducing the operational risks of the communication network and power grid. A consultation mechanism has been established with the provincial maintenance company, integrating communication network and equipment, especially optical cable risk pre-control, into the management of power grid risk pre-control.

For major communication maintenance work, the organization coordinates with the construction management department, design unit, supervision unit, construction unit, equipment manufacturer, and dispatch management department to hold a communication maintenance coordination meeting, clarify the work focus, control the schedule milestones, regularly organize consultations, steadily advance the project progress, greatly enhance the control ability and level of major maintenance.

2.2.4 Safety “Leading” - Implementing Risk Control and Strengthening Intrinsic Safety

The State Grid Henan Information and Communication Company has taken the lead in introducing power grid safety risk assessment, enhancing risk warning mechanisms, and controlling communication maintenance work risks at four stages. First, risk assessment involves holding construction coordination meetings for major communication maintenance work to identify the causes, categories, and severity of the risks, establishing a sound long-term risk assessment mechanism from the bottom up. Second, warning release involves formulating corresponding warning and control measures for changes in operation methods brought about by communication maintenance and construction, extreme weather, natural disasters, and special requirements for communication system operation during major safeguard periods. Third, warning handling involves signing and issuing risks of level five or above by the relevant provincial company offices according to the regulations of “State Grid Company Communication Operation Risk Warning Management Regulations (Trial)” and level six or below by the provincial information and communication company leadership to the relevant operation and maintenance units. Fourth, warning removal involves the operation and maintenance unit receiving the warning order, formulating targeted risk control measures according to the risk pre-control requirements in the warning order, strengthening equipment inspection, maintenance, defect rectification, and safety protection, and arranging personnel for on-site duty. The communication system operation risk warning is lifted after confirmation by the provincial information and communication company after the warning period.

Furthermore, an innovative mechanism has been established for the provincial joint analysis of communication network annual operation mode, which includes statistics and analysis of single power supply, single fiber optic cable path, and equipment defects throughout the province. Based on the reports and rectification status of various units, a dynamic database of communication system defects is established to urge units to make improvements. At the end of each year, all units are

required to provide corresponding maintenance tickets to clear the database, strengthening the dominant position of communication maintenance management and promoting effective communication safety management. Semi-annually, comprehensive and detailed operation and maintenance data is provided to 18 municipal information and communication companies, provincial maintenance companies, and power transmission companies to achieve synchronization of material, operation, and maintenance of communication work across the province.

2.2.5 Emergency “In Place” - Realistic Drills, Rolling Revision of Contingency Plans

The State Grid Henan Information and Communication Company continuously improves and enhances the emergency management system of the power communication system in accordance with the requirements of “horizontally to the edge, vertically to the bottom, corresponding top and bottom, internal and external connection.” This is done through the implementation of “four measures to enhance” (i.e., establishing a routine mechanism for script-free emergency drills, promoting the standardization of emergency repair for communication failures, improving technical support means for communication emergency drills, and promoting the construction of communication emergency drill training bases). For emergencies such as summer flooding and ice cover on fiber optic cables, which cause frequent and easily occurring communication system faults, script-free emergency drills are conducted at least twice a year. These emergency drills are used to identify discrepancies and shortcomings, propose improvement measures, urge units to carry out rectification and improvement work, strengthen the standardized operation level of communication emergencies, and promote the comprehensive improvement of safety awareness, rapid response capabilities, normative fault handling capabilities, dispatcher’s comprehensive capabilities, and the planning and organization capabilities of all personnel.

The State Grid Henan Information and Communication Company takes “innovation and pragmatism” as its tenet, and coordinates with municipal companies to improve emergency plans for communication systems and enhance emergency equipment. As of October 2023, the company has compiled a total of 26 sets of emergency plans for various levels and types of communication systems, including emergency plans for large-scale power outages, consisting of 7 sets of summer flood prevention and 15 sets of emergency plans for optical cable icing. Furthermore, the emergency plans are continuously updated based on the operational status of the communication network and work requirements. Additionally, Henan Company has equipped 3 satellite vehicles, 6 satellite phones, and established one emergency command system, effectively guaranteeing timely and efficient emergency command and fault handling in case of emergency situations.

