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Audiovisual and Communication Technologies for a Safe, Secure, and Comfortable Society

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Changes for the Better

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Mitsubishi Electric ADVANCE

Audiovisual and Communication Technologies for a Safe, Secure, and Comfortable Society

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Technical Reports

Precis

Toward realizing a society that is safer, more secure and more comfortable, Mitsubishi Electric Corporation has nurtured its audiovisual and communication technologies over a long period, while focusing on security, video content analysis (VCA), high speed and large capacity, reliability improvement and others.

This special issue introduces various advanced technologies that can enhance security through the use of surveillance cameras, improve productivity at industrial facilities through the use of VCA, enhance the reliability of high-speed large-capacity communications and improve train service management.

Overview

Author: *Kengo Tanaka**

Foreword to Special Issue on Audiovisual and Communication Technologies for a Safe, Secure, and Comfortable Society

A digital transformation (DX) to use new advanced technologies, such as the Internet of Things (IoT), big data analysis, and artificial intelligence (AI), in various fields is under way around the world. This transformation is improving convenience and comfort in society while also making social systems more complex in both the real world and cyberspace, increasing the risks to both security and safety. The Mitsubishi Electric group is therefore promoting initiatives to create value, such as simultaneous achievement of "sustainability" and "safety, security, and comfort", by helping to solve social issues.

Audiovisual and communication technologies are important for improving convenience and comfort while reducing risks. Mitsubishi Electric Corporation has been working on video surveillance and video content analysis (VCA) technologies and the underlying communication technologies as follows.

For audiovisual technologies, our proprietary compact AI "Maisart" and VCA technologies are being used to help ensure safety, resolve labor shortages, and improve quality by detecting people with white canes and by improving the quality and productivity of operations by analyzing the movement of workers at plants.

For optical communication technologies, we have been working on the following to cope with the increase in communication traffic due to 5G: developing next-generation passive optical network (PON) systems for optical access networks; and improving the speed and reliability of optical cross-connect systems for core metro networks, thus making communication flow more comfortable.

Regarding wireless technologies, we have rapidly deployed smart meter systems over a wide area of Japan, making meter-reading more intelligent for the electric infrastructure. For transportation infrastructure, we have been improving the level of operation management and the convenience and comfort of various services on trains by digitizing and speeding up train radio communications and adding more functions.

Regarding IoT, we have increased the throughput of IoT gateways, provided different models based on environmental resistance, and implemented cybersecurity functions.

Mitsubishi Electric will continue to develop audiovisual and communication technologies and appropriately apply advanced technologies such as IoT, 5G, and AI, to help build a safe, secure, and comfortable society.

**Communication Systems Engineering Center*

Fixed Dome Camera with Improved Impact Resistance

Authors: *Yoshio Okinishi** and *Nobuhiro Tachibana**

1. Introduction

There is an increasing demand for surveillance camera systems to enhance security for the 2020 Tokyo Olympic and Paralympic Games.

Surveillance cameras are installed at various places for specific purposes. However, those installed within reach, such as on low ceilings and walls, may be vandalized such as by hitting with an umbrella. To prevent such destruction, surveillance cameras that can resist impact are needed.

To meet such demands, Mitsubishi Electric Corporation has developed fixed dome cameras with improved impact resistance.

2. Fixed Dome Cameras with Impact Resistance

2.1 Specifications

Figure 1 shows the appearance of a fixed dome camera with impact resistance, and Table 1 lists the specifications.

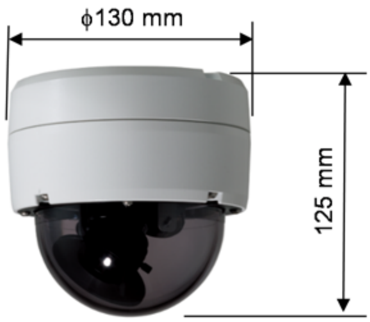


Fig. 1 Fixed dome camera with impact resistance

Table 1 Specifications

No.	Item	Specification
1	Image sensor	1/3 CMOS
2	Effective pixel count	Approx. 1,310 thousand pixels
3	Picture size	SXVGA, VGA, QVGA
4	Dynamic range function	Provided
5	Electronic sensitization	16 times max.
6	Automatic electronic sensitization function	Automatic and manual switching
7	Digital sensitization	8 times max.
8	Lowest written illuminance	With a smoked dome Normal time: 0.50 lux 0.04 lux (Electronic sensitization: 16 times) With a clear dome Normal time: 0.250 lux 0.016 lux (Electronic sensitization: 16 times)
9	Impact resistance	50 J (conforming to JIS C 60068-2-75)
10	Service temperature and humidity	−10 to 50°C, 80% RH or less (no condensation)
11	Outside dimensions	Approx. ϕ130 × 125 (H) (mm)
12	Mass	<900 g

CMOS: Complementary Metal Oxide Semiconductor
VGA: Video Graphics Array
SXVGA: Super eXtended VGA
QVGA: Quarter VGA
RH: Relative Humidity

2.2 Advantages

Fixed dome cameras with impact resistance have the following advantages.

(1) Higher impact resistance to prevent breakage

Impact resistance of 50 J was achieved in a hammer test (JIS C 60068-2-75).

(2) Good resolution

The resolution of the dome cover is 2 million pixels.

(3) Reduced stray light

Deterioration of image quality due to light entering from outside of the angle of view is reduced.

3. Development Details

3.1 Issues and solutions

Figure 2 shows the development flow, issues, and solutions.

3.2 Impact resistance specifications and testing standards

3.2.1 Impact resistance specifications

In the fixed dome camera market, the impact resistance specifications are broadly divided into impact

*Communication Networks Center

[Development flow]

Determining the specifications

Issue:
- Determining the highest impact resistance specification in the industry.

Solution:
- Researched the market trend of fixed dome cameras.

Impact resistance

Issues:
- Securing the strength of cases with the required resistance (determining the material of the cases).
- Determining the thickness of the dome cover such that when an impact is applied, the cover will not touch the lens.

Solutions:
- Designed the strength of the cases through shock analysis.
- Designed the thickness and clearance through preliminary testing and shock analysis.

Resolution

Issue:
- Determining the tolerable thickness of the dome cover.

Solution:
- Clarified the correlation between the thickness and modulation transfer function (MTF) when a dome cover is installed through optical analysis.

Reducing stray light

Issue:
- Understanding the directions of incoming light beams and their intensity that cause a stray light phenomenon.

Solution:
- Calculated the light intensity through optical path analysis and designed a structure to suppress stray light.

Fig. 2 Development flow, issues and solutions

energy of 20 J according to IEC62262 for Europe and America and impact energy of 50 J based on JIS C 60068-2-75 for the Japanese market.

We set the impact energy of our dome cameras at 50 J, which is the highest level in the industry, based on JIS C 60068-2-75.

3.2.2 Testing standards

An impact resistance of 50 J means that the impact energy value obtained in accordance with the hammer testing standards is 50 J (at maximum). In the hammer test, as shown in Fig. 3, a 10-kg hammer is used to hit a sample three times from 0.5 m high using a pendulum.

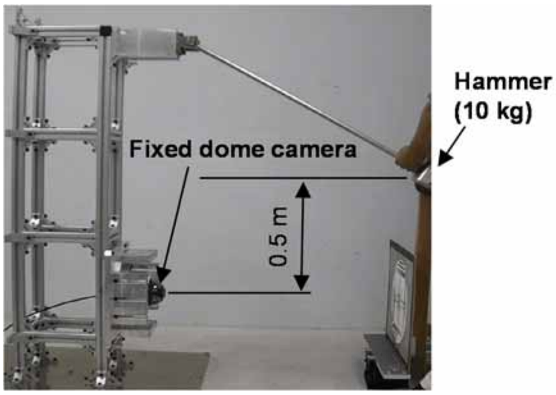


Fig. 3 State of hammer test

3.3 Development details

Figure 4 illustrates the configuration of a fixed dome camera. The camera unit and lens unit (inner parts) are secured with cases and protected with a transparent dome cover. For the fixed dome cameras with impact resistance developed this time, existing types of camera and lens units were used and new types of cases and dome cover were developed. An impact from outside of the product is absorbed by the cases and dome cover. Furthermore, a rubber blackout hood with shock absorbing structure is provided near the lens. In this way, the structure has achieved the impact resistance of 50 J.

With this design, we have succeeded in commercializing fixed dome cameras that satisfy the

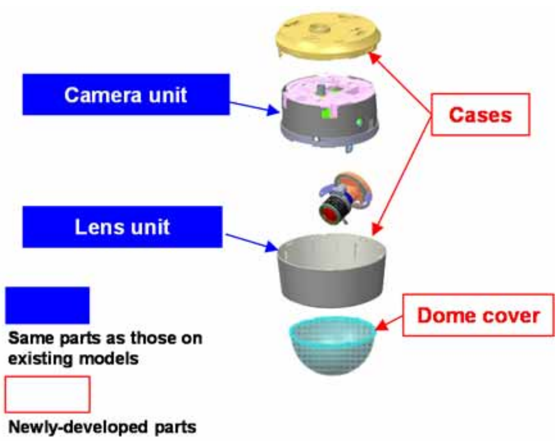


Fig. 4 Configuration of fixed dome camera

impact resistance of 50 J while providing the necessary optical performance.

3.3.1 Thickness of dome covers to secure impact resistance(2)(3)(4)

(1) Change to the material of cases

Since an impact applied to a dome cover is transmitted to the cases, the cases must have enough strength. Therefore, the material of the cases was changed from the resin used in conventional products to die-cast aluminum.

(2) Design of the impact resistance of dome covers

The lens unit inside a dome camera is protected by a hemispherical dome cover. If an impact is applied to the dome cover, it may momentarily deform, and if it touches the lens unit, the lens unit may break. To avoid this problem, the thickness of the dome cover and the clearance between the cover and lens unit should be sufficient such that even if the cover deforms, the impact will not be directly transmitted to the lens unit. Generally, the thicker the dome cover, the smaller its deformation when an impact is applied. However, there is a limit on the thickness as shown in Section 3.3.2 below and so it needs to be optimized. The deformation of a dome cover when an impact is applied was calculated through shock analysis and a preliminary test was carried out to understand the variation and obtain a factor to correct for errors in the analytic values. The value was then used to improve the design accuracy.

The obtained correction factor was used to carry out shock analysis shown in Fig. 5 with the curvature radius and thickness of the dome cover as main parameters. In the analysis, the necessary thickness (A mm or more) of the dome cover was calculated such that it will not come into contact with the lens when it momentarily deforms in relation to the clearance between the lens and cover.

3.3.2 Thickness of dome cover to secure the resolution

The thicker a dome cover, the larger the optical path difference due to refraction. Therefore, a thicker cover affects the focusing performance of the lens and reduces the resolution. To check that sufficient resolution could be secured, optical analysis was performed with the curvature radius and thickness of the dome cover as main parameters to determine the thickness. Figure 6 illustrates the optical analysis model. Light beams incident into the dome cover from infinity are condensed by the lens and the CMOS calculates the defocus amount when they are received. MTF is obtained as an indicator for the resolution. Figure 7 shows the correlation between the MTF and the thickness of the dome cover obtained from the optical analysis results. Based on these results, the required thickness (B mm or less) of the cover that satisfies the standard MTF value was obtained. Since the thickness of A mm or more obtained in Section 3.3.1(2) is required to secure the impact resistance, the thickness of the cover should be between A mm and B mm. The risk is lower for thinner dome covers considering the formability (such as sink marks poor appearance) and material strength (brittleness). Therefore, the thickness of A mm that would satisfy both impact resistance and resolution was selected.

