http: //d2.cigre.org /	CONSEIL INTERNATIONAL DES GRANDS RÉSEAUX ÉLECTRIQUES INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS **STUDY COMMITTEE D2** INFORMATION SYSTEMS AND TELECOMMUNICATION **2015 Colloquium** **October 15 to 16, 2015** **Lima – PERU**

D2-02_05

Undertakings to utilize Satellite Line to enhance Communications Network Disaster Resistance

by

Kouichirou KATSURADA*
Kyushu Electric Power Co., Inc.
(JP)

Shintarou MICHIWAKI
Kyushu Electric Power Co., Inc.
(JP)

Tetsuya SEKI
Nishimu Electronics Industries Co., Ltd.
(JP)

Satoko MANO
Fujitsu Limited
(JP)

Kazutaka HORI
Cisco Systems G.K.
(JP)

Kazutaka SHIMOOSAKO
Furukawa Electric Co., Ltd.
(JP)

SUMMARY

Recognizing the importance of robust communications networks, Japanese electric power companies have been engaged in the building of such networks in order to ensure stable supply of electricity. The results of these undertakings demonstrated that their private networks were able to continue operating even during the Great East Japan Earthquake that struck on March 11, 2011, even though public communications services were disrupted. At the same time, the experience of this earthquake disaster created an awareness of the need to promote enhanced availability, diversity and multiplexing as well as improvements such as the capability to construct temporary networks quickly in the event of a disaster.

This paper introduces two initiatives to further improve network reliability based on experiences such as the above. The first is a multiplexed IP network that utilizes a satellite line for integrated dam management systems and the second comprises the realization of diversification/multiplexing, implementation of earthquake countermeasures and introduction of an emergency communications vehicle for the purpose of constructing a nuclear emergency preparedness network to meet the New Regulatory Requirements.

KEYWORDS

Satellite line, Telecommunications lines for electric power systems, Earthquake disaster, Nuclear emergency preparedness network

* 1-82, Watanabe-dori, 2-Chome, Chuo-ku, Fukuoka, Japan 810-8720
Fax: +81-92-761-7749 e-mail: Kouichirou_Katsurada @kyuden.co.jp

1. Initiatives by Japanese Electric Power Companies to realize Robust Networks

Japanese electric power companies have constructed networks to communicate control information to ensure the stable supply of electricity and disaster prevention information to maintain plants. They have promoted the application of IP technologies to networks constructed in recent years and also implemented measures to meet the network requirements of high quality and high availability to ensure disaster resistance. These initiatives have assumed even greater significance since the Great East Japan Earthquake of March 11, 2011 and, particularly, demands for diversification and multiplexing of networks have grown as disaster prevention measures. To meet these demands, in particular, to realize network diversification, both fiber-optic lines and microwave radio links resistant to earthquakes have been used, thereby realizing multiplexing through diversification using different communication media. In addition, the tendency has been to use new communication media such as satellite lines to achieve diversification. Satellite lines are considered to be a new means of making a network available to restoration bases in the event of disasters. Measures to address issues identified relating to the use of satellite lines have been implemented and studies into utilization as network equipment are underway.

2. Strengthening of IP Network for Integrated Dam Management System in Kyushu Electric Power Company (Kyushu EPCO)

The integrated dam management system comprises remote supervisory control systems (TC), image monitoring systems (ITV) and civil engineering computer units (CPU) that perform tasks including water level measurement, gate operation and the generation of discharge alarms essential to the running, operation and management of dams.
For the purpose of renewal of the integrated dam management system that was started in FY2013, because the method of communication between the integrated and individual dam management offices uses IP, it was decided to accommodate the system in the existing IP network for electric power systems. During the process of renewal, in light of the fact that accommodation of the system in the IP network for electric power systems was the first attempt of its kind by Kyushu EPCO, integration testing of the IP network and integrated dam management system was carried out to achieve optimization of the network in which the system was incorporated and to check the system behavior both in the event of failure and during system recovery. The configuration of the integrated dam management system and network is shown in Fig. 2-1.

