Risk Evaluation Method of Transmission Corridor Based on Panoramic Monitoring

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Abstract: Transmission corridor, which is the key link of the transmission network, is composed of some high voltage and capacity transmission lines. With the increase of outside destroy risk points and transmission lines, the traditional prevention work of outside destroy of transmission line needs more human and material resources. This paper analyzed outside destroy failures of Zhejiang grid. Research on panoramic monitoring of transmission line developed by state grid Zhejiang power company was introduced. Based on the work the risk evaluation method of transmission corridor has been proposed.

1. Introduction

Due to the rapid economic development, dense population and scarce land resources in East China, governments at all levels often arrange the land for transmission corridors in a relatively narrow range based on the consideration of land use, which results in the dense arrangement of AC and DC transmission lines with different voltage levels in the transmission channels. Especially in Shanghai, Jiangsu and Northern Zhejiang, the lines are more dense, and there are three circuits on the same pole, four circuits on the same pole, UHV and 500kV lines on the same pole. These dense corridor sections with high voltage and large capacity transmission lines often become the key section of the line channel. Especially after Fufeng, JinSu, lingshao, binjin, Yanhuai, Xitai and other UHVDC and UHVDC north ring are put into operation, East China Power Grid has entered the era of UHVDC hybrid grid[1-2].

With the rapid development of urbanization in China, Zhejiang power grid is faced with large-scale planning and construction, which leads to the transmission line channel being compressed. The illegal construction of houses and trees, illegal construction work, sudden and seasonal external break in the transmission protection zone pose a great threat to the safe and stable operation of the line. The equipment failure caused by external break has become one of the main causes of line failure[3]. At the same time, there are crossing conditions of different voltage levels in the channel, and the crossing distance changes with line load and environmental conditions, which also becomes one of the dangerous hidden dangers of line operation.

At present, manual inspection is still the main method to identify the risk of line break and crossing distance. However, due to the strong randomness of the risk of line break, there is the possibility of false alarm and missing alarm. With the increase of the mileage of the line, the inspection workload is increasing day by day. In order to ensure the operation safety of key sections of overhead transmission lines, new technical means have been applied to line operation and maintenance, such as the rapid development of 3D laser point cloud modeling technology and binocular stereo vision technology in recent years. Based on the above-mentioned virtual reality technology and visualization technology, Zhejiang electric power company further built a 3D panorama combined with geographic information system. The three-dimensional panoramic monitoring technology adopted in the monitoring platform has the characteristics of full angle, wide range and multi-element monitoring. Relying on the platform, the online monitoring data can be combined with the State Grid GIS platform and PMS management platform, which can be used to assist the HIRA risk assessment of the transmission channel and ensure the operation safety of the

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transmission channel.

2. Zhejiang Power Grid's Overhead Line Breaking Fault Situation

According to the general arrangement of the notice of the State Grid transportation inspection department on strengthening the “six prevention” work of overhead transmission lines (YJ2 [2015] No. 16) issued by the State Grid Corporation of China, the main factors causing the failure and outage of overhead transmission lines are divided into six categories, namely, external breaking, wind damage, ice damage, lightning strike, pollution flashover, bird damage, etc., and the prevention work of these six categories is referred to as “six prevention” for short. Among them, the external breaking events mainly include three main categories: foreign material short circuit, construction line collision and mountain fire[4]. From 2013 to 2017, Zhejiang power grid 500kV and above lines tripped 9 times due to external force damage, of which 5 times resulted in failure outage. The external force damage trip situation in each year is shown in Figure 1.

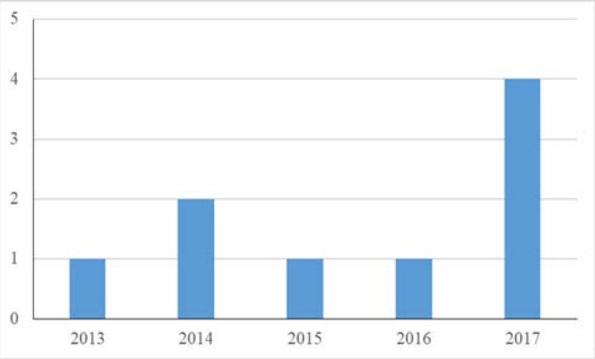

Fig.1 Outside Destroy Failures of Zhejiang Grid in Recent Years

From the data above, it can be seen that in 2017, the number of external force damage trips of Zhejiang power grid was more than that of the previous year, reaching 4 times. Among the main causes of external force failure in Zhejiang Province, foreign material short circuit accounts for the vast majority, accounting for 89%, and the rest is mountain fire, accounting for 11%. The distribution of external failure causes is shown in Figure 2.