3.3.3 Reduction of stray light phenomenon

The larger the clearance between the lens unit and dome cover, the more the stray light phenomenon occurs, which deteriorates the image quality. To reduce such

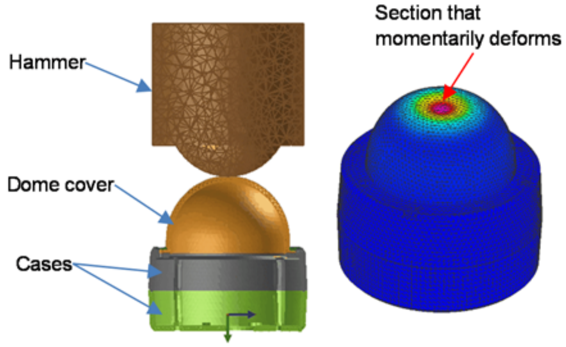


Fig. 5 Results of shock analysis

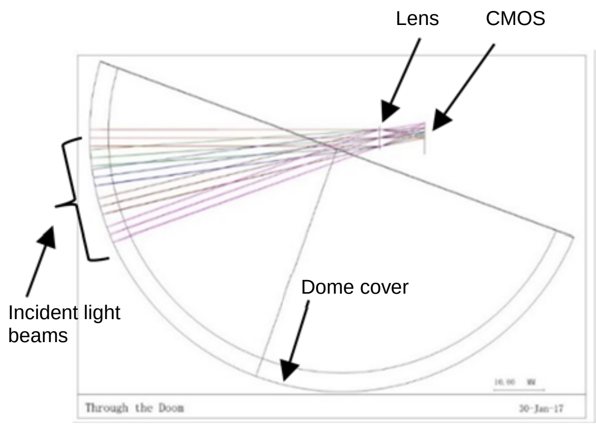


Fig. 6 Optical analysis model

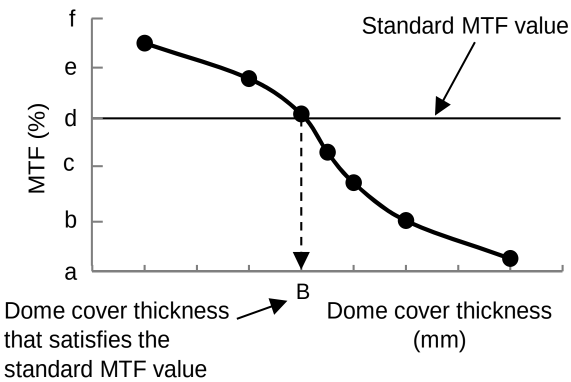


Fig. 7 Results of optical analysis

deterioration, optical path analysis was performed to identify the ray paths that would cause stray light. A blackout hood to shield light is provided to reduce stray light, while the rubber blackout hood with shock-absorbing structure increases the impact resistance.

(1) Stray light phenomenon

The stray light phenomenon is unnecessary light scattering that occurs inside the body tube of optical equipment. For surveillance cameras, it means that light beams from outside of the angle of view of the lens are unnecessarily reflected in the lens and refracted, and enter the images. As a result, they appear in images as objects that do not exist in the angle of view. Figure 8 shows an example of the stray light phenomenon. The figure shows that fluorescent light beams entering from the rear of the lens, etc. are reflected in the dome cover and other parts and appear in the image as flares.

(2) Optical path analysis

To reduce the stray light phenomenon described in (1), when developing our fixed dome camera this time, we performed optical path analysis to calculate and understand the paths of light beams passing through the lens and their intensity. Figure 9 shows the results of the analysis. The stray light phenomenon occurs (1) when a light beam from the rear of the lens is reflected inside the dome cover and enters the lens, and (2) when a light beam from the side of the lens is reflected in the edge of the lens and inside the dome cover and enters the lens.

(3) Structure for suppressing stray light

The optical path analysis results in (2) show that the stray light phenomenon occurs due to light beams coming from the two paths shown in Fig. 9. Therefore, a hood to shield light was added to reduce the stray light. Figure 10(c) shows the images taken before and after installing the hood. On the image before installation, the lens is reflected in the dome cover, while on the image after installation, such reflection is reduced.

3.3.4 Shock-absorbing structure

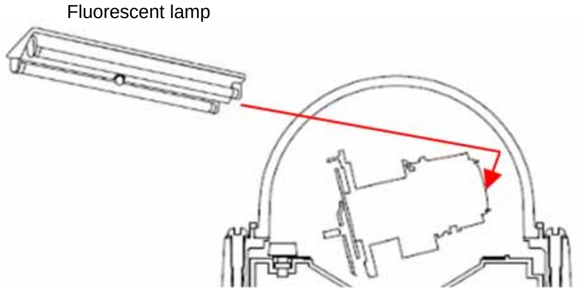
As described previously, to reduce the stray light phenomenon, a blackout hood was installed near the lens, but as a result of this structure, an impact to the dome cover tended to be transmitted to the lens. To prevent this, the following two modifications were made to the blackout hood to absorb external impacts (Fig. 11).

(1) The blackout hood is made of rubber material.

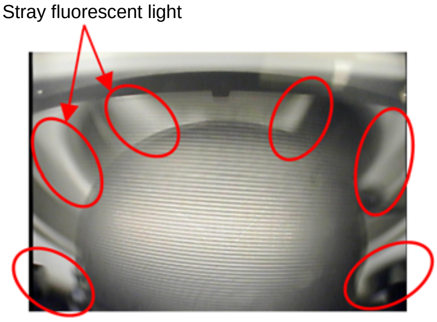
(2) A constriction structure is provided at the base of the blackout hood to serve as the starting point of deformation.

4. Conclusion

The fixed dome cameras with impact resistance (models: NC-6710 and NC-8610) developed this time offer higher impact resistance to prevent damage while enabling use of the coaxial and LAN cable networks of existing surveillance camera systems. We will continue to increase the product types and support the development of social infrastructure to help create a safe and secure society.

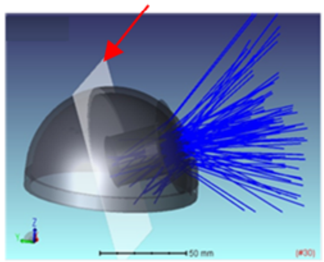


(a) Entry path of light

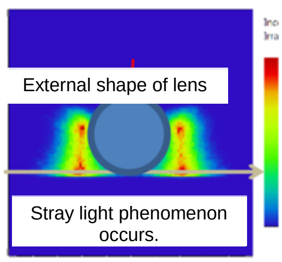


(b) Stray light phenomenon

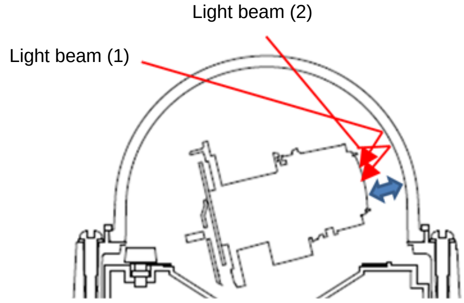
Fig. 8 Path of light entering the lens and occurrence of stray light phenomenon



(a) Entry path of light beams

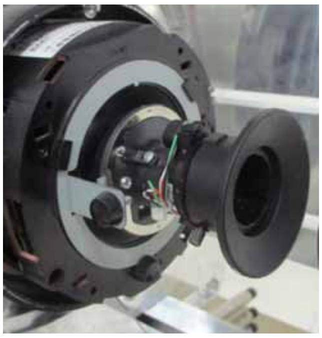


(b) Light intensity distribution

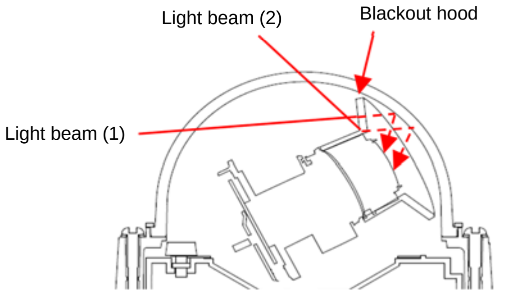


(c) Entry path of light beams

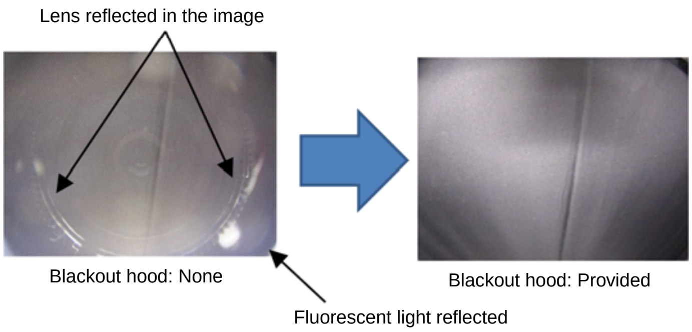
Fig. 9 Results of optical path analysis



(a) Blackout hood

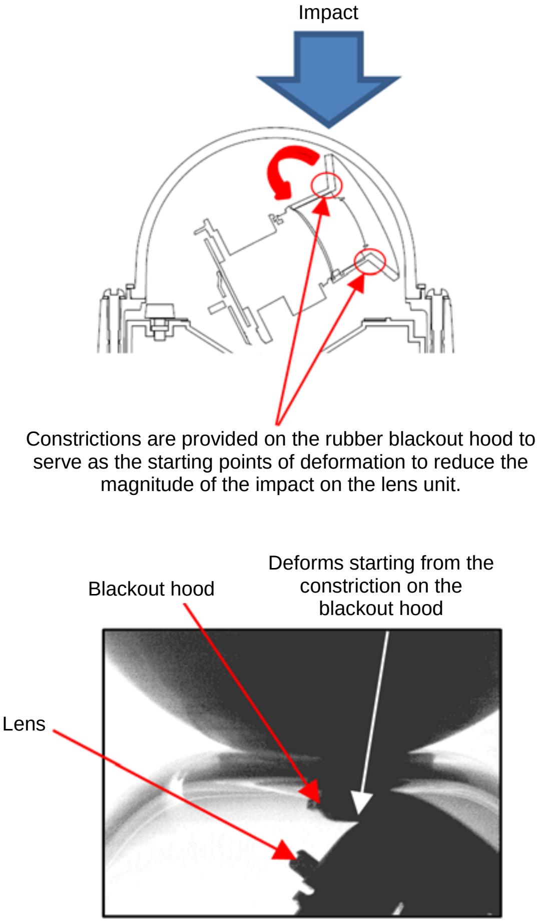


(b) Blackout hood for shutting out the light



(c) Improvement

Fig. 10 Structure for suppressing stray light and improvement effect



Deformation of hood under impact

Fig. 11 Shock-absorbing structure

References

(1) Mitsubishi Electric Corporation, Mitsubishi Network Camera System MELOOK3 http://www.mitsubishielectric.co.jp/nwcamera/support/catalogue.html

(2) Y. Kasai, et al.: PTZ Camera with HD and IP for Wide Area Surveillance System, Mitsubishi Denki Giho, 90, No. 6, 357–361 (2016)

(3) J. Yoshizawa, et al.: Thermal and Earthquake Resistant Design and Verification Technologies for Control Console, Mitsubishi Denki Giho, 87, No. 4, 244–248 (2013)

(4) N. Tani, et al., Method of Drop-impact Analysis for large Enclosure, Mitsubishi Denki Giho, 84, No. 12, 681–684 (2010)

Video Analysis Solution for Manufacturing Lines

Authors: *Masahiro Matsue** and *Shogo Shimizu***

1. Introduction

In recent years, amid labor shortages and increasing awareness of food safety, there is a growing need for improving the productivity of manufacturing lines and preserving quality. Accordingly, more cameras have been installed to monitor manufacturing sites and analyze the work. Meanwhile, the operators who conduct the monitoring and analysis need to review large amounts of image data sent from cameras in order to respond. Such tasks need to be automated to improve efficiency.