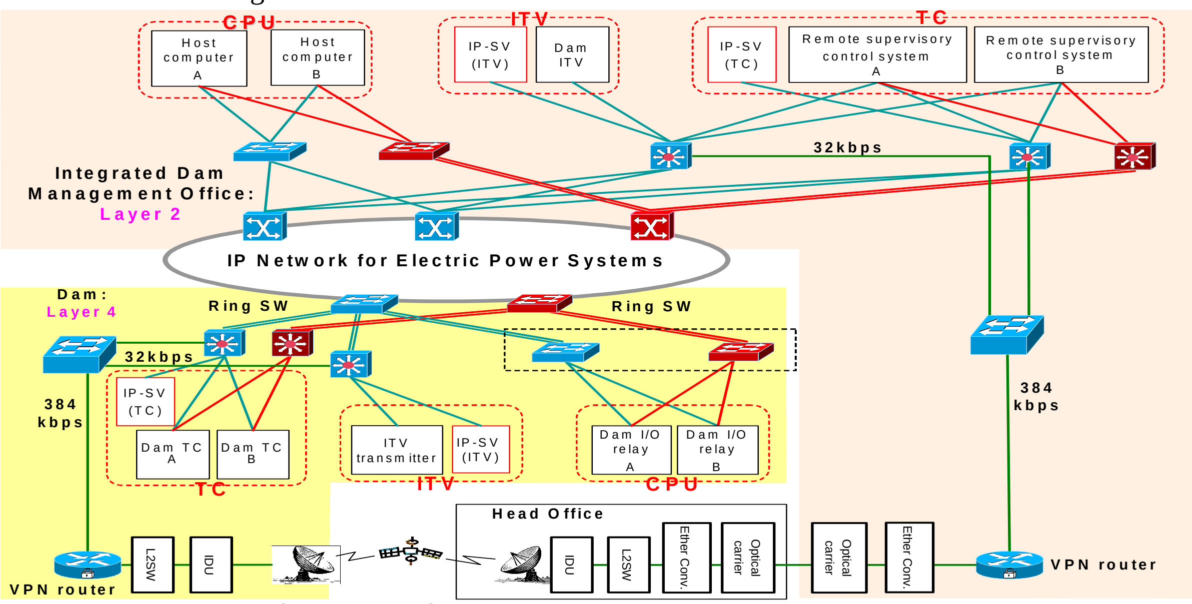

Fig. 2-1 Configuration of Integrated Dam Management System and Network

2.1 Overview of Integrated Dam Management System and System Requirements

The following three types of VPN (Virtual Private Network) exist in the IP network for electric power systems that accommodates the integrated dam management system.

(1) Remote supervisory control systems (TC)
Transmit and receive gate control information including gate opening/closing operation and gate monitoring information including gate apertures and water levels between the integrated and individual dam management offices. The bandwidth required per dam is 64kbps. (It is also 64kbps when a satellite line is used.) The maximum allowable traffic disruption time is 2 seconds.

(2) Image monitoring systems (ITV)
Transmit images from dam management offices to the integrated dam management office. The bandwidth required per dam is approximately 10Mbps. (This video traffic is compressed to 128kbps by the system when a satellite line is used.)

(3) Civil engineering computer units (CPU)
Transmit and receive information delivered on the web on the results of calculation of items such as dam outflow and inflow rates and weather information. The bandwidth required per dam is approximately 1Mbps.

Of these three, because of their importance, TC and ITV use a satellite line constructed as backup in addition to the terrestrial lines (fiber-optic and microwave radio) used during normal operation. Since a satellite line has an extremely narrow bandwidth of only 384kbps, 64kbps of which is used for discharge alarms, the bandwidth used is compressed by incorporating contacts of IP-SV for monitoring of the terrestrial lines into system equipment.

2.2 Switching to a Satellite Line and QoS Control

The communication routes using terrestrial lines during normal operation and the satellite line as backup are shown in Fig. 2-2.