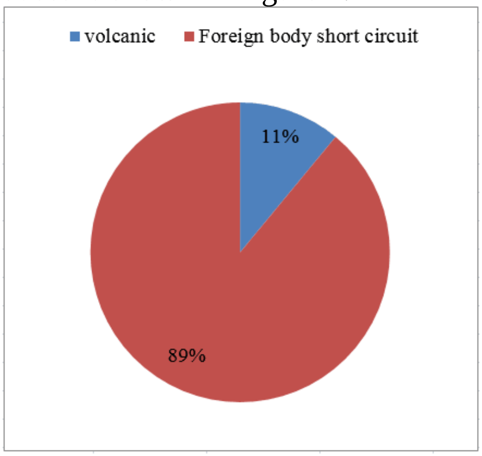

Fig.2 Reasons of Outside Destroy Failures of Zhejiang Grid

From 2013 to 2017, there was no line trip caused by construction touch in Zhejiang power grid due to the external break of overhead lines. This is mainly because Zhejiang electric power company has a high quality of patrol inspection for overhead lines, especially the dangerous points of lines, and has established a perfect emergency mechanism for the external break of construction, so the control effect for the external break of line construction is better. With the increase of the number of overhead lines and the vigorous development of infrastructure construction in various regions, the situation of construction machinery entering into the line protection zone increases, and the workload of management and control of the external damage of overhead lines is also increasing.

In this context, Zhejiang electric power company has carried out the application research of binocular panoramic monitoring technology in the prevention and control of transmission channel damage, established the panoramic monitoring system and alarm platform of transmission channel, and carried out the pilot application in Jiahu channel of Zhejiang Province.

3. Transmission Channel Panoramic Monitoring System

The three-dimensional panoramic monitoring system based on binocular vision technology consists of binocular stereo vision monitoring sub platform, three-dimensional laser point cloud monitoring sub system, background server and mobile app alarm platform. The system function structure diagram is shown in the figure below.