To satisfy such market needs, Mitsubishi Electric Corporation has developed a video analysis solution for manufacturing lines, which is characterized by the use of VCA technology called EIMON. EIMON visualizes the time of each task in manufacturing processes and automates the detection of abnormal work, making it possible to reduce the workload on those who conduct monitoring and analysis. In addition, we have worked to apply this solution to tasks ranging from the introduction of equipment into manufacturing lines to studies on work, by linking with the MELOOK3 series that was released as a surveillance camera system for monitoring and crime prevention.

This paper describes, in consideration of trends in the manufacturing sector, a work analysis technology based on the EIMON VCA technology, and the results of a demonstration experiment of the video analysis solution performed at our factory using the MELOOK3 system and future development.

2. Trend in the Manufacturing Sector and Issues

2.1 Use of IoT technologies in the manufacturing sector

Since the announcement of “Industry 4.0” (Germany) in 2011, reforming the manufacturing industry by actively using IoT technologies has been gaining attention. The governments of various countries have released similar concepts, such as “Connected Industry” (Japan) and “Made in China 2025.”

The main element of Industry 4.0 is smart factories where IoT technologies are used to connect manufacturing equipment, sensors, and other types of systems in factories to enable visualization and higher efficiency. Mitsubishi Electric has been promoting “e-F@ctory” since 2003 as a comprehensive solution for smart factories that delivers added value such as higher productivity, quality, and safety.

To further improve efficiency by turning to smart factories, it is important to use information on humans in addition to information on goods. Although information on goods such as equipment can be easily collected by IoT technologies, it is usually difficult to collect information on humans such as workers. One possible method of doing so is to use sensors. However, since contact sensors are stressful for workers for both physically and mentally, image sensors and other types of non-contact sensors are desired.

A main example of the use of image sensors in the manufacturing industry is visual inspections to detect apparent abnormalities in products. In conventional image analysis systems, algorithms need to be selected and combined for each target. However, in recent years, once systems with artificial intelligence (AI) technologies have learned a sufficient number of correct (good) images and incorrect (poor) images, they can make inspections with high accuracy.

Thus, whereas still images are often used for visual inspections, to obtain required information on humans at smart factories, various human movements need to be sensed, and this requires motion video. Since more computer resources are required to analyze motion video than still images, video has not been actively used to date. One possible likely application is to use image sensors to analyze the paths of human movements and to use the data to optimize the layout in factories.

2.2 Issues in the manufacturing sector

While the latest technologies have been introduced in smart factories, it is difficult to secure workers at actual manufacturing sites, the same as in other industries. According to the 2017 White Paper on Manufacturing Industries (*Monozukuri*) issued by the Japanese Ministry of Economy, Trade and Industry, 57.1% of manufacturing companies selected “It is getting more difficult to secure human resources due to the labor shortage” as a problem for maintaining and improving workplace skills at manufacturing sites (Fig. 1). In addition, 21.7% of the companies selected “Making operations more efficient by actively using IT and thorough streamlining” as the most

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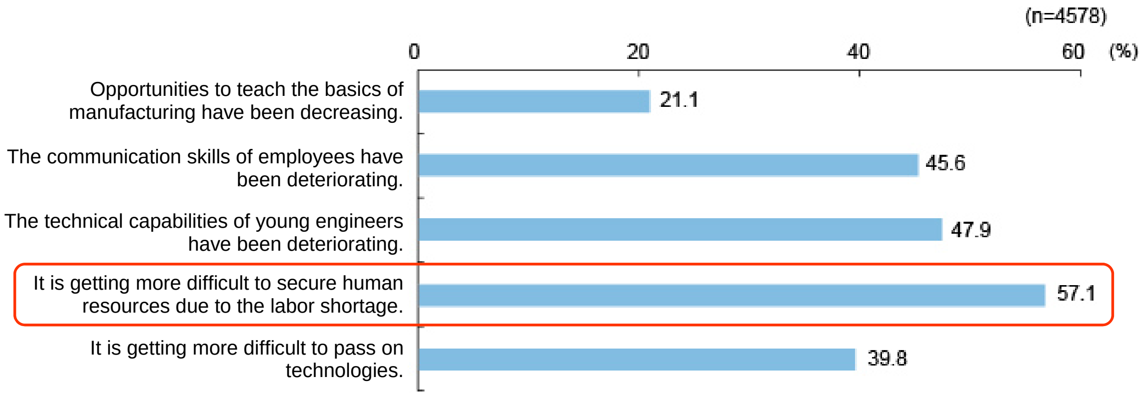

Fig. 1 Challenges in maintaining and strengthening workplace skills

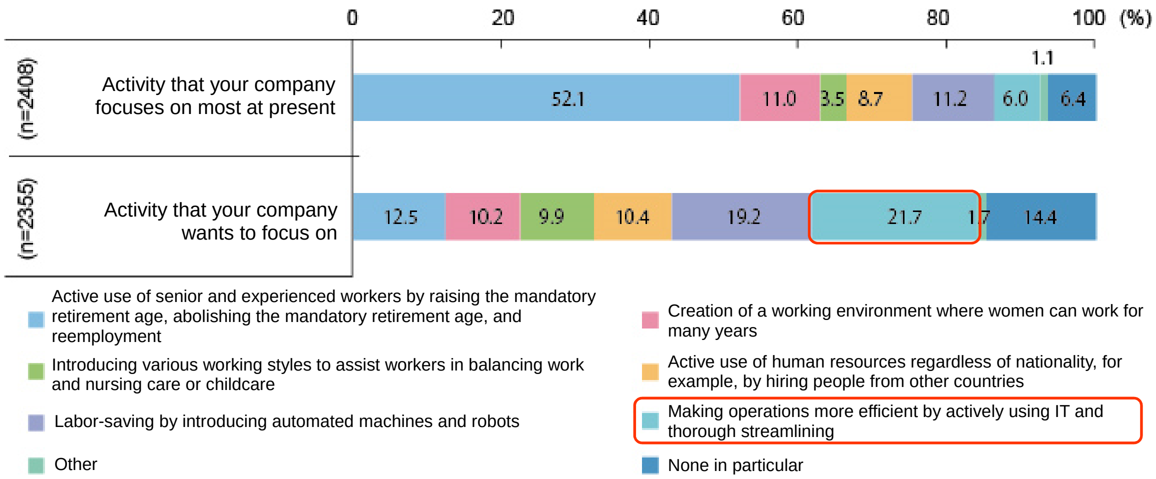

Fig. 2 Most valuable activities amid the shortage of skilled workers (current and future)

important future task to address the labor shortage (Fig. 2).

3. VCA Technology for Production

3.1 Issues to be addressed

To solve such issues, it is necessary to improve productivity by making full use of human resources at manufacturing sites while leveraging the latest technologies such as IoT and AI.

On manufacturing lines, to achieve the planned productivity by improving the production efficiency every day, operators' work is analyzed to reduce wasted movements. In work analysis, the work is analyzed for each process (e.g., assembly and inspection) to identify differences between the normal time and actual work time and thus detect wasted movements that can be improved.

Conventionally, work time was visually measured and at the same time abnormal work and normal work were analyzed. However, the same working process was repeatedly checked and multiple cycles were measured, which imposed a heavy workload on the analysts.

3.2 EIMON

To solve the above issues, Mitsubishi Electric has developed a work analysis technology involving the EIMON VCA technology. In this new technology, the video of actual work (input video) is compared with the analysis target video (reference video) recorded in advance for analysis. This can automate work time measurement and abnormal work detection, which analysts used to do visually. For comparative analysis, a video feature quantity (EIMON) created from each type of video is used. EIMON is a video feature quantity in which the quantity of generation of motion vectors in each direction is calculated for each frame comprising the video and the quantities are arranged in chronological order (Fig. 3). It shows a characteristic pattern unique to each work.

Generally, work on manufacturing lines consists of repeated identical movements. As a result, on EIMON of the input video, the same pattern as that on EIMON of the reference video is repeatedly shown. The execution of work is determined by detecting this repeated pattern and the work time is measured based on the pattern length. In addition, abnormal work is detected by detecting a section that is different from EIMON of the reference video when the factory is operating (Fig. 4).

To obtain information on motion vectors, which is important for creating EIMON, generally it is necessary

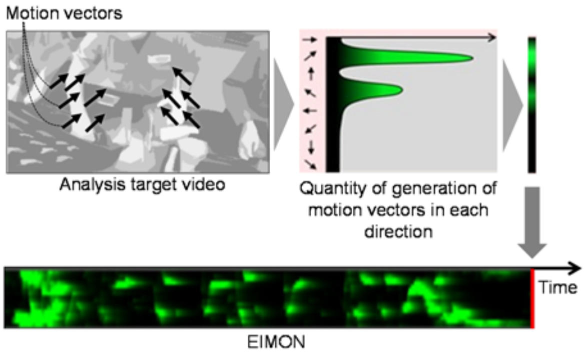

Fig. 3 EIMON generation processing

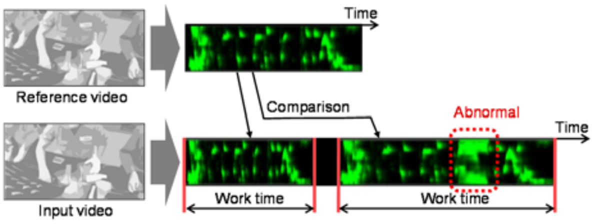

Fig. 4 Same pattern detection and abnormal term detection

to use a decoder to decode compression-encoded video data and then calculate motion vectors using an image processing method (e.g., optical flow). However, decode processing and motion vector calculation take time and the analysis target video cannot be analyzed in real time.

Therefore, we focused on motion vectors in compression-encoded video data since they can be extracted by performing part of the decode processing, thus reducing the burden of decode processing and omitting the motion vector calculation process. This new technology reduces the computational complexity in the process of creating EIMON from video data by approximately 65% (comparison by Mitsubishi Electric) and enables the target video to be analyzed in real time (Fig. 5).

3.3 Commercialization development

We have developed a video analysis solution based on the work analysis technology described in the previous section. In this technology, video is used to analyze workers' movements on manufacturing lines and work time measurement and abnormal work detection are performed in order to support work analysis and quality improvement. Its main advantages are described below.

3.3.1 Screen for distinguishing work details more easily

In addition to numerical data (e.g., work time for each work cycle), normal work and abnormal work are classified by color and the work time is graphed, which allows the analysis results of multiple cycles to be visually checked (Fig. 6).