While the satellite line captures a satellite when transmitting and receiving data packets, it is not desirable that the IP network for electric power systems captures a satellite even during normal operation. Therefore, rather than dynamic routing protocols, floating static routes where no data packets are transmitted or received during normal operation of the IP network have been adopted as the means of switching to the satellite line.

Since the satellite line has an extremely narrow bandwidth, PQ (Priority Queuing) is performed based on CoS values by the satellite line aggregation center switch to prioritize processing of data from TC. In addition, factoring in 64kbps used for discharge alarms, VPN routers shape the total bandwidth used for TC and ITV to 260kbps at the output port for satellite connection.

For data from ITV, bandwidth compression is performed by the system that receives alarm notices from IP-SV when all terrestrial lines are disrupted. In addition, bandwidth shaping to 128kbps is performed at the output ports of L3 switches for ITV at dam management offices in case the timing of switching to a satellite line is earlier than the timing of bandwidth compression by the system.

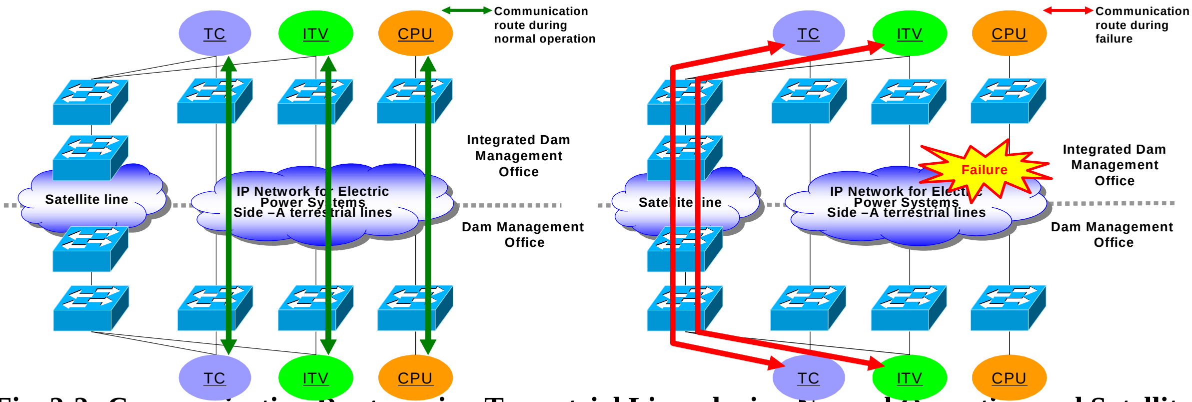

Fig. 2-2 Communication Routes using Terrestrial Lines during Normal Operation and Satellite Line as Backup

2.3 Results of Testing using a Satellite Line

The details and results of testing conducted to verify that the requirements for the IP network for electric power systems are satisfied even when using a satellite line are shown below.

(1) Network failure testing

Network failure testing was conducted to measure traffic disruption time by causing network failures (line and power failures). Since the network is configured with 2 sides (A and B) for TC and CPU where data packets are accepted on a first-come basis with the second discarded, switching to the other side or a satellite line was performed basically with no disruption, and since the network is configured with side-A only for ITV, switching to a satellite line was performed within 20 seconds. These results confirmed that the requirements of the system were satisfied.

Switching to a satellite line using floating static routes is triggered by a loss of OSPF route. If the OSPF default timer values (hello interval: 10 seconds and dead interval: 40 seconds) are used, the time needed to switching to a satellite line using floating static routes when an indirect link failure occurs cannot satisfy the line switching requirement for the IP network for electric power systems of a maximum switching time of 20 seconds. For this reason, the OSPF timer values have been changed to 3 seconds for the hello interval and 9 seconds for the dead interval to satisfy the requirements.

(2) QoS testing

A dummy load of 10Mbps was applied to L3 switches for ITV between the integrated and individual dam management offices and traffic measured at the output ports of VPN routers for satellite connection. The measured traffic was approximately 128kbps, and this result confirmed that ITV bandwidth control was performed correctly.