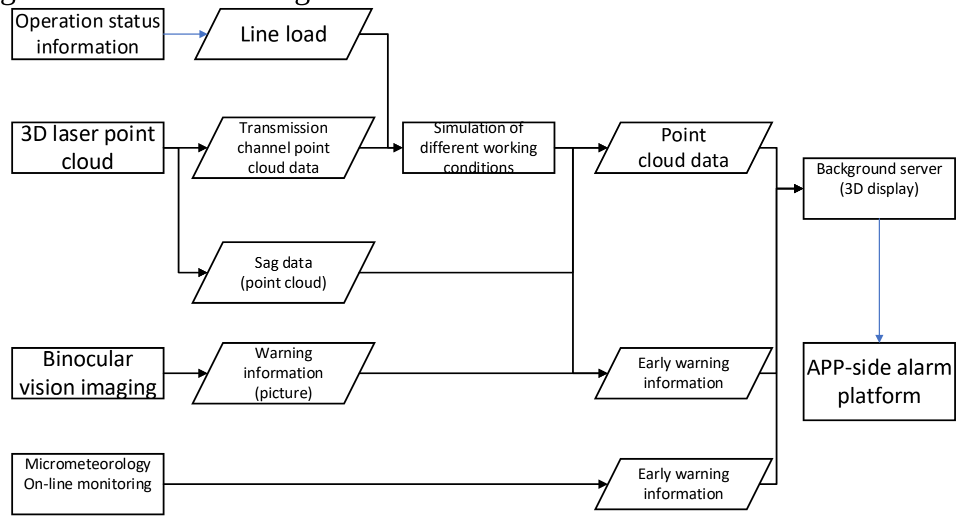

Fig.3 Functional Diagram of Panoramic Monitoring System

3.1 Binocular Stereo Vision Monitoring Sub Platform

The binocular stereo vision monitoring sub-platform is used to monitor the risk factors of external force damage such as construction, dangerous operation, high vegetation and mountain fire in the channel, and set up one or more sets of binocular photogrammetric equipment on the tower to obtain the two-wire wire in real time. The video image of the ground target is calculated by image matching and target recognition, and the spatial position, displacement and time of the target are calculated to determine the risk level of the target, and the ground space tracking and risk level determination is realized. The on-site video surveillance system is installed in the middle of a #4012 pole tower of a UHV DC line in Zhejiang. The video direction points to the #4013 pole tower. It is powered by solar panels and batteries. Based on the wireless data transmission method, the monitoring data is uploaded to the background server. The channel live video monitoring equipment. The installation situation and the panoramic scene shooting situation are shown in Figure 4 and Figure 5 respectively.

Fig.4 Installation of Monitoring Device

Fig.5 Field Panoramic Shot Photo of Transmission Corridor

3.2 Three Dimensional Laser Point Cloud Monitoring Subsystem

The three-dimensional laser point cloud monitoring subsystem includes the airborne laser scanning measurement system and the three-dimensional modeling platform. The airborne laser scanning measurement system carries GPS, IMU, laser scanner, digital camera and other equipment through the UAV. Its active sensing system (laser scanner) uses the returned pulse to obtain the high-resolution distance, slope, roughness, reflectivity and other information of the target in the channel. The passive photoelectric imaging technology (digital camera) can obtain the digital imaging information of the detection target, and then generate the three-dimensional coordinates of the sampling points one by one after the processing of the three-dimensional modeling platform. Combined with the GIS system information of State Grid, the three-dimensional positioning and imaging results in the region can be obtained through comprehensive processing.

Three dimensional laser point cloud monitoring technology can achieve full angle monitoring and modeling in the transmission channel area, make up for the limitation of the monitoring area caused by the fixed installation position and shooting angle of the binocular stereo vision monitoring sub platform, and is particularly suitable for the full scene monitoring of complex structure transmission channel, such as the accurate modeling of the cross line area, and then get the cross distance data of overhead line. Integrate the image data and the line operation information of PMS system to realize the visual management of line operation and maintenance.

According to the management requirements, 3D laser point cloud scanning and modeling are carried out for a ±800kV UHV DC line cross section in Zhejiang Province. The transmission channel in this section also includes a number of 500kV and above overhead lines and a 220kV cross overhead line. The line situation and 3D laser point cloud model in the section are shown in Figure 6 and Figure 7 respectively.

Fig.6 Situation of Transmission Line Crossing Section

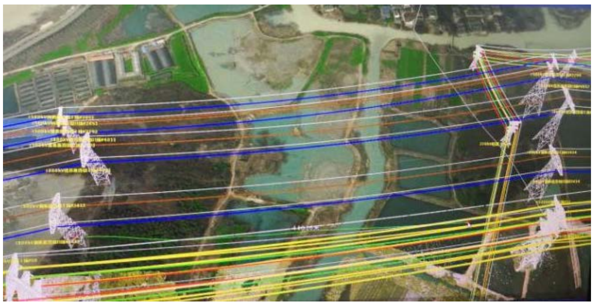

Fig.7 Model of Transmission Line Crossing Section

3.3 On Line Micro Meteorological Monitoring System

Micro meteorological monitoring equipment is installed on the tower at the channel site, which is installed on the same tower as the binocular stereo vision monitoring equipment. It is used to monitor the temperature, humidity, wind direction and speed, light radiation intensity, rainfall and other meteorological conditions around the channel line, and regularly upload to the background server. The on-site installation of the micro meteorological monitoring equipment and the data uploaded to the server are shown in Figure 8 and Figure 9 respectively.