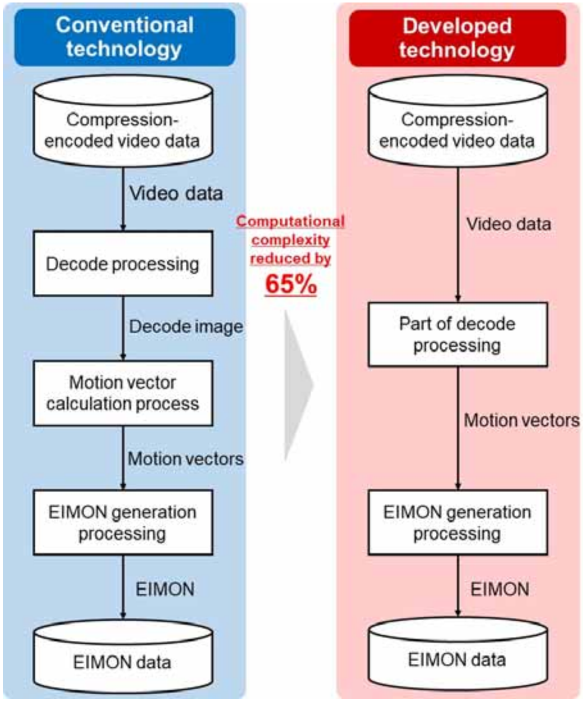

Fig. 5 Comparison between conventional technology and development technology

3.3.2 Analysis based on the application

(1) Offline analysis

When past analysis target video data stored in an external medium (e.g., MELOOK3 recorder and USB memory stick) is imported and the work is analyzed, work time measurement and abnormal work detection can be done by offline analysis (Fig. 7).

(2) Real-time analysis

By connecting the solution to a MELOOK3 system and obtaining a live video stream from the MELOOK3 camera, work time measurement and abnormal work detection can be done in real time (Fig. 7, Table 1). This enables the operator to be notified of abnormal work immediately it occurs.

4. Demonstration Experiment at a Factory of Mitsubishi Electric

To check whether the solution works well in actual use and to understand issues during installation at actual sites, a demonstration experiment was carried out at the Mitsubishi Electric factory that produces the MELOOK3 series.

4.1 Line selection

Mitsubishi Electric has various types of manufacturing lines at factories: lines on which many tasks are done and those on which multiple workers do a number of small operations. As a line for which EIMON is used to analyze the work, the MELOOK3 camera manufacturing line was selected for the following two reasons: (1) Work analysis is frequently performed and

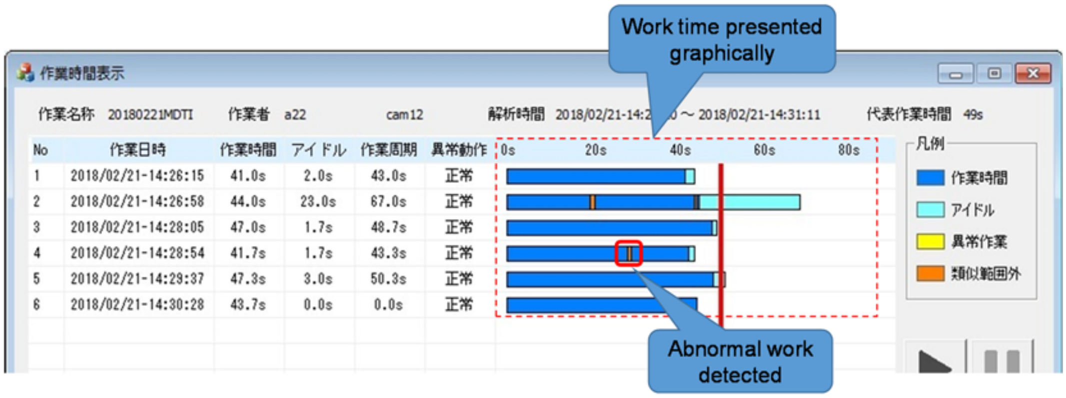

Fig. 6 Analysis result screen

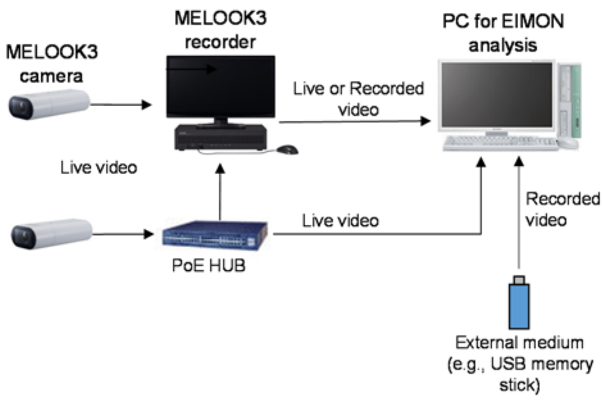

Fig. 7 System configuration

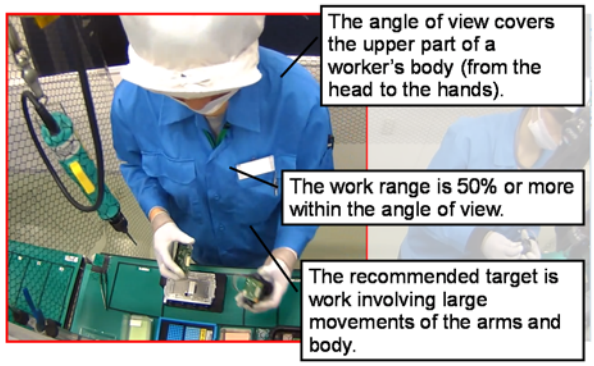

Fig. 8 Angle of view of analysis camera

Table 1 Key points of real-time analysis

Number of streams for analysis	1
Video encoding method	H.264 (High Profile)
Compatible camera	MELOOK3 camera
Compatible recorder	MELOOK3 recorder
Protocol	RTP/UDP
Resolution	1920 × 1080 (FHD)/1280 × 720 (HD)

(2) operations are carried out in a cyclic manner.

4.2 Analysis camera installation

It is important to install analysis cameras so that they can capture movements adequately. We adjusted the angle of view of the camera so that it could capture the upper part of a worker's body including the arms and fingers that are moved particularly frequently, assembly parts, and production tools (Fig. 8).

4.3 Reference video selection

Reference video is essential for work analysis using EIMON. As the reference video, model work in which the tasks were carried out by the predetermined procedure in the normal time was recorded. Then, the start and end of the work cycle were determined and the range of each task was clarified. This was used as the reference video.

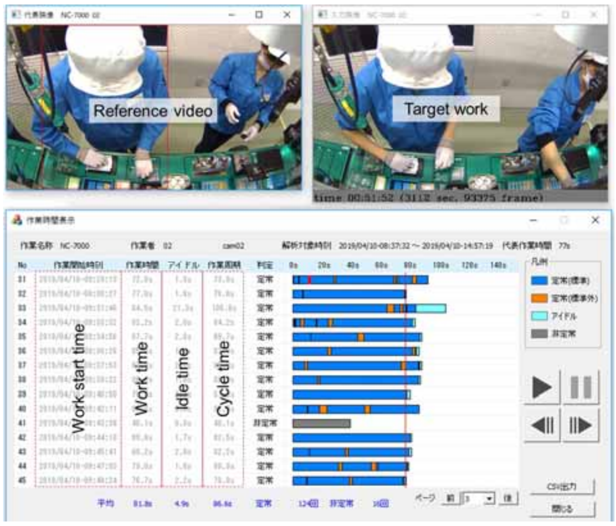

Fig. 9 EIMON analysis

4.4 Work time measurement and abnormal work detection

The MELOOK3 camera production line was shot all day for real-time analysis. The work time measurement function enabled graphing of the work time, which made it easier to see variation in the work cycles. In addition, abnormal work detection results were notified to the worker in real time and thereby abnormal work could be checked on the screen at a glance (Fig. 9).

In conventional visual time measurement, in addition to making the actual measurements themselves, the measured data needed to be organized and plotted on a graph. For example, the manufacturing line used in this study is divided into three processes and the mean work cycle is approximately 90 seconds. Analyzing ten cycles of the work by the human eye would take approximately 45 minutes (90 seconds × 10 cycles × 3 processes), and would take more than an hour including compilation and graphing.

By using EIMON, we could analyze the work in real time and automatically graph the measurement results, reducing the operations by the analyst to a few minutes. EIMON also reduced the workload of the analyst to one tenth or even lower, a remarkable improvement.

4.5 Summary of experimental results

We performed work analysis using EIMON at a manufacturing line at a Mitsubishi Electric factory. As a result, the work time could be measured in real time and automatically graphed, which made the analysis of work time more efficient, and reduced the workload and operation time of the analyst.

In addition, the application has made it possible to detect variations in work time due to irregular work in real time and analyze the work time of all cycles, which used to be impossible, without significant human cost. These improvements help prevent quality problems, solve them quickly, and find new sources of waste and points to be improved, which used to be impossible to find, raising expectations for more efficient manufacturing lines.

Regarding the analysis accuracy, verification at the Mitsubishi Electric factory has confirmed that work cycles can be detected with a high accuracy of approximately 92% and the work time can be measured with a mean error of just 3%. In addition, abnormal work detection allows differences in small movements in work, which used to be difficult to know, to be found promptly.

We found that one factor degrading the analysis accuracy was that movements of workers other than the target worker included in the video affected the generation results of EIMON (Fig. 10). This problem can be solved by optimizing the angle of view and masking the areas of masking the non-target areas.

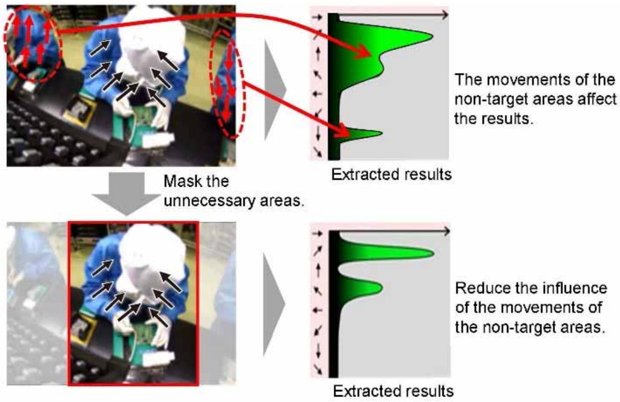

Fig. 10 Effect of movement by non-target workers

5. Future Development

The video analysis solution can provide more detailed work analysis by defining elementary operations such as “tightening a screw” and “attaching a label” in advance. Such analysis may make it possible to improve work in a detailed manner by analyzing each elementary operation and extracting bottleneck processes.

We will continue to help raise the productivity of manufacturing lines by improving the analysis accuracy and usability and increasing the product value by performing more demonstration experiments at Mitsubishi Electric factories and actively using the knowledge acquired at manufacturing lines.

6. Conclusion

By combining the EIMON VCA technology with MELOOK3 systems, we have developed a video analysis solution that ranges from taking video to automating abnormal work detection and work time measurement and that can help boost productivity. In addition, the demonstration experiment at a Mitsubishi Electric factory confirmed that the solution can accumulate knowledge through actual operations and also reduce the workload on analysts, showing the usefulness of our solution.

In the future, we will extend the development to create new added values and provide solutions for sectors other than crime prevention by using VCA technologies, while leveraging various VCA technologies involving deep learning and other AI technologies.