In addition, a dummy load of 10Mbps was applied to L3 switches for TC and ITV and traffic measured in a similar environment. The measured traffic was approximately 260kbps for TC and 0kbps for ITV, and these results confirmed that TC priority control was performed correctly.

(3) Actual TC traffic measurement

The results of measurement of the maximum traffic during operation of all dam gates showed a peak rate of approximately 45kbps. Although traffic over satellite links is shaped to 260kbps by a VPN router, the network is designed to give top priority to TC and ITV traffic is also shaped to 128kbps. For these reasons, we have determined that there is no problem with TC traffic.

Based on the above results, it has been verified that the network operates normally in compliance with the requirements of the integrated dam management system even when a satellite line is used by making optimal parameter settings using network technologies such as redundancy and bandwidth guarantee. Thus, a robust and disaster-resistant IP network for electric power systems has been constructed not only by providing the network with redundancy by existing wired terrestrial lines (fiber-optic network), but also by assigning different priorities to minimum necessary system applications and utilizing a satellite line in case of disasters or other serious events.

3. Construction of Nuclear Emergency Preparedness Network

The Great East Japan Earthquake that struck on March 11, 2011 caused massive damage mainly in areas along the Pacific coast from the Tohoku to Kanto regions, and serious damage was also caused to the telecommunications infrastructure, an essential lifeline.

While all public communication services around the Fukushima Daiichi Nuclear Power Station of Tokyo EPCO were brought to a halt, private communication lines for electric power systems continued operating normally. This was due to the efforts that had been made by Japanese EPCOs to strengthen their telecommunications networks up to that time. Nevertheless, this earthquake disaster has spurred Japanese EPCOs to engage in further strengthening of the nuclear emergency preparedness network with the aim of “improving nuclear safety” to meet the New Regulatory Requirements.

3.1 Strengthening of Nuclear Safety (New Regulatory Requirements）

In the process of implementing measures to improve safety of nuclear power stations based on the experience of the Great East Japan Earthquake, Kyushu EPCO needs to satisfy the following three criteria: "1: Implementation of emergency safety measures," "2: Overall safety evaluation" and "3: Plans to put technical findings (30 items), etc. into practice" set up by the government as "Judgment Criteria for Safety on the Restart of Nuclear Power Plants." In addition, the "Nuclear Reactor Regulation Law (New Regulatory Requirements)" that came into force on July 8, 2013 also needs to be satisfied to further enhance safety.
The basic concept of the New Regulatory Requirements is shown below.

(1) Strengthening of design basis and establishment of new requirements
To prevent simultaneous loss of all safety functions caused by common factors such as earthquakes or tsunamis, levels of anticipated natural phenomena and requirements for necessary measures for safety facilities for nuclear power plant equipment have been raised substantially.

(2) Measures against severe accidents
In case of severe accidents beyond the design basis set up according to the above requirements, new measures are needed to prevent severe accidents from developing by utilizing portable equipment.

3.2 Design of Telecommunications Facilities to conform to the New Regulatory Requirements

The New Regulatory Requirements require telecommunications facilities to be configured to provide diversity so that minimum necessary telecommunications facilities are available for use to deal with accidents, no matter how severe. The details are shown in Table 3-1.

Table 3-1 Design of Telecommunications Facilities to conform to the New Regulatory Requirements

Facilities	Design
Telecommunications Facilities (For communications inside the power station)	o Various types of telecommunications facilities to communicate operation and work instructions and safety alarms to issue evacuation instructions from the central control room to personnel in buildings such as reactor containment facilities and to persons outside such buildings in the event of a design basis accident (DBA) must be installed.
Telecommunications Facilities (For communications outside the power station)	o Telecommunications facilities for communication and contact with entities outside the power station must be connected to dedicated telecommunications lines with guaranteed diversity to ensure availability for use at all times in the event of a DBA.
Data transmission facilities (For transmission to outside the power station)	o A Safety Parameter Display System (SPDS) must be installed in the reactor auxiliary building and buildings around the nuclear power reactor to transmit necessary data to the Emergency Response Support System (ERSS) and other relevant systems outside the power station and connected to dedicated telecommunications lines with guaranteed diversity to ensure availability for use at all times in the event of a DBA.
Power supply facilities	o Telecommunications and related facilities must be designed with emergency in-house power sources, rechargeable batteries and dry cells to ensure operational capability even when external power sources cannot be relied upon. o Telecommunications and related facilities must be designed with the capability to be supplied with power by an alternative power supply system (including standby power supply systems such as batteries) in the event of incidents such as severe accidents (SAs).

