Internet of Things Application in Satellite Communication in Power Transmission, Transform and Distribution

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***Abstract*—In the national grid enterprise system, the geographical environment of transmission, substation lines and equipment distribution is very complicated. Transmission lines and substation equipment built in complex environments such as plateaus, forests, canyons and borders are often subjected to earthquakes, floods and blizzards. The threat of mudslide disasters, the ground communication network is greatly affected by extreme natural disasters, and it is impossible to repair and rescue in time when disasters occur. In response to the needs of facility operation and maintenance under emergency anomalies, Tiantong No. 1 satellite is a communication satellite with independent intellectual property rights in China. It has functions such as voice communication, image transmission, positioning, and data reporting. It can set up satellite Internet of Things to realize real-time monitoring and equipment. Conveniences such as inspections and emergency rescues reduce the operation and maintenance costs of the power transmission and transformation process.**

Keywords-Tiantong Satellite; Audio And Video Transmission; Inspection; Satellite Ground Station; Ground Network

I. INTRODUCTION

The Ubiquitous Electricity Internet of Things connects people , things and power users , power grid enterprises ,power generation enterprises , suppliers and their equipment to generate shared data for users, the grid, power generation, and suppliers And government social services; use the power grid as a hub, play a platform and sharing role, create value for the development of the industry and more market players, and provide value services.

The essence of the ubiquitous electric power Internet of Things is to fully apply modern information technologies such as "big data, cloud platforms, the Internet of Things, mobile Internet, artificial intelligence" to create a smart service system with comprehensive status perception, efficient information processing, and convenient and flexible application

In January 2019, the State Grid first proposed the strategic goal of "three types (hub type, platform type, shared type) two networks (Strong Smart Grid, Ubiquitous Electricity Internet of Things)" in the "two sessions" report, and proposed the construction The important material foundation of a world-class energy Internet company is to build and operate the "two networks." In March 2019, the State Grid clarified the definition of the ubiquitous electric power IoT for the first time at a teleconference on the deployment of ubiquitous electric power IoT construction work, and proposed a two-phase strategic arrangement for the construction of the next five years. The most urgent and important task is to accelerate the construction of the ubiquitous electric power Internet of Things.

At present, a large number of devices and applications have been developed in the application layer, platform layer, network layer and perception layer. Such IoT devices have been deployed in areas covered by terrestrial networks with stable business

capabilities and reasonable use costs. The development of services in areas without ground network signal coverage urgently needs to be improved, and current ground network and IoT equipment cannot support this demand.

Due to the characteristics of the satellite network: covering no dead zones, communication distance has nothing to do with cost, convenient networking, safe and reliable communication, and can be used as a last-guaranteed communication method in the event of ground network paralysis caused by earthquakes, floods, and snowstorms, Particularly suitable as a supplementary application in the power industry. The ubiquitous electric power Internet of Things-related services, in areas where there is no ground network signal coverage, or where new ground networks cover higher cost areas, the most effective technical implementation is achieved by satellite communications using satellites as relays. Ubiquitous power satellite IoT solution.

The application of satellites to electricity is accompanied by the rapid development of satellite networks, combined with the objective communication needs of the power industry in areas without ground network coverage. The ubiquitous power satellite IoT will be an extension and supplement of the ubiquitous power IoT. Add satellite communication capabilities on the basis of existing power IoT equipment to ensure that it meets the needs of power applications and expands the use of locations and scenarios. In short, it extends from areas with terrestrial networks to areas without ground network coverage.

This article will analyze the application of ubiquitous power satellite IoT in the power system's power generation, transmission, substation distribution and power consumption process.

II. OVERVIEW OF SATELLITE COMMUNICATIONS IOT TECHNOLOGY SUPPORT

A. Satellite communications overview

Satellite mobile communication refers to the use of artificial earth satellites as relay stations to forward radio waves used for communication between mobile users or between mobile users and fixed users to achieve mobile communication between two or more points. Satellite communications generally use the L, S, C, X, Ku, and Ka frequency bands, while high-throughput satellites generally use the C, Ku, and Ka frequency bands. However, resources in the C and Ku frequency bands are tight, so currently Qualcomm satellites are increasingly The development of Ka band, the frequency resources of Ka band are more abundant. Typical satellite mobile communication systems include space segment, ground segment and user segment. The space segment is composed of one or more satellite constellations. As a communication relay station, it provides the connection between the network user and the gateway. The ground segment usually includes the gateway, the network control center, and the satellite control center. Operation; The user segment is composed of various user terminals. There are mainly two types of terminals-mobile terminals and handheld terminals.