References

(1) H. Saito, et al., Video Content Analysis on Surveillance Systems, Mitsubishi Denki Giho, 92, No. 6, 366–370 (2018)

(2) H. Yomogida, et al., Network Camera “MELOOK3,” Mitsubishi Denki Giho, 89, No. 6, 343–347 (2015)

(3) A. Tsujii, Network Video Recorder “MELOOK3,” Mitsubishi Denki Giho, 89, No. 6, 348–352 (2015)

(4) Ministry of Economy, Trade and Industry, White Paper on Manufacturing Industries (Monozukuri) (2017)

Optical Path Restoration Method for Mesh Networks

Authors: *Noriaki Nakamura** and *Sota Yoshida***

1. Introduction

Internet connection lines and mobile devices are increasingly using broadband channels, causing traffic volumes to surge. For optical access, there is the 10 Gigabit Ethernet Passive Optical Network (10G-EPON) which provides high-speed lines at reasonable prices. For mobile devices, the spread of high-speed communication services (e.g., Long Term Evolution (LTE)) and 5G services may increase the capacity in the future. Recently, with the spread of social networking services (SNSs), most users collect information for daily life via the Internet, making communication services essential for modern life and society.[2] A failure in the optical transmission networks that underpin such services would greatly affect society, and so there is increasing demand to make such networks more reliable. Accordingly, optical cross-connect systems that can establish mesh networks with multiple routes that can be used as restoration routes in case of failure have been introduced.

Mitsubishi Electric Corporation has developed an optical cross-connect system with the following functions:[1] a colorless, directionless, and contentionless (CDC) function for which the independence of wavelengths and directions is high and that is suitable for establishing flexible mesh networks; a supervisory function; and a pre-planned restoration (optical path restoration) function that switches signals to predetermined restoration routes when a failure occurs.

In recent years, the scale of mesh networks has been expanded to cope with the expected growth in communication traffic. This has driven demand for economic optical path restoration technologies to cope with simultaneous failures at multiple points due to a natural disaster or other reasons and an unexpected failure over a wide area. To satisfy such needs, Mitsubishi Electric has additionally developed optical cross-connect systems. The new system has a PCE function that automatically designs an optimum restoration route from complicated routes in a large-scale network and a dynamic restoration function for switching signals to restoration routes calculated based on the resource status when a failure occurs.

This paper describes the advantages of the CDC, supervisory, and pre-planned restoration functions of Mitsubishi Electric's conventional optical cross-connect system in Section 2, and the additionally developed PCE and dynamic restoration functions in Section 3.

2. Mitsubishi Electric's Optical Cross-connect System

For optical transmission networks, mesh networks are increasingly being used instead of conventional ring/linear networks. To realize highly reliable optical cross-connect systems suitable for mesh networks, the following functions are essential: a CDC function that can change the settings of wavelengths and directions remotely without affecting the existing optical signals; a highly resilient supervisory function; and a pre-planned restoration function for switching signals to predetermined restoration routes through remote control when a failure occurs.

2.1 CDC function

The CDC function enables optical path switching without affecting the existing optical signals. Conventionally, every time an optical path is established, the fibers are manually reconnected and the wavelengths and directions are changed. In contrast, the CDC function can be realized by connecting a fiber to a port in advance, and allowing all wavelengths and directions to be freely switched remotely. In addition, the optical multiplex/de-multiplex (MUX/DEMUX) function section and mesh-switch (MSW) function section, which form the CDC function, are configured as shown in Fig. 1 such that each function is physically independent. This configuration increases the independence of wavelengths and directions and can reduce physical wavelength interference. These advantages realize a highly reliable system that can reduce the influence of main signals on other directions when wavelengths and directions are expanded or reduced or when a failure occurs.

2.2 Supervisory function

One task in mesh networks is to ensure network management that can continue supervision even when multiple failures occur. We have developed such a supervisory technology for mesh networks. As shown in Fig. 2, out-band communications that use the external lines of the devices are combined with in-band communications that use free communication domains between the devices, and each device broadcasts in the configuration. For the out-band communications of the

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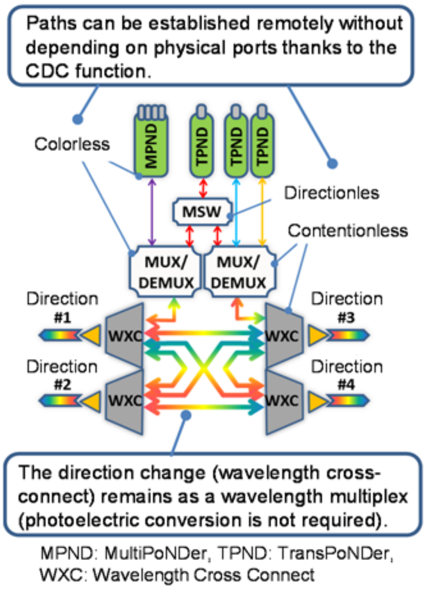

Fig. 1 Structure of CDC function

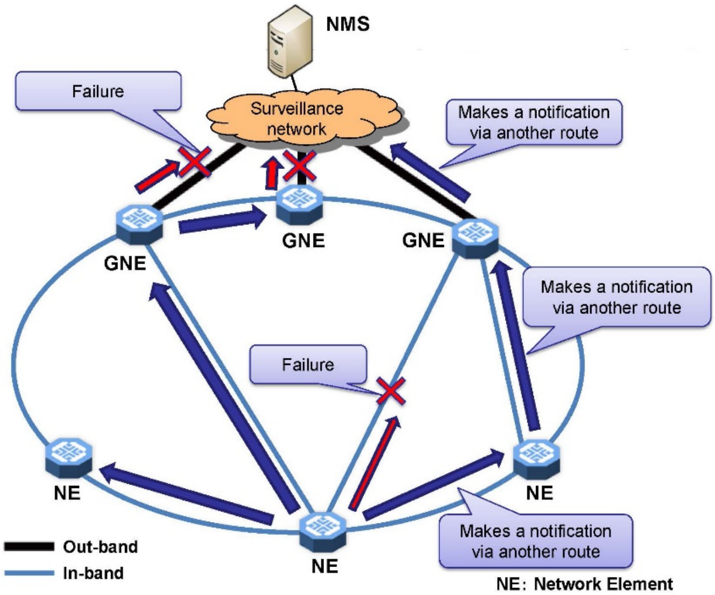

Fig. 2 Mesh supervisory network

devices, three gateway network elements (GNEs) are installed for each arbitrarily definable sub-network and notifications are sent to the NMS via the three routes in the configuration. For the in-band communications, the devices broadcast the same message to each route and the receiving side deletes redundant notifications, which makes the channel redundant configuration robust. This configuration enables continuously controllable supervision without affecting the supervision of optical signals even when multiple failures occur.[3)]

2. 3 Pre-planned restoration function

Figure 3 illustrates the pre-planned restoration function. In the pre-planned type, circuitous routes and wavelengths (pre-planned restoration paths) that will replace the working paths are registered to the NMS in advance; when a failure occurs, the registered spare pre-planned restoration path is established to replace the working path. By registering multiple pre-planned restoration paths for working paths, signals can be restored even if multiple failures occur.[4)] After a failure on a working path is detected, signaling is performed to set the pre-planned restoration path and thereby the resources of the pre-planned restoration paths can be shared between multiple working paths. This makes it possible to effectively use the wavelength resources and allows re-shaping, re-timing, and re-generation (3R). Resource sharing is allowed only when working paths do not pass the same link. This requirement makes restoration from a single failure possible without exception.

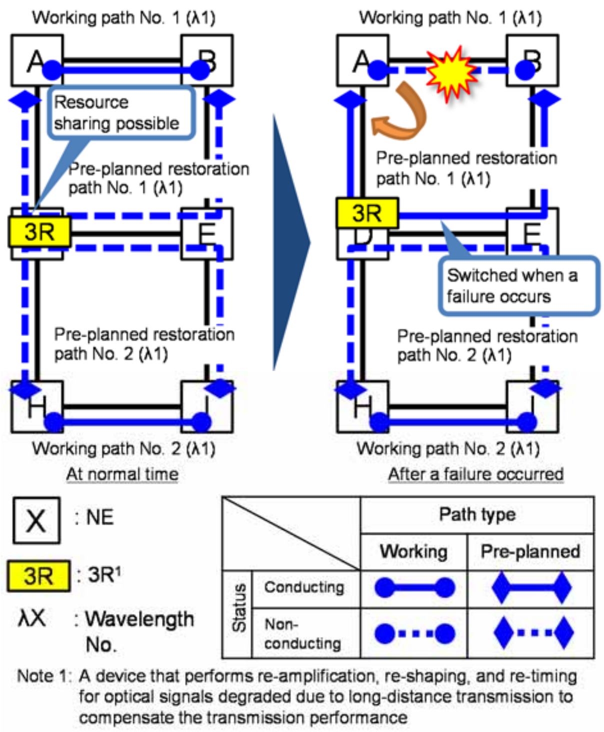

Fig. 3 Pre-planned restoration function

3. Optical path Restoration for Large-scale Mesh Networks

In large-scale mesh networks, since many redundant routes can be established, it is important to calculate economic and highly reliable restoration routes and realize optical path restoration that allows the services to be continued even when multiple failures occur.

3.1 PCE function

Since a large-scale mesh network has innumerable route patterns from the starting point of optical signals to the end point, it is difficult to select an economic and highly reliable optical path. In the pre-planned restoration method, in particular, the resources of pre-planned restoration paths can be shared between multiple working paths. Therefore, technologies are needed to automatically calculate an optical path group to improve the resource efficiency. We have developed a PCE function[5)] that calculates an optical path group that satisfies the route search requirements entered by operators and that can minimize the allocation of wavelength resources and 3R.

Figure 4 shows the flow of route search by the PCE function when optical paths are added to an existing mesh network in designing. Network information (e.g., node-element (NE) layout, optical transmission section (OTS) link connection, and existing path information) and transmission line information (e.g., transmission distance and transmission loss parameter) obtained from the NMS are sent to the PCE. The PCE calculates the optical signal to noise ratio (OSNR) based on the route search requirements (e.g., path type, passing nodes/links, and number of pre-planned restoration paths) entered by the operator and transmission line information. If the transmission performance needs to be compensated, the PCE function automatically designs passing routes and the layout of 3R such that the number of 3R becomes the minimum necessary in the entire mesh network and calculates the optimum optical path group. The searched optical path group is output as path design information, which makes it easier for the operator to add optical paths based on the output information.

When the working paths are completely different routes, it is possible to set to share the wavelength resources of pre-planned restoration paths and 3R as much as possible. Thanks to this, the PCE function has a route search algorithm that ensures a restoration rate of 100% at the time of a single failure and that improves the resource efficiency. In designing pre-planned restoration paths, multiple pre-planned restoration paths can be designated as search targets for a single working path, which secures multiple pre-planned restoration paths depending on the importance of a working path and enhances the resilience.