3.3 Overview of Telecommunications Facilities for Communications inside Power Stations of Kyushu EPCO

Kyushu EPCO has installed and operates safety alarms (emergency siren and paging system) and telecommunications facilities with guaranteed diversity (e.g., phones over a dedicated network, transceivers and satellite phones) capable of communicating operation, work and evacuation instructions from the central control room to locations inside and outside buildings that people may enter. An overview of telecommunications facilities for communications inside power stations is shown in Fig. 3-1.

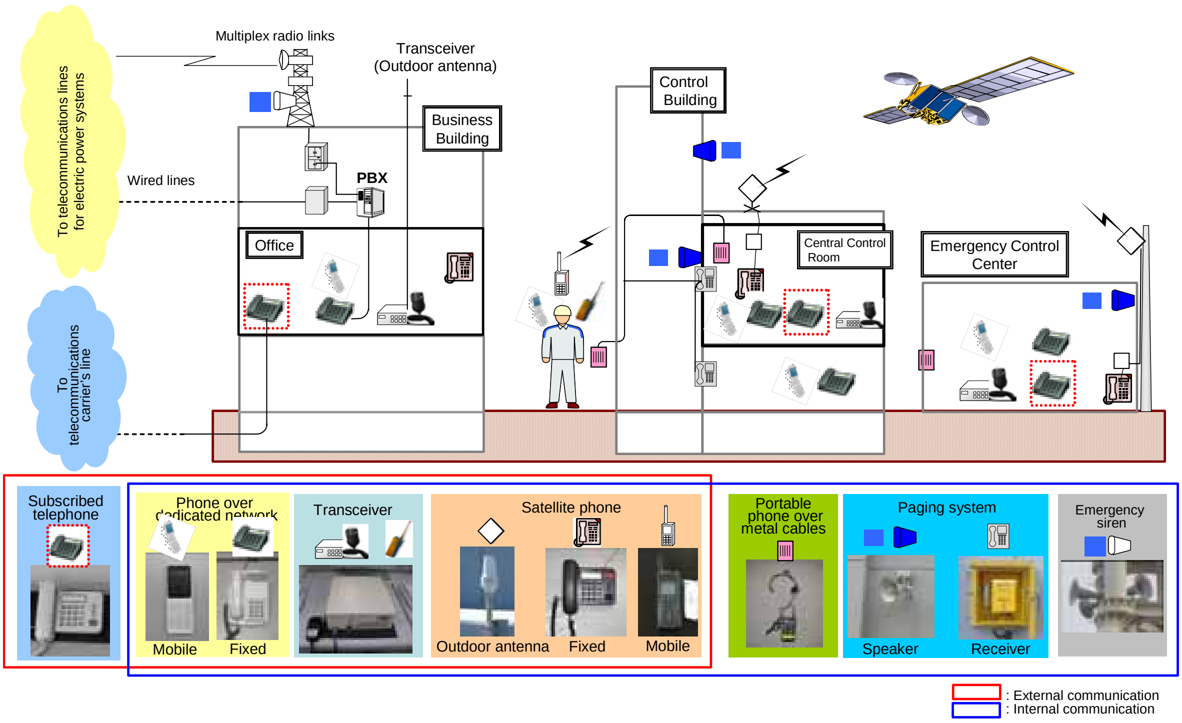

Fig. 3-1 Overview of Telecommunications Facilities for Communications inside Power Stations

3.4 Overview of Telecommunications Facilities inside Kyushu EPCO for Communications outside Power Stations

The New Regulatory Requirements require telecommunications facilities capable of communicating with entities outside power stations to ensure availability under any circumstances. To meet this requirement, Kyushu EPCO has connected phones over a dedicated network and the teleconference system to its private telecommunications lines (wired lines and multiplex radio links) for electric power systems and a dedicated telecommunications line (satellite line) provided by a telecommunications carrier, thereby realizing dedicated telecommunications lines with guaranteed diversity. An overview of telecommunications facilities inside Kyushu EPCO for communications outside power stations is shown in Fig. 3-2.