New satellite technology has developed rapidly, and there are many mature commercial systems, such as Tiantong, High-throughput, Iridium, etc. There are also many satellite newcomers who will launch thousands of satellites and put them into operation in the next few years. Figure 2 Basic composition of

satellite.

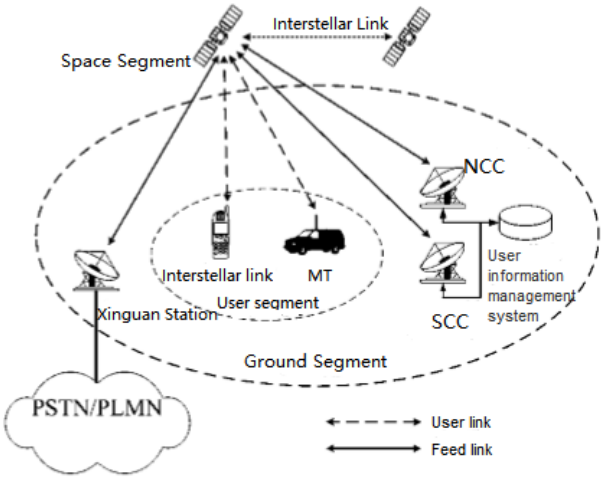

Figure 1. Basic composition of satellite communication link

B. *Satellite communication applications*

Mobile satellite communications are an effective complement to terrestrial cellular mobile communications. In addition to the characteristics of mobile communications, it also has the inherent advantages of satellite communications, including: ① long communication distances, large coverage areas, and multi-address connectivity. A geosynchronous orbit communication satellite can cover 42% of the earth's surface. The large communication distance between two points on the ground is about 18 000 km, and all earth stations in the area covered by the satellite can use the same satellite to communicate with each other. ② Large communication capacity and many types of transmission services. Typical communication satellites have a capacity of tens to hundreds of megabits per second and can serve hundreds of video channels or tens of thousands of voice and data links. ③ Good communication quality and low line bit error rate. Since the radio waves of mobile satellite communications mainly propagate in the space beyond the atmosphere, the propagation characteristics are relatively stable, and they are not easily affected by natural conditions and interference. The normal operating rate of satellite communications is above 99.8%, and the transmission quality is high. ④ The "on-the-move communication" of the mobile platform can be realized. Diverse users of mobile satellites, satellites

Terminals can be mobile carriers located on the ground, at sea, in the air or even in space. It is combined with terrestrial cellular mobile communication systems and other communication systems to form a global coverage seamless communication network. In addition to the above advantages, satellite mobile communication also has the following constraints: ① the size, weight and power consumption of mobile terminal equipment are limited, the size and shape of the antenna are limited by the installed carrier (such as aircraft, cars, ships, etc.), handheld terminals The requirements are even more demanding. ② The satellite antenna beam should be able to adapt to changes in the ground coverage area and keep pointing. The antenna beam of the user's mobile terminal should be able to keep pointing to the satellite as the user moves, or an omnidirectional antenna beam. ③ Due to the movement of the mobile body, when the link between the mobile terminal and the satellite transponder is blocked, a “shadow” effect will occur, causing communication to be blocked. ④ A satellite constellation system composed of multiple satellites requires the establishment of inter-satellite communication links and on-board processing and on-board exchanges, or the establishment of a gateway station with exchange and processing capabilities.

C. *Development Status of Satellite Communication System*

1) *Tiantong Satellite*

The Tiantong-1 satellite mobile communication system is composed of a space segment, a ground segment and a user terminal, and the space segment is planned to consist of multiple geosynchronous orbit communication satellites. As the first star of China’s satellite mobile communication system, Tiantong-1 was launched on August 6, 2016. It belongs to China

Satellite Communications Group Co., Ltd. It is mainly developed by China Academy of Space Technology and uses new plastic antennas. New equipment and technologies such as stand-alone integrated technology, the communication frequency is designed in the S band, and the cellular technology with a bandwidth of 30 MHz can form hundreds of spot beams. The signal transmission loss is small and the communication quality can be effectively guaranteed. At the same time, it uses communication satellite frequency multiplexing technology and a large-scale expandable antenna on board, which greatly improves the sensitivity of satellite receiving signals and increases the capacity of satellite communications.