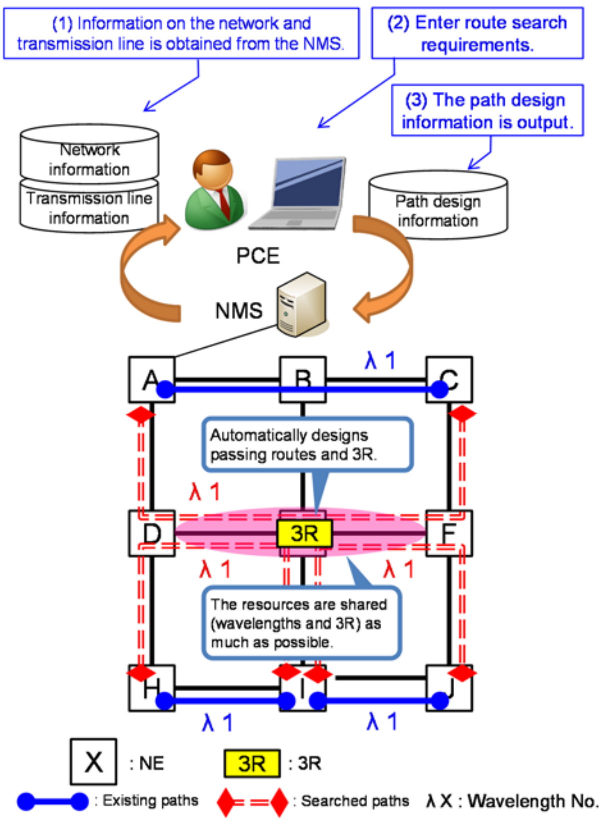

Fig. 4 Route search flow by PCE function

Furthermore, as networks are becoming more complicated, we have developed a graphical user interface (GUI) for the PCE function that operators can intuitively use. Figure 5 shows an example PCE screen. The PCE imports the network information obtained from the NMS and lists the NE layout, OTS link connection, existing path information, and other information. The imported existing paths and new paths designed by the PCE can be listed on the optical path display section. By clicking a path, its passing route can be visually checked.

3.2 Dynamic restoration function

By providing the PCE function on NMS, we have developed a dynamic restoration function. When a failure occurs, the dynamic restoration function calculates restoration routes in real time based on the latest network status and switches the signals to them. In the dynamic type, when a failure occurs the NMS calculates usable circuitous routes in real time to determine circuitous routes and wavelengths (dynamic restoration paths) and to use the circuitous routes instead of the working optical paths. As is the case with the pre-planned type, signaling is performed after a failure is detected on a working path and thereby the spare resources can be used in an efficient way. Figure 6 shows an example of dynamic restoration switching. Thanks to the combination of the dynamic type and pre-planned type, when switching to all pre-planned restoration paths fails, the NMS with the PCE function calculates a dynamic restoration path and switches signals to it. For failures that can be expected, pre-

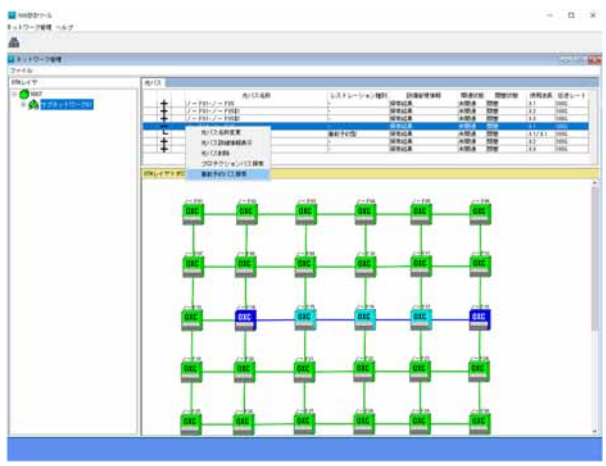

Fig. 5 Example of PCE screen

planned restoration paths are used for restoration as planned, while for unexpected large-scale failures, dynamic restoration paths are used to make it possible to maintain the continuity of optical signals.

3.2.1 Real-time route calculation technology

Figure 7 illustrates dynamic restoration switching by the PCE function. The NMS server updates the network resources (NE connect information, OTS link, wavelength resources, and 3R) in real time successively based on changes in the network topology information and notification (e.g., occurrence of a failure and restoration from a failure). When a failure occurs on the working path, the PCE function section calculates a dynamic restoration path based on the latest network resources and switches signals to the restoration path automatically. Since the NMS server manages route switching control and network resource management in a centralized way, accurate switching control to avoid conflict between the routes is possible. This function makes it possible to use available network resources effectively and allows flexible switching that can cope with unexpected large-scale failures.

In addition, the NMS server has a redundant hot standby configuration (0: ACT, 1: STANDBY), and the two servers always coordinate the data while functioning. Even if a failure occurs in one server, monitoring and control can be continued without interruption. This configuration makes it possible to continue route calculation and optical path switching even if a failure occurs on one server during wavelength restoration switching.

3.2.2 Highly reliable path switching technology based on switching priority

For such a system, multiple pre-planned restoration

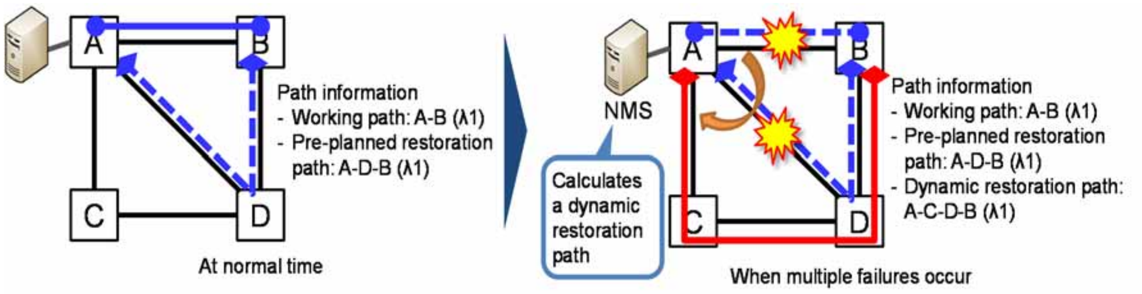

Fig. 6 Example of dynamic restoration switching

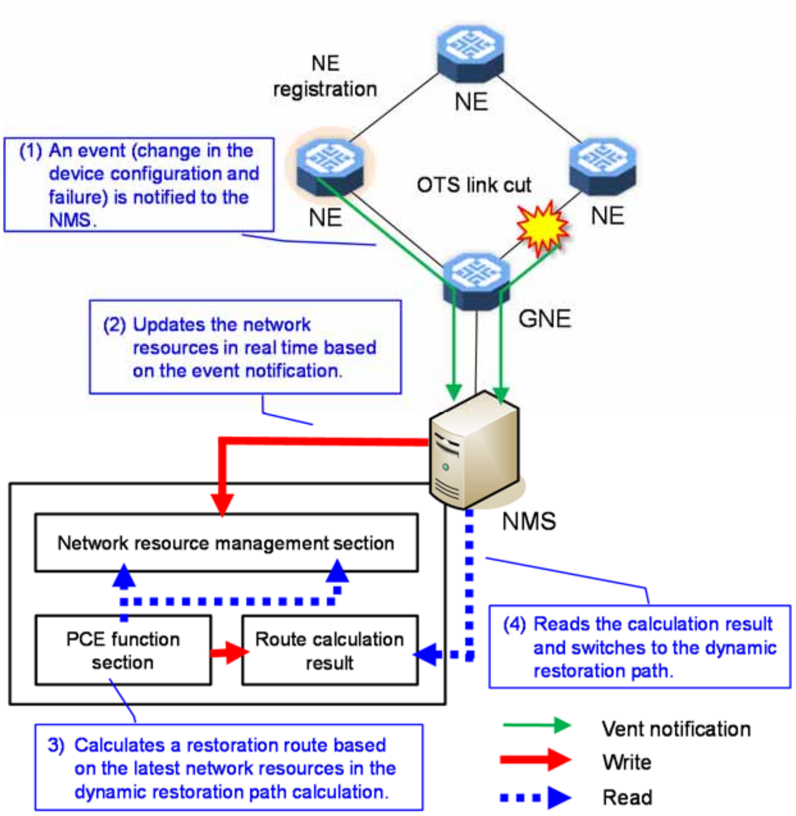

Fig. 7 Dynamic restoration switching by PCE function

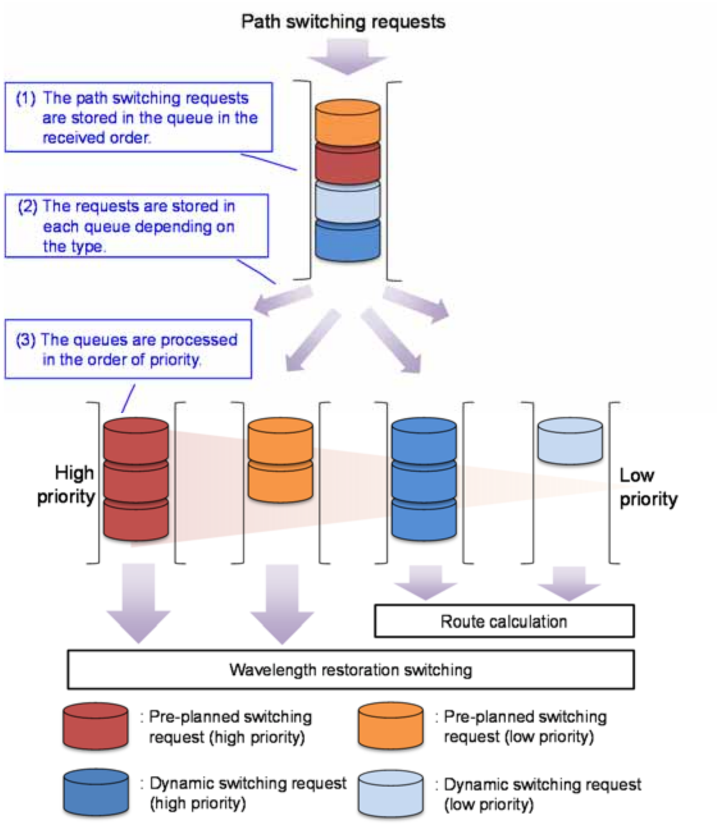

Fig. 8 Dynamic restoration switching by priority

paths and dynamic restoration paths can be set for a single working path. By determining the switching priority for each working path, the working paths can be switched according to the order of priority when wavelength restoration switching is activated. Figure 8 shows wavelength restoration switching in accordance with the switching priority. In the order of notifications received in the NMS, the path switching requests are stored in a queue and then they are stored in other queues based on the switching type (wavelength restoration type and priority). Switching is performed to the queues in the order of priority and thus, even if network resources are not sufficient, important path(s) can be preferentially restored from a failure. If switching fails due to an optical path unblocking failure or other factor, switching requests for unprocessed pre-planned restoration paths or dynamic restoration paths are sent again. This technology realizes both economic and highly reliable restoration that uses fewer resources to establish restoration routes and restoration from multiple failures due to a disaster or unexpected failure.

4. Conclusion

This paper described the PCE function for automating the designing of optimum optical paths in mesh networks and the dynamic restoration function for switching to restoration routes to be calculated in real time when a failure occurs. These technologies make it possible to establish flexible and highly reliable optical transmission networks and are also useful for business continuity planning (BCP) to prepare for the expected Nankai Trough earthquake or an earthquake located directly below a metropolitan area.

We will continue implementing new technologies in the hardware (e.g., network devices) and software including restoration operations to realize highly reliable resilient networks, thus creating safe and secure social infrastructure.