Fig.8 Installation of Micro-Meteorological Equipment

Fig.9 Monitoring Data of Micro-Meteorological Equipment

3.4 Background Server and App Alarm Platform

Background server is responsible for multi-dimensional information integration and fusion, including 1. Field binocular stereo vision monitoring data and 3D laser point cloud monitoring data; 2. Basic geographic information data of transmission channel provided by State Grid GIS system, including grid data (such as DOM image, DEM elevation) and vector data (grid grid structure, road network, administrative division, water system, railway, etc.); 3. PMS system The power grid business data provided includes line design parameters, equipment account, online monitoring data and other power grid related business data. Build a 3D panoramic display platform based on the above data, and build a local database to store all the data.

The system provides an app alarm platform, which is used to push alarm information to line maintenance personnel. The alarm information includes the out of line channel alarm information provided by the binocular stereo vision monitoring system, and the crossing alarm information provided by the three-dimensional laser point cloud monitoring system.

The background processing server is mainly responsible for analyzing and processing the video monitoring data from the scene. Based on the binocular vision technology, it obtains the moving direction and speed of the objects in the line channel, realizes the identification, positioning and tracking detection of the dangerous sources in the transmission channel, and identifies the foreign matters on the wire and the mountain fire in the channel, so as to replace the current manual inspection and dangerous source tracking identification work.

4. Risk Assessment Method of External Failure of Dense Transmission Lines

4.1 Out-of-Line Risk Hira Method

HIRA (hazard identification & Risk Assessment) is the abbreviation of hazard identification and risk assessment, which was first applied in the insurance industry. In 2014, State Grid Corporation of China issued a complete set of risk assessment methods for important transmission lines (hereinafter referred to as “headquarters method”), which determined the basic idea of risk assessment for external force damage of lines, and can be used as the safety work guidance for external force damage risk prevention. This method uses HIRA for reference, and analyzes the risks faced by overhead lines from the perspectives of personnel, equipment, machines, methods and environment. Among them, foreign matters, mechanical touch line and mountain fire are the key contents. The risk assessment method proposed by State Grid Corporation Based on HIRA is LEC Method, as shown in the following formula: $R = L \times E \times C$ (1)

Where R is the risk value, L is the severity of the consequences, E is the frequency of the hazard event, and C is the probability of the consequences. The risk value R is the final score. According to the risk value, the risk degree of the technical elements can be determined. According to the light to heavy, it is divided into four grades, namely I, II, III and IV, of which: below 30, the risk degree is I; 30 to 70, risk level II; 70 to 200, risk level III; 200 to above, risk level IV.

The severity of the consequences L can be divided according to the level in Table 1.

Table 1 Consequence Severity Score Table

Serial number	The severity of the consequences	Score
1	Special severity	100
2	Seriousness	50
3	More serious	25
4	General	15

In Table 1, special severity refers to the level-1 Grid Accident; severity refers to the level-2 grid event; comparative severity refers to the level-3 grid event; generality refers to the level-4 grid event.

Hazardous event is the first accident that may cause accident sequence. The frequency of hazardous events is reduced from continuous 10 points to special 0.5 points, which is divided according to the level in Table 2.

Table 2 Score Table of Frequency of Hazard Events

Serial number	Frequency of hazardous events	Score
1	Continuous (or many times a day)	10
2	Often (about once a day)	6
3	Sometimes (from weekly to monthly)	3
4	Occasionally (from monthly to yearly)	2
5	Rarely (it is said that it happened)	1
6	Very few, almost impossible	0.5

Probability is defined as the complete accident sequence of an event over time and resulting in an accident and consequence (the chance of a hazardous event leading to consequences) once a hazardous event occurs. The score of probability is shown in Table 3.

Table 3 Score Table of Possibility of Consequences

Serial number	Possibility	Score
1	If a dangerous event occurs, it is the most likely and expected result	10
2	It's not uncommon. It's about 50 / 50 chance	6
3	Probably	3
4	Very few possibilities, once happened	1
5	It's quite rare, but it's possible. It hasn't happened in many years	0.5
6	Despite years of exposure, it never happened	0.1

4.2 Risk Assessment Method Based on Panoramic Monitoring

As mentioned above, the transmission channel panoramic monitoring platform is used for real-time monitoring of line abnormalities in the channel, which can replace the manual line patrol work. In the transmission channel risk assessment, panoramic monitoring provides multi-element monitoring and assessment work. This paper analyzes the transmission channel risk assessment method based on panoramic monitoring, taking the short circuit of line foreign matters and external construction damage as an example.