The area covered by the 01 star of Tiantong No. 1 is mainly China and its surroundings, the Middle East, Africa and other related regions, and most of the Pacific Ocean and the Indian Ocean. There are no restrictions on the coverage of the terrain, and the ocean, mountains, Shangyuan, forests, Gobi, and desert can be seamlessly covered. Covers all types of mobile users including vehicles, airplanes, ships, and individuals. It provides all-weather, all-day, stable and reliable mobile communication services for various fields such as personal communications, marine transportation, ocean fishing, aviation rescue, and tourism research. When natural disasters occur in voice, short message and data services, the emergency communication capabilities of Tiantong One can play a great role. In addition, the main advantages of Tiantong One 01 are reflected in the miniaturization and mobile phone of the terminal, which is easy to carry.

The ground service of Tiantong No. 01 is operated by China Telecom Corporation, which will form a mobile communication network with ground mobile communication systems, and provide voice and data communication coverage for various handheld and small mobile terminals in China's land and surrounding sea areas. It is understood that China Telecom has launched an operation and plans to launch a mobile phone with mobile satellite communication capabilities. Even if it reaches the end of the earth, you can use it to talk to family and friends, send text messages, chat on WeChat, and communicate with video.

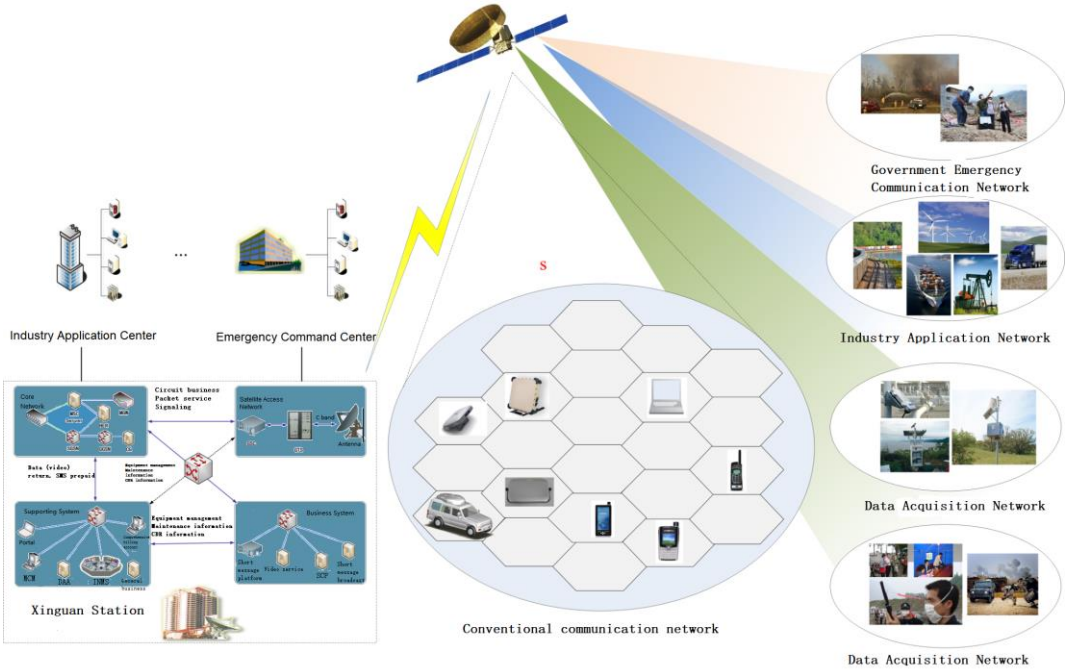

Figure 2. Tiantong-1 satellite mobile communication system

It is estimated that by 2025, China 's mobile communication satellite system will have more than 3 million end users, and its services will cover disaster relief, personal communications, marine transportation, ocean fishing, air passenger transport, bipolar scientific research, and international peacekeeping. During this period, we will also launch multiple Tiantong-1 satellites to further increase the satellite mobile communication service capacity and coverage area, and expand from the surrounding areas of China to form a regional mobile communication system integrating satellite and ground integration to achieve satellite mobile communication. Large-scale application and operation build an important support platform for the country's 'Belt and Road' strategy.