References

(1) Y. Yamasaki, et al., 88-Wavelengths and 8-degrees Optical Cross Connect Systems, Mitsubishi Denki Giho, 90, No. 6, 327–331 (2016)
(2) Ministry of Internal Affairs and Communications, Information and Communications in Japan (2018) http://www.soumu.go.jp/johotsusintokei/whitepaper/index.html
(3) H. Kataoka, et al., Supervisory Control System, Japanese Unexamined Patent Application Publication No. 2014-232944
(4) N. Yoshihara, et al., Optical Transmission System, Management System, Optical Transmission Node, and Optical Transmission Method, Japanese Patent No. 6465627
(5) N. Nakamura, et al., Route Search System and Route Search Method, Japanese Unexamined Patent Application Publication No. 2017-98593

Digital Train Radio System for Okinawa Urban Monorail and Tokyo Tama Intercity Monorail

Author: *Mamoru Yamazaki**

1. Introduction

High-quality, high-stability, and high-speed radio communication is essential between trains traveling at high speed and ground crews in order to satisfy strict safety requirements.

Mitsubishi Electric Corporation has been involved in many projects to switch train radio systems to digital radio, thus accumulating related technologies and know-how.

At present, an analog or inductive radio method is used for most train radio systems on private railways, subways, monorail systems, and new transportation systems. However, such systems will increasingly be switched to digital to improve the quality and reliability of radio channels and to add new values such as data communications and application linkage.

Accordingly, Mitsubishi Electric has developed a 150-MHz band digital train radio system featuring the latest technologies.

This paper describes the outline and advantages of the digital train radio system (Fig. 1) delivered to Okinawa Urban Monorail Inc. in 2016. In 2018, we also delivered a similar system to Tokyo Tama Intercity Monorail which features operating information distribution services as a new function. This paper also describes this new function.

2. Outline of the Digital Train Radio System

2.1 System configuration

The digital train radio system consists of a central control unit, base station systems, on-board systems, and other equipment. Digital radio channels are used for communication between ground crews and trains. Table 1 outlines the functions of the various units.

2.2 Radio specifications

The radio communication system between ground crews and trains uses digital radio channels by the frequency-division multiple access (FDMA) / single channel per carrier (SCPC) method. Table 2 lists the radio specifications.

2.3 Functions

The system has the following functions.

(1) Voice communication and broadcasting function

(i) Dispatching call: Communications between dispatchers and crews on all trains

(ii) Individual call: Communications between dispatchers and crews on a designated train

(iii) Emergency call from passenger carriages: Communications between dispatchers and

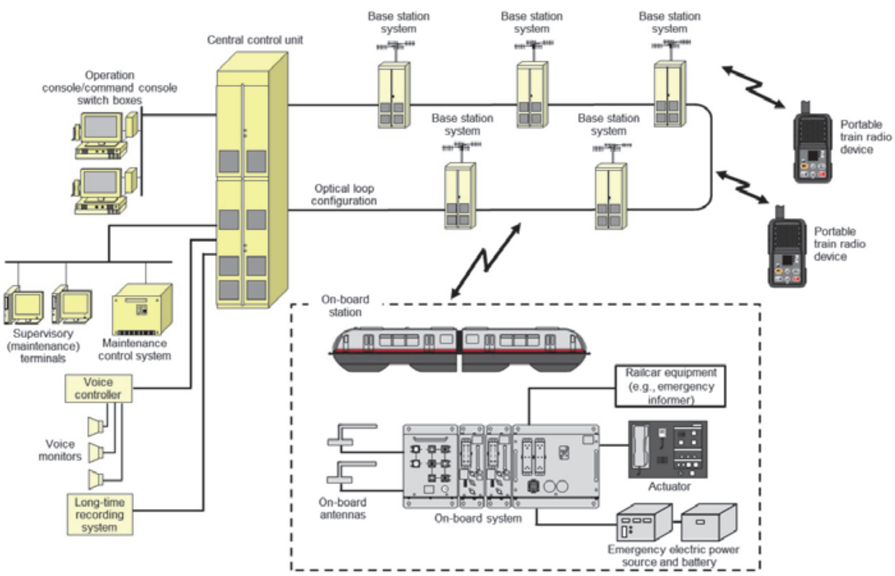

Fig. 1 Train radio system for Okinawa Urban Monorail lines

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Table 1 Outline of functions of units

Unit	Location	Main functions
Central control unit	Central equipment room	(1) Controls voice communication and data communication channels (2) Interfaces with the base station systems (3) Interfaces with the operation console and external equipment
Base station system	Wayside	(1) Communicates with the on-board systems by radio (2) Interfaces with the central control unit
On-board system	Railcar	(1) Communicates with the base station systems by radio (2) Controls voice communications with dispatchers (3) Interfaces with other devices on trains
Operation console	Control center	(1) Works as a user interface with voice communications and data communications for dispatchers
Maintenance control system	Central equipment room	(1) Centrally manages information on supervisory control and maintenance
Portable train radio device	—	(1) Allows voice communications with dispatchers (2) Allows voice communications between maintenance engineers

Table 2 Radio specifications

Item	Specifications
Transmission line	Space wave/LCX
Access method	FDMA/SCPC method
Frequency band	150 MHz band
Frequency interval	6.25 kHz
Modulation method	π/4 shift QPSK
Transmission speed	9.6 kbps
Transmission power	Base station system: 4 W, on-board system: 1 W
Diversity configuration	Base station system: Transmission time diversity, Receiver diversity On-board system: Receiver diversity

passengers on trains

(iv) Public announcements to an individual train: Broadcasting from dispatchers to passengers in a designated train

(2) Data transmission function

(i) Railcar dead-man notice: If a train crew member falls unconscious or a similar accident occurs while the train is traveling, the on-board system detects dead-man information and notifies the dispatchers of the abnormal state of the train crew member.

(ii) Emergency warning: In case of emergency (accident resulting in injury or death), a warning is issued to the control center and all trains. The power to the train may be cut to stop the train forcibly, depending on the details of the warning.

(3) Voice monitor function

(i) Voice monitor: Outputs the conversation between dispatchers and train crews to monitors in the central and station service offices.

(4) Call log function

(i) Call log: Records the conversation between dispatchers and train crews at all times.

(5) Remote supervisory control function

(i) Remote supervisory: Supervises and controls the operation statuses of various units and network channels remotely using supervisory (maintenance) terminals.

3. Advantages of the Digital Train Radio

3.1 Quality improvement by transmission time diversity and adaptive equalization

Generally, when the same signals in the same frequency are sent from multiple antennas, the radio waves disappear in the antiphase due to interference of the same waves, causing the signals reaching the receiving side to have large errors (Fig. 2). Such disappearance of radio waves periodically occurs depending on the frequency difference of the transmitters (beat interference).

To solve this problem, our system has transmission time diversity (1): it sends signals that were sent from adjacent base stations or antennas with a fixed time difference in order to avoid canceling each other out at the mobile station (Fig. 3). In addition, for mobile stations, an estimation technology by adaptive equalization (Fig. 4) is used, which makes it possible to use the aforementioned waves delayed by the transmission time diversity as signal components and to demodulate them. Furthermore, to improve the quality of radio channels, base and mobile stations feature receiver diversity.

3.2 Measures for blind zones and weak electric fields

New buildings and other factors may affect the radio wave environments in the vicinity and degrade the quality of the radio channels in the future. The degradation of channel quality in such cases can easily be eliminated simply by adding a base station or installing a satellite antenna to apply the anti-interference technology described in section 3.1 (Fig. 5).

3.3 Connection to railcar equipment

To cope with one-man operation, in this system, a railcar dead-man's device, emergency informers in passenger carriages, and public announcing device are connected to the on-board system. This enables the following operations in case a train crew member falls unconscious or another emergency occurs while a train is traveling as shown in Fig. 6: (1) The on-board system detects a dead-man notice, (2) a dead-man notice is sent to the dispatchers, (3) the dispatchers make a public