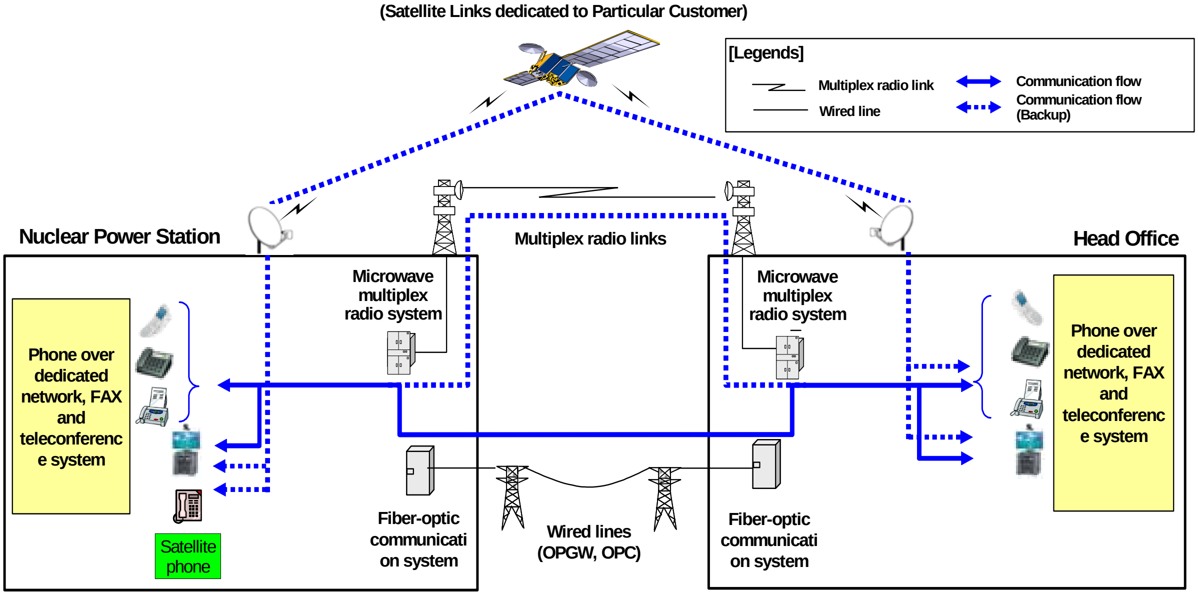

Fig. 3-2 Overview of Telecommunications Facilities inside Kyushu EPCO for Communications outside Power Stations

3.5 Overview of Telecommunications Facilities outside Kyushu EPCO for Communications outside Power Stations

Kyushu EPCO has installed data transmission equipment to transmit data to telecommunications facilities and systems such as the Emergency Response Support System (ERSS) connected to diversity-guaranteed lines (terrestrial lines and satellite links provided by a telecommunications carrier) dedicated to the Integrated Nuclear Emergency Preparedness Network. A separate route via the Head Office over Kyushu EPCO's private telecommunications lines for electric power systems has also been constructed as backup for data transmission equipment. An overview of telecommunications facilities outside Kyushu EPCO for communications outside power stations is shown in Fig. 3-3.