Risk assessment of foreign material short circuit in transmission channel

According to the short-circuit risk assessment method of foreign matters, the main factors affecting the risk value include personnel, equipment, machines and tools, methods and environment, among which personnel refer to inspection quality, three-level wire protection and personnel training, equipment refers to tower form, wire height, line spacing and other factors, and method refers to emergency system, hidden danger point account and hidden danger treatment. , warning signs, video monitoring, live line removal and other elements. In terms of environment, it refers to the type of foreign matters, severe weather, distance from the foreign matters to the conductor, and tall buildings around the line. The assessment idea is shown in the figure below.

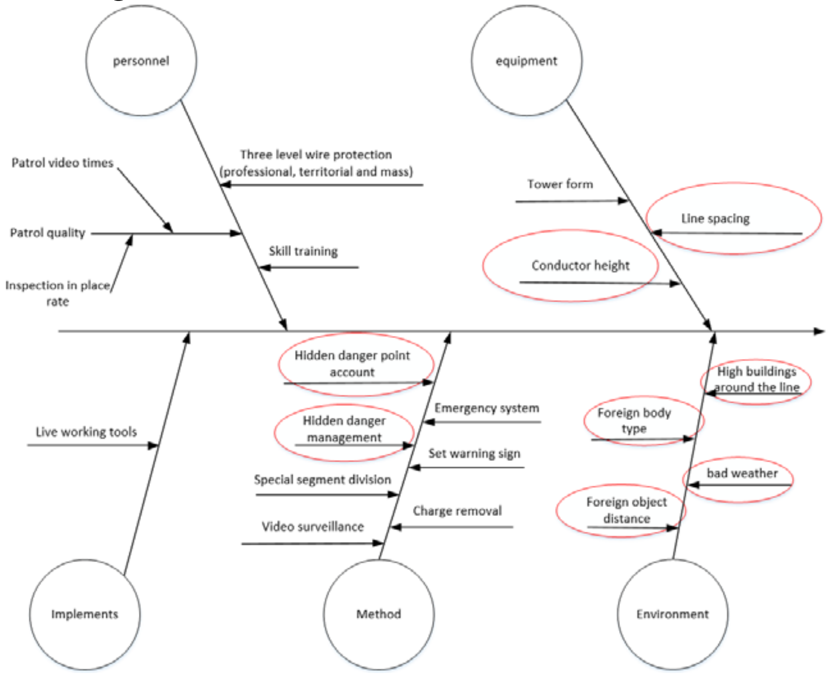

Fig.10 Risk Evaluation Method of Foreign Body Short Circuit

Among the above main factors affecting the risk value, video monitoring technology has been applied in some lines in Zhejiang Province, but there are defects such as small monitoring range, unable to locate in space, etc. panoramic monitoring platform has the characteristics of large range, full angle and spatial ranging. In the process of risk assessment of foreign material short circuit in transmission channel, panoramic monitoring technology covers manual inspection, video monitoring, pole tower shape. Type, distance between lines, height of wires, types of foreign matters, distance between foreign matters and lines, severe weather, tall buildings around the lines and other factors account for half of all risk factors, as shown in the table below.

Table 4 Summary of Foreign Body Short Circuit Influencing Factors Monitored by Panoramic Monitoring System

Serial number	Risk factors	Technical means
1	Manual inspection	Binocular visual monitoring
2	Video surveillance	Binocular visual monitoring
3	Tower form	Binocular visual monitoring / PMS account
4	Line spacing	Three dimensional laser monitoring
5	Wire height	Three dimensional laser monitoring
6	Heterospecies	Binocular visual monitoring
7	Distance of foreign matters from the line	Binocular visual monitoring
8	bad weather	Micrometeorological monitoring
9	Tall buildings around the line	Binocular visual monitoring /Three dimensional laser monitoring

Risk assessment of line collision in transmission channel construction

The risk factors of construction touch line are mainly concentrated in four aspects: personnel, equipment, methods and environment, including three levels of personnel protection, inspection quality, inspection methods, risk section division, law enforcement, online monitoring equipment, prevention and control plans, Protection of propaganda, warning devices, line crossings, wire-to-ground distance, mechanical construction, sand mining vessels, barbaric construction and linkage mechanisms, and many other risk factors. The risk assessment method for the transmission line of the transmission channel is shown in the figure below.