2) Iridium Satellite

1. The Iridium satellite system was the first LEO satellite cellular system with global coverage. It was launched by Motorola in the late 1980s and developed in the early 1990s. The "Iridium" star system includes space segment, ground segment and user segment[9]. The networking and coverage are shown in Figure 2. Space segment The initial design of the constellation consisted of 77 LEO satellites, evenly distributed in 7 polar orbits, and all satellites were moving in the same direction. It is similar to the 77 electrons of iridium orbiting the nucleus, hence the name of the system. The actual constellation consists of 66 satellites distributed on 6 circular near-polar orbital planes with an inclination of 86.4 °, with an interval of 27 ° and an orbital height of 780 km. Each satellite provides 48 spot beams, forming 48 cells on the ground. At a small elevation angle of 8.2 °, the diameter of each cell is 600 km, and the coverage area of each satellite is approximately 4700 km. The constellation forms seamless cellular coverage on the global ground. One spot beam of each satellite supports 80 channels, A single satellite can provide 3840 channels. It was officially operated on November 1, 1998. At present, it has more than 1.5 million users and uses 66 low-orbit satellites to cover the world. The characteristics are low orbit, fast transmission speed, small information loss, and greatly improved communication quality. The ground receiving station, equipment is miniaturized, and it is interconnected with the ground network, which makes the communication in the uninhabited, barren land, remote areas with backward communication, and the scene of natural disasters unobstructed.

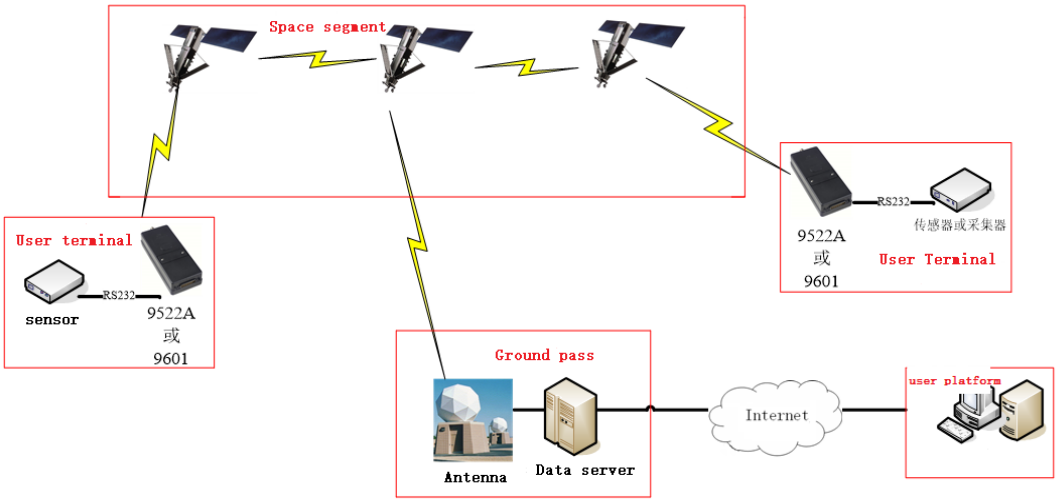

Figure 3. Iridium satellite system

3) High Throughput Satellite

The "Practice No. 13" satellite first applied Ka-band broadband technology to China's communication satellites, with a total communication capacity of 20Gbps, exceeding the total capacity of communication satellites developed and launched in China, marking that China's satellite communications has entered a high-throughput era At the same time, the "Thirteenth Practice" satellite carried out the first international two-way laser communication test between high-orbit satellites and the ground, with a speed of up to 5Gbps, which established China's global leading position in the field of high-speed space information transmission. The "Thirteenth" satellite is China's first electric propulsion satellite. Compared with conventional chemical propulsion satellites, its launch weight is greatly reduced, which reduces the requirements for the carrying capacity of the launch vehicle. The amount of data will no longer be a constraint on the life of the satellite, and the design life of the communication satellite will generally exceed the current 15-year limit and reach 18 to 20 years.

The "Practice No. 13" satellite will mainly provide services for users in China and other regions. It can realize the access of mobile communication base stations in remote areas and be used in the fields of enterprise private networks, distance education, medical treatment, digital news gathering and emergency communications. At the same time, the star can facilitate users to quickly access the network, download and return rates up to 150Mbps and 12Mbps, which can effectively meet the needs of passengers on the high-speed vehicles such as aircraft, high-speed rail to access the Internet anytime, anywhere.