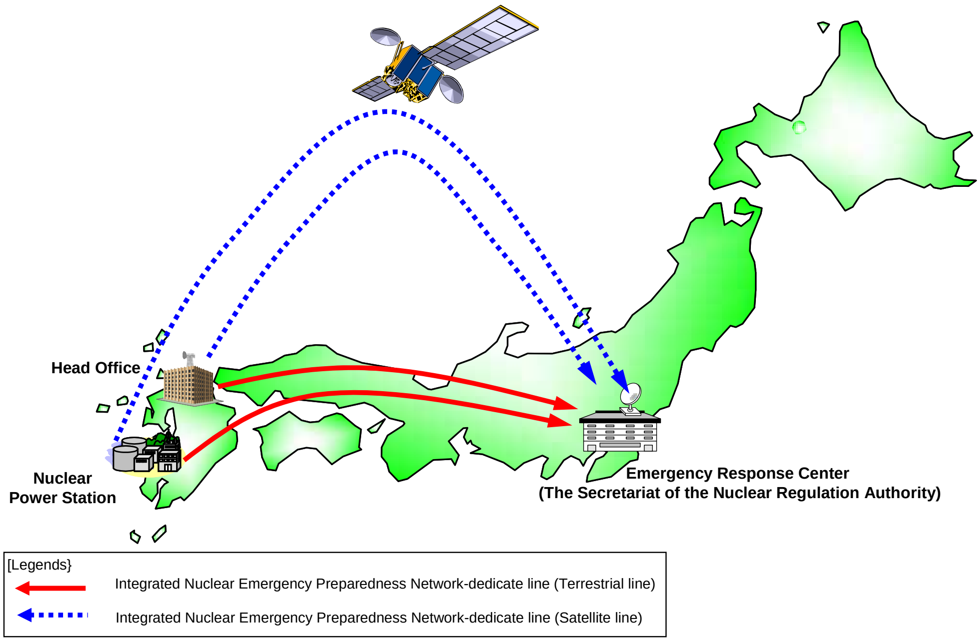

Fig. 3-3 Overview of Telecommunications Facilities outside Kyushu EPCO for Communications outside Power Stations

3.6 Aseismic Measures in Kyushu EPCO

For the purpose of seismic assessment, Kyushu EPCO conducted vibration testing according to the national standard at a vibration testing machine manufacturer's factory to assess the integrity of telecommunications equipment against the design-basis earthquake ground motion. This testing enabled understanding of the effects in a real environment by simulating telecommunications equipment mounted with an antenna or installed in a rack, as shown in Fig. 3-4.