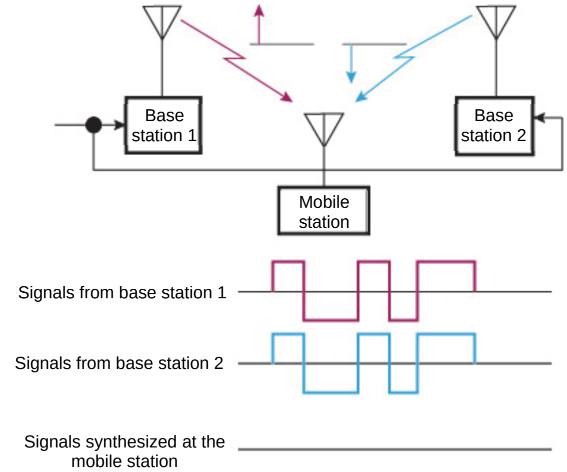

Fig. 2 Signal disappearance due to interference of same waves

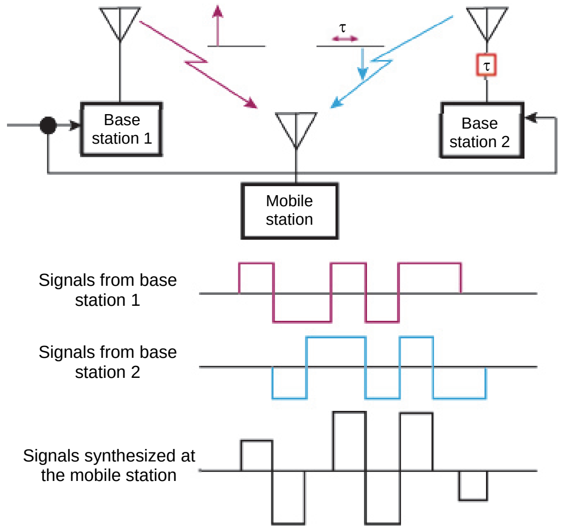

Fig. 3 Transmission time diversity

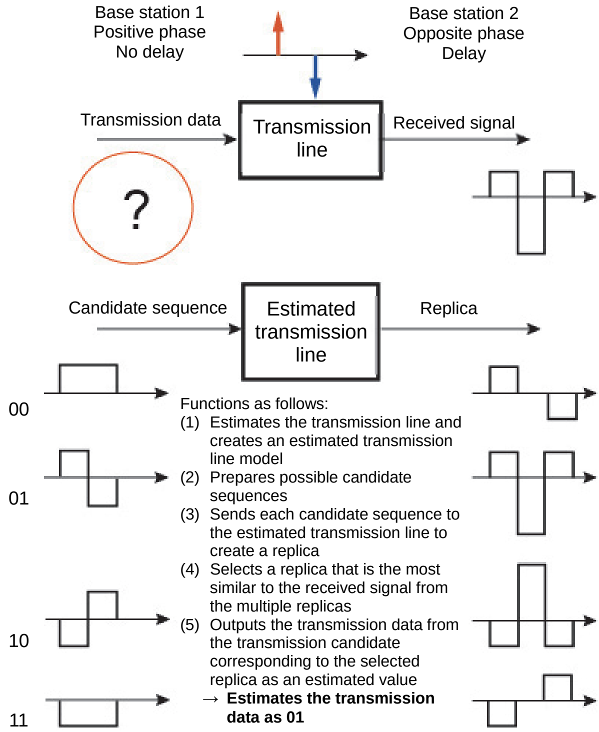

Fig. 4 Estimation by adaptive equalization

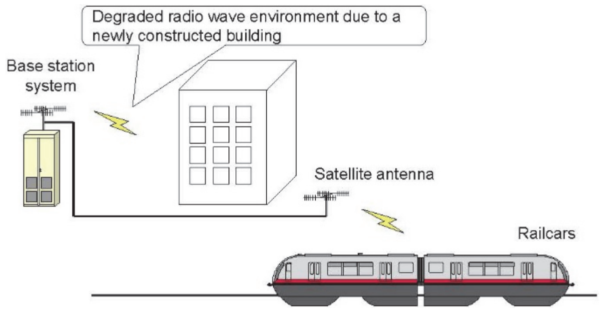

Fig. 5 Measures for blind zones and weak electric field

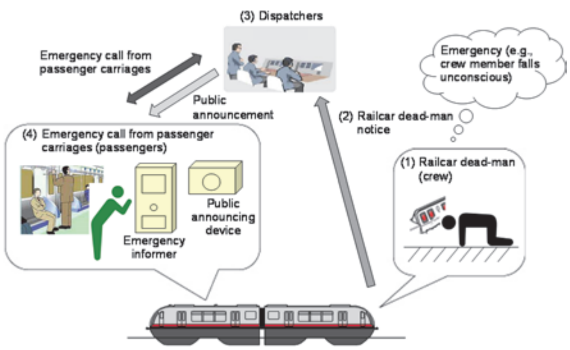

Fig. 6 Example connection with railcar equipment

announcement to notify the passengers of the situation, and (4) the emergency call function provided in the passenger carriages is used for communication between the dispatchers and passengers on the train. This system allows dispatchers to communicate with train crews and passengers on trains without fail in case of emergency.

3.4 Simultaneous transmission of voice and data

To ensure stable operation of trains, even during voice communications, a railcar dead-man notice and other important data need to be sent immediately. The radio sets of the system's on-board system and base station systems have a function for using a telephone communication channel and another function for using a control/data channel, allowing the two channels to be used at the same time. This ensures simultaneous transmission of voice and data. Figure 7 illustrates the on-board system configuration.

(1) Telephone communication channel

The channel is used for voice communications and broadcasting. Two channels are provided: a primary telephone communication channel and a secondary telephone communication channel.

(2) Control/data channel

The channel consists of a control channel used for communication control and a data channel for railcar dead-man notices and emergency warnings.

3.5 Clear sound quality by high sound quality voice codec

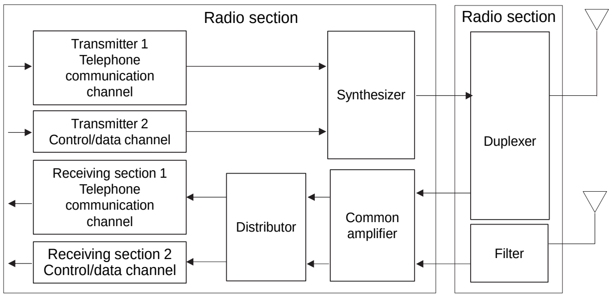

Fig. 7 On-board system configuration

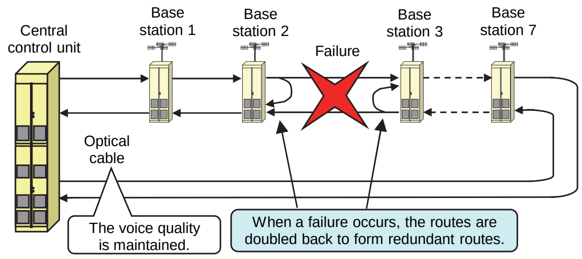

Fig. 8 Optical networking of approach lines

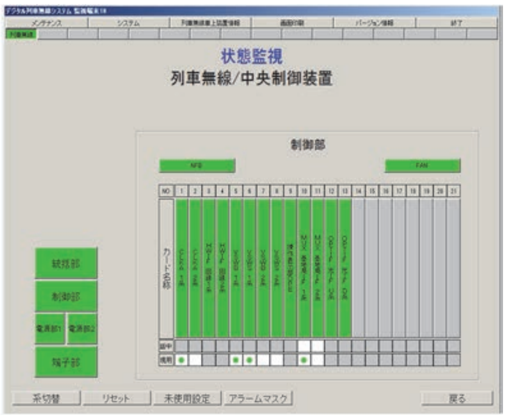

Fig. 9 Example screen of operation on supervisory (maintenance) terminal

This system uses our proprietary voice codec specific for train radio—Rail System-Code Excited Linear Prediction (RL-CELP). In the code configuration, priority is given to voice to ensure noiseless high-quality telephone communications in order to support accurate telephone communications between dispatchers on the ground and crews/passengers on the train.

3.6 Approach lines between the central control unit and base station systems

Optical networks using digital signals are used as approach lines between the central control unit and base station systems. The central control unit and all base station systems in the zone are connected in series using fiber optic cables. In such double-loop configuration, even if a failure occurs on a cable or at another section, the redundant configuration makes it possible to continue operation, enhancing the reliability (Fig. 8).

3.7 Higher maintainability thanks to remote supervisory control

Table 3 Radio specifications of portable devices

Item	Specification
Transmission line	Space wave
Access method	FDMA/SCPC method
Frequency band	150 MHz band
Frequency interval	6.25 kHz
Modulation method	π/4 shift QPSK
Transmission speed	9.6 kbps
Transmission power	0.8 W
Diversity	None

Supervisory (maintenance) terminals installed at operation bases have various functions: for remote supervision of the operation statuses of various devices and network channels; remote control of switching of the redundant sections in various devices; remote log collection for various devices; and downloading of software and other data. Figure 9 shows an example screen of operation on a supervisory (maintenance) terminal. These functions make it possible to supervise and control the statuses of various devices remotely from operation bases and eliminate the need for maintenance engineers to go to the devices installed at each station, which facilitates maintenance.

4. Functions Added to the Digital Train Radio

In addition to the advantages described in Chapter 3, the train radio system for Okinawa Urban Monorail lines includes portable train radio devices that can control telephone communication channels without involving dispatchers, thus reducing maintenance work. In addition, for the train radio system for Tokyo Tama Intercity Monorail lines, operating information distribution services that are combined with our full-color LED in-vehicle guidance displays are provided, improving the guidance services for passengers. The functions of these devices and services are described below.

4.1 Portable train radio devices that can select and control telephone communication channels

A conventional portable train radio device uses a fixed single telephone communication channel for communications. However, if multiple portable devices are used in a zone, it is difficult to share the single telephone communication channel. For the portable train radio devices for Okinawa Urban Monorail lines, a portable device can use two telephone communication channels, which is convenient for maintenance engineers. Figure 10 illustrates an example of channel control of portable devices, showing the flow from selecting a telephone communication channel to ending the communications (Table 3).

4.2 Higher added value thanks to operating information distribution services

Operating information distribution services are a

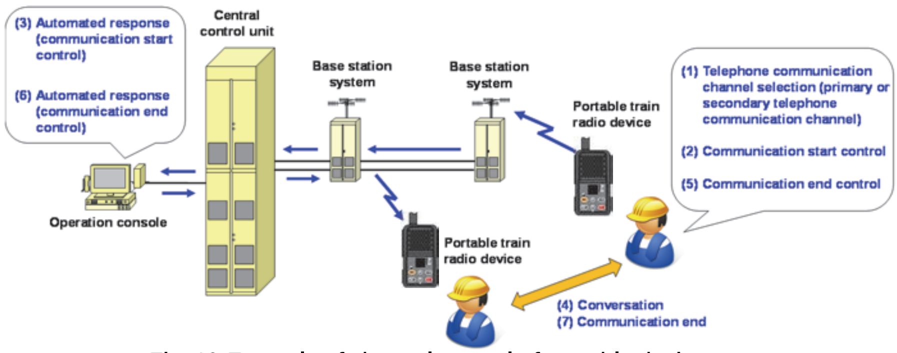

Fig. 10 Example of channel control of portable devices

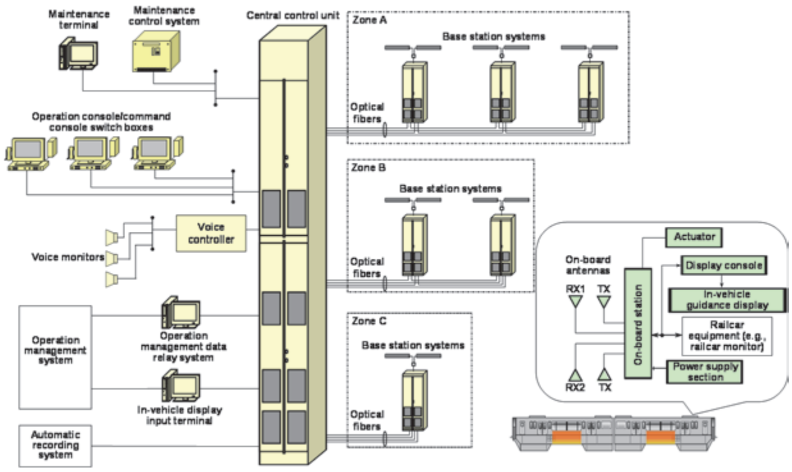

Fig. 11 Train radio system for the Tokyo Tama Intercity Monorail lines

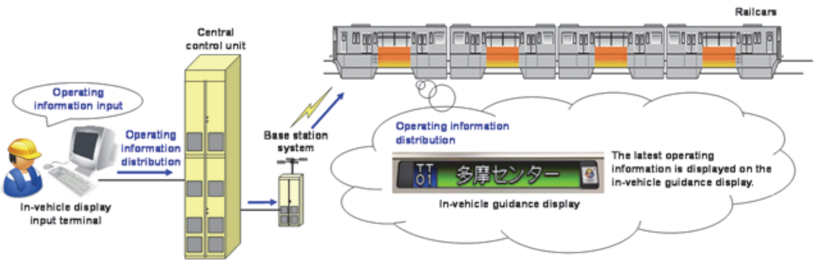

Fig. 12 Operating information distribution services

data transmission function introduced into the Tokyo Tama Intercity Monorail lines. The function sends the latest operating information (service statuses of various lines) to trains via the digital train radio and displays such information on the in-vehicle guidance displays in the passenger carriages. This function, made possible by cooperation between the train radio system and railcar system businesses of Mitsubishi Electric, improves the passenger services and adds value. Figure 11 shows the configuration of the train radio system for the Tokyo Tama Intercity Monorail lines. Figure 12 illustrates the operating information distribution service function.

5. Conclusion

This paper described the outline and advantages of the digital train radio systems delivered to Okinawa Urban Monorail and Tokyo Tama Intercity Monorail.

The digital train radio systems are mainly used for telephone communications at present. We will consider expanding the scope of application of the data transmission function to add new values, such as support for crews, better passenger services, crime prevention, and reduction of maintenance work, thus contributing to the development of the railway industry and establishment of social infrastructure.

We sincerely thank Okinawa Urban Monorail Inc., Tokyo Tama Intercity Monorail Co., and others for their support in developing these systems.

Reference

(1) H. Kubo, et al., Beat Interference Suppression Techniques by means of Transmission Diversity and Adaptive Equalization, Transactions of the Institute of Electronics, Information and Communication Engineers. B, J86–B, No. 3, 468–476 (2003)

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