High-throughput satellites are an important part of satellite communications and broadcasting systems in China's integrated space-ground information network. They are an effective complement to terrestrial communication systems and can be widely used in areas where terrestrial communication systems are difficult to cover or where construction costs are high. After the completion of the “Global Coverage, On-Demand Access, On-Demand Services, Safe and Trustworthy” integrated information network in the world, China will have global space-time continuous communication, highly reliable and secure communication, regional large-capacity communication, and high-mobility full-range information transmission. And other capabilities to meet national strategic needs such as expanding national interests, safeguarding national security, safeguarding national economy and people's livelihood, and promoting economic development. In view of the strategic significance of high-throughput satellites in the space and information fields, China will continue to deploy ultra-high-capacity high-throughput satellites. It is expected that by 2020, it will form a communication capacity that can cover the entire territory of China and the Asia-Pacific region with a capacity of nearly 200Gbps. To meet the urgent needs for broadband communications in the construction work of "Broadband China" and the country's "Belt and Road", the relevant industrial chain is expected to usher in rapid development.

4) 'Hongyan' Project

Construction goal: "Communicate and connect everything, the world will never lose touch"

It is planned to invest 100 billion yuan in 300 low-orbit satellites. The first test star was launched on December 29, 2018. The backbone constellation system is expected to be built in 2023. Its satellite data exchange function can provide two-way, real-time data transmission worldwide, as well as multimedia data services such as short messages, pictures, audio, and video. After the system is completed, services such as intelligent terminal communications, Internet of Things, mobile broadcasting, navigation enhancement, aviation and maritime surveillance, and broadband Internet access will be launched. The system has a

global real-time communication capability under all-weather and full-time terrain conditions.

5) 'Hongyun' Project

China Aerospace Science and Industry plans to launch 156 satellites. The satellites will be networked in orbits 1,000 kilometers above the ground to build a space-borne broadband global mobile internet network. The first test star was launched on December 22, 2018.

The entire Hongyun project is divided into three phases. The first phase is to launch the first star at the end of 2018; the second phase is to launch four business test stars at the end of the "Thirteenth Five-Year Plan", or before the end of 2020; the third stage is to "Ten In the middle of the 4th Five-Year Plan period, around 2023, 156 satellites will be launched, and the construction of the heaven-earth integration system will be completed initially, with full operating conditions. After the entire plan is completed, it will realize Internet access at anytime, anywhere, on the "Belt and Road" and even globally, and achieve a high-speed, high-quality Internet / IoT application experience.

6) OneWeb of United States

One Web plans to deploy 648 small satellites in low-Earth orbit to form an Internet satellite network, enabling users around the world to connect to satellites and access 3G, LTE, 5G, and Wi-Fi networks through small, low-cost user terminals. It is characterized by multiple satellites, interconnection with the Internet, and a single ground terminal download rate of 50Mbps.

7) SpaceX of United States

SpaceX Starlink:7, 518 low-Earth orbit satellites not exceeding 346 kilometers in height (Launch of Microsat-2a and Microsat-2b in early 2018)

III. Application of Satellite Communication in the Process of Power Transmission, Transformation and Distribution

A. Transmission fault monitoring system

The transmission fault monitoring system, consisting of tower poles, sensor cluster, satellite wireless transceiver, power monitoring center, and mobile phone of the responsible person, to realize the status monitoring, information reporting, and fault early warning of the transmission line. The transmission fault monitoring system is a supplement to the online monitoring system of the entire smart grid transmission line. By using satellite technology, it provides strong support in areas that cannot be covered by existing monitoring systems.

The business capability is increased to realize the visual real-time monitoring and fault early warning of various states of the transmission line without the coverage of the ground network. The monitoring of the status of important electrical devices on the tower pole, such as circuit breakers, load switches, section switches, and other switch monitoring and fault early warning on 10kV lines. The logic diagram of the high-level scheme of the transmission fault monitoring system is shown below:

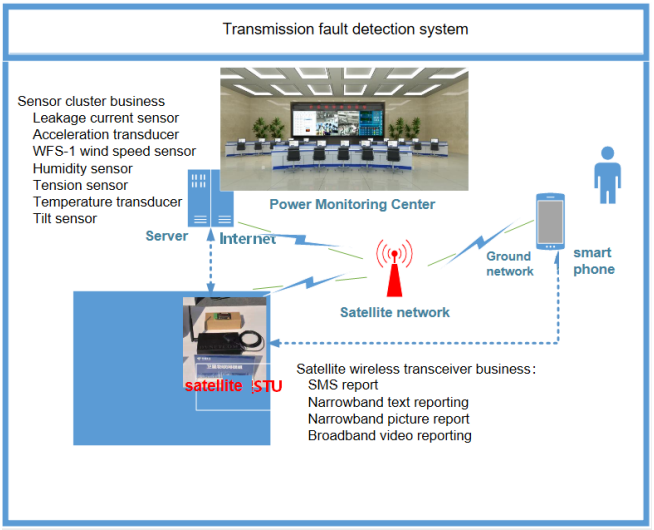

Figure 4. The logic diagram of the high-level scheme of the transmission fault monitoring system

The description of each part of the transmission fault monitoring system is as follows:

Satellite STU: It acts as an information transmission channel, and is particularly suitable for routine monitoring scenarios in areas without ground network coverage and disaster prevention and relief scenarios in areas without ground network coverage.