3. Implementation Effects

Based on the practical issues encountered in the operation, maintenance, and management of the power communication system, State Grid Henan Information and Communication Company continuously explores and researches effective methods to promote the safe operation of the power communication network, forming an “Five in One” management system and achieving good implementation effects in practical work.

3.1 Effective Enhancement of the Security Level of the Power Communication Network

By implementing “integrated and lean” management from the five dimensions of “scheduling, planning, maintenance, safety, and emergency,” the company comprehensively manages and controls the entire process and risk prevention in various areas and links of the power communication system, ensuring that various management measures, technical measures, and safety measures are effectively implemented. This has further improved the accuracy of communication resources, optimized the communication network structure, strengthened the standardization of communication management, improved communication operation indicators, and significantly enhanced the efficiency of communication operation and maintenance, effectively improving the overall security level of the power communication system in the province. The improvement in performance indicators for

communication professionals in the industry and performance evaluation details can be seen in Table 1.

Table 1. “Five in One” Index System of Communication Management

No.	Indicator Name	Indicator Content	Target value	Performance
1	One-time Approval Rate for Maintenance Tickets	One-time Approval Rate for Maintenance Tickets = Number of primary and secondary backbone network maintenance tickets approved on the first attempt / Number of maintenance tickets submitted for approval × 100%.	100%	100%
2	One-time Approval Rate for Maintenance Plan	One-time Approval Rate for Maintenance Plan = Number of primary and secondary backbone network maintenance plans approved on the first attempt / Number of maintenance plans submitted for approval × 100%.	100%	100%
3	Planned Maintenance Execution Rate	Planned Maintenance Execution Rate = Number of planned maintenance items executed / Total number of planned maintenance items × 100%.	100%	100%
4	Timely Disposal Rate of Communication Equipment and Optical Cable Faults	Timely Disposal Rate of Communication Equipment and Optical Cable Faults = (Number of times the repair time for communication equipment defects meets requirements + Number of times the repair time for optical cable section defects meets requirements) / (Total number of communication equipment defect repairs + Total number of optical cable section defect repairs).	100%	100%
5	Monthly Ad Hoc Maintenance Rate	Monthly Ad Hoc Maintenance Rate = Number of ad hoc maintenance projects in the month / Total number of maintenance executed in the month × 100%	0	0
6	Risk Warning Order Execution Rate	Whether the risk control measures are implemented according to the relevant requirements of the risk warning form, and no warning events have occurred.	Compliance	Compliance
7	Risk Warning Order Feedback Rate	Whether to give feedback according to the requirements of the risk warning form	Compliance	Compliance

3.2 Significant Enhancement of Lateral Coordination and Vertical Linkage Capabilities

By standardizing communication operation and maintenance management standards, actively communicating and coordinating with business departments, and using information technology to support the flow of business processes, the work processes are solidified into the TMS system, achieving lateral coordination, and effectively promoting the transformation of communication management and improving efficiency. Following the principle of “centralized control and graded execution,” the centralized provincial network management achieves intensive management of the provincial communication network and a hierarchical execution of operation and maintenance by city and county teams, comprehensively enhancing the effectiveness of provincial, municipal, and county linkage, improving the standardization and refinement of communication work management, ensuring the controllability of the safe operation of the provincial communication network, and achieving the overall process control goals.

3.3 Good Promotion and Application Value

The “Five-in-One” lean management system within the company’s various power supply companies is universal, standardized, and expandable. It can provide good experience and reference for lean management of communication system operation and improvement of the security level of operation within other units in the system, demonstrating good promotion and application value, and providing strong support for the construction of an internationally leading energy internet enterprise with Chinese characteristics.

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