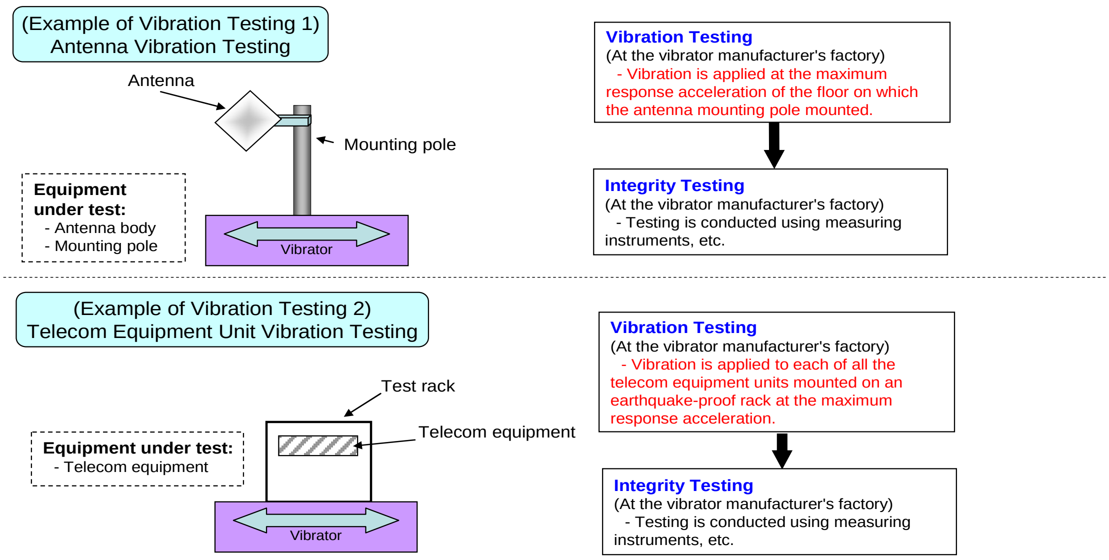

Fig. 3-4 Overview of Vibration Testing

3.7 Emergency Communications Vehicle under Consideration by Kyushu EPCO

Because means of communication and contact need to be available immediately even in the event of a severe accident due to a disaster such as an earthquake or tsunami, Kyushu EPCO is now considering the introduction of an emergency communications vehicle mounted with communication equipment including satellite communication and video conference systems that has already been introduced by other electric power companies. An overview of the emergency communications vehicle is shown in Fig. 3-5.

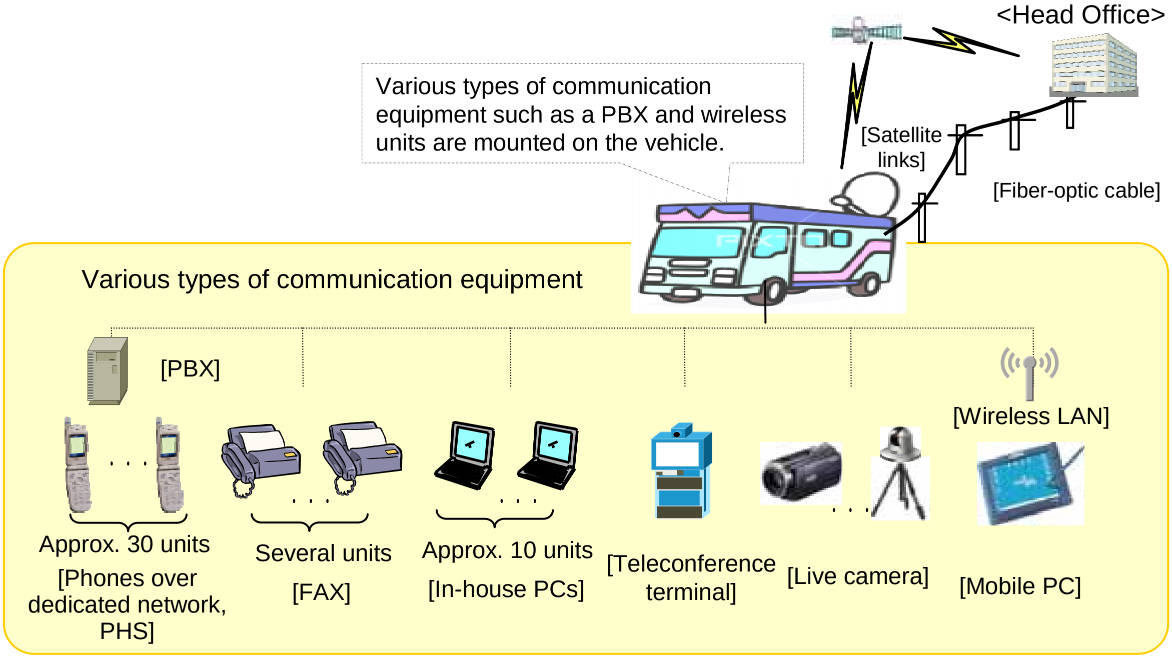

Fig. 3-5 Overview of Emergency Communications Vehicle

4. Conclusion

As stated above, electric power companies in Japan need to provide telecommunications networks for locations such as integrated dam management offices and nuclear power stations with redundancy and diversity to ensure availability of minimum telecommunications facilities required to deal with possible severe accidents even in the event of disasters such as earthquakes and tsunamis. During this undertaking, Kyushu EPCO has successfully provided the telecommunications network for electric power systems with redundancy by connecting to telecommunications lines (wired lines and multiplex radio links) for electric power systems or a satellite line provided with multiple routes and has also enhanced disaster resistance by diversifying means of communication, thereby strengthening the telecommunications network.

We intend to continue to work to further strengthen and improve the telecommunications network in the future, for example, by introducing an emergency communications vehicle.