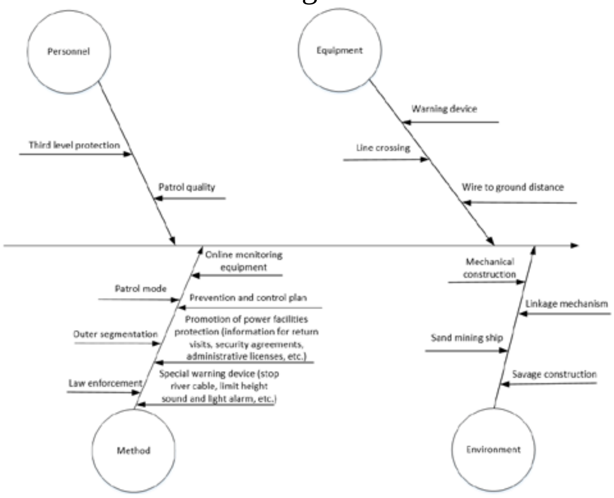

Fig.11 Risk Evaluation Method of Line Hitting by Construction

Among the above factors that affect the construction of external failure, panoramic monitoring technology covers such factors as manual inspection, division of external failure section, online monitoring, line crossing, distance from conductor to ground and construction machinery monitoring, accounting for one third of all risk factors, as shown in the table below.

Table 5 Summary of Line Hitting by Construction Influencing Factors Monitored by Panoramic Monitoring System

Serial number	Possibility	Score
1	Manual inspection	Binocular visual monitoring
2	Division of external breaking section	State Grid GIS system
3	On-line monitoring	Panoramic monitoring platform
4	Line crossing	Three dimensional laser monitoring
5	Distance between conductor and ground	Three dimensional laser monitoring
6	Construction machinery monitoring	Binocular visual monitoring

5. Simulation Alarm Test of Panoramic Monitoring System

The panoramic monitoring system has been running for three months in Jiahu channel of Zhejiang Province, during which the line is in good condition without any alarm event. In order to test the APP-side alarm function of the system, the scope of the source of the external risk source is adjusted, and the construction material of the construction site near the transmission channel is included in the risk source of the floating object, which is considered to cause a short circuit of the foreign body of the line, and the range of the protection area of the transmission channel is adjusted, assuming construction during the work of the tower crane lifting arm, the channel protection area may be invaded to test the identification and alarm function of the panoramic platform for the risk source.

The operation results show that the system can correctly identify the risk sources of foreign material short circuit and construction external damage, and regularly upload alarm information to the server before the risk is eliminated. The alarm information is then pushed to the mobile app for the operation and maintenance personnel to browse. The alarm page in the app is shown in the figure below.

Fig.12 Alert Message on Mobile Phone App Software

Three options of “shelving”, “handled” and “false alarm” are provided in the app of mobile terminal for the same alarm event, so that the operation and maintenance personnel can choose the disposal scheme according to the actual situation. The disposal result will be uploaded to the server from the mobile terminal to form a disposal record for query.

6. Conclusion

In this paper, a panoramic monitoring platform is built for the operation and management of the transmission line channel, and it is applied in the Jiahu channel of Zhejiang Province, which provides reference and reference for the treatment and optimization design of the external fault and trip of the transmission line channel. According to the analysis and summary of this paper, the conclusions are as follows:

Panoramic monitoring technology has the technical characteristics of full angle, wide range and multi elements, which can automatically identify the risk sources of transmission channel damage. Relying on the background server and the foreground mobile phone terminal app system, it can realize the closed-loop management of transmission channel.

Panoramic monitoring technology can replace the traditional manual inspection to some extent and improve the management level of the line.

Panoramic monitoring system can automatically monitor and identify many elements of HIRA assessment method, and distinguish risk level, so as to realize technical support for HIRA risk assessment of transmission channel.

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