Power monitoring center: It is the existing monitoring center of the power system, not a newly deployed system platform, in order to save customers' capital investment budget to the greatest extent.

Responsible person's mobile phone: When an important failure occurs, the corresponding responsible person's personal mobile phone is notified by SMS to speed up the progress of failure handling and reduce accident losses. Of course, the level of important faults and the mobile phone number of the person in charge can be set before the implementation of the plan, which will not cause excessive SMS business and bring unnecessary pressure on the Responsible person

Sensor clusters: The main business capabilities realized in the entire scheme, that is, the types of transmission line status collection, depend on the configuration of the sensor clusters.

B. Distribution fault monitoring system

Transformer fault monitoring system, consisting of tower poles, sensor clusters, satellite STU, power monitoring center, and mobile phone of the responsible person, realize the status monitoring, platform docking, information reporting and fault early warning of distribution and transformation links.

The power distribution fault monitoring system is a solution to the fault monitoring and early warning requirements of physical nodes in the power distribution and transformation business that need to increase communication support. Conventional equipment on the ground network can partially address these needs, but cannot guarantee emergency communications during natural disasters. The terminal equipment STU used in the power distribution fault monitoring system is a combination of terrestrial network DTU, terrestrial network TTU, and satellite terminal technology, which can improve the reliability in the process of power distribution and transformation. Considering the cost of satellite service, it is recommended to construct and install it in important substations and distribution stations, but not in ordinary stations.

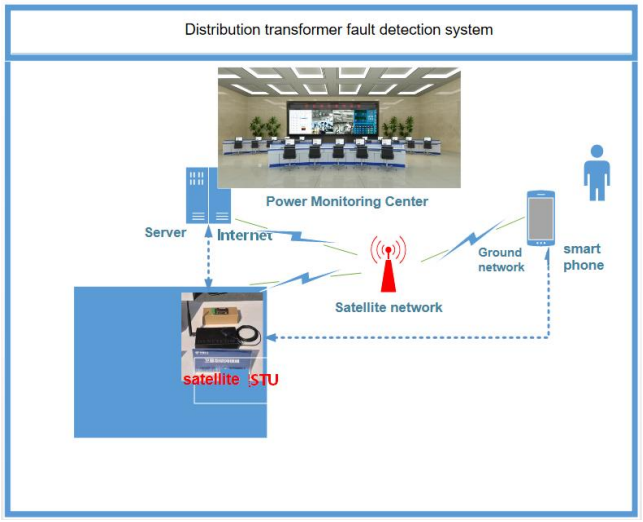

Figure 5. The logic diagram of the high-level scheme of the Distribution fault monitoring system

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which will not cause excessive SMS business and bring unnecessary pressure on the Responsible person

The satellite mobile communication system can quickly form an emergency communication network in an emergency area without relying on the original communication network, enabling the field headquarters and the command center to quickly establish communication links, and provide a certain bandwidth transmission rate, while transmitting voice, images, and data And other information, supporting real-time transmission of multi-directional dynamic images, high-definition video conferences, etc. Therefore, the use of satellite mobile communication means can realize emergency communications support for emergency rescue and disaster relief in large-scale disasters and meet the requirements of "all-weather, whole-process, all-round" emergency communications support, which is the future development trend of emergency communications.

IV. CONCLUSION

In the event of a very catastrophic disaster such as a blizzard, hurricane, earthquake, mudslide, etc., public communication network facilities may be catastrophically damaged and paralyzed. At this time, the communication of the emergency report and rescue command is urgent, which is convenient for effectively monitoring the field power transmission and transformation facilities, and at the same time, it can achieve rapid and effective rescue in the event of a disaster. The monitoring program uses China's Tiantong satellite with independent intellectual property rights to establish a remote monitoring system for power transmission and transformation facilities based on the Internet of Things of Satellites. This system has high security and anti-interference, and can effectively solve remote monitoring of the wild environment. , Data communication, positioning and other problems, to facilitate better operation and maintenance of power transmission and transformation facilities, reduce the failure rate of facilities, improve accident repair capacity, rescue timeliness and power supply reliability.

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