Featured Articles III

Remote Maintenance System and New Maintenance Service for Elevators Enabled by New IoT Service Platform

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OVERVIEW: The primary goal of elevator maintenance is to ensure that customers continually receive safe and comfortable service 24 hours a day, 365 days a year. Hitachi has always worked to ensure service quality, and became an industry pioneer with the development of the remote intelligent diagnostic system. It recently upgraded the system by creating a new IoT service platform that improves measurement precision to enable detection of minute changes before device problems appear. Hitachi has also created a new remote maintenance system that completely mechanizes the functional inspections previously done by maintenance engineers, thoroughly improving maintenance quality. It has also augmented the new maintenance service to give users more peace of mind and convenience through features such as operation linked to Japan's EEW system.

INTRODUCTION

PUBLIC concern over elevator safety and quality has been growing. The Ministry of Land, Infrastructure, Transport and Tourism announced "New Government Guidelines for Proper Maintenance and Management of Elevators" in February 2016 after a 2006 accident involving a competitor-brand elevator in Tokyo's Minato ward. There is also a growing need to minimize elevator inspection time and other downtime as users become increasingly elderly.

This article looks at the development history of a remote intelligent diagnostic system that improves the quality and efficiency of elevator maintenance. It also discusses Hitachi's remote maintenance system [a new approach to maintenance that provides better maintenance quality by means of a new Internet of Things (IoT)-based service platform], and new maintenance service that gives customers more peace of mind and convenience.

HITACHI'S REMOTE ELEVATOR MONITORING SYSTEM

Remote Elevator Monitoring System Development Timeline

In 1987, Hitachi developed a remote elevator monitoring system that used the public telephone network. The system had a function that automatically notified the control center of equipment problems, enabling prompt dispatching of maintenance engineers.

Upgrades to this monitoring system led to the 1994 development of a remote intelligent diagnostic system for elevators that was the first system in the industry to provide preventive maintenance by identifying electrical and mechanical changes in elevator equipment[1]. A version of the system designed for escalators was developed in 1999.

In conjunction with the release of the 2014 version of its standard machine-room-less elevator model, Hitachi recently improved the precision of the measurement functions in the remote intelligent diagnostic system and expanded the items that it measures. The system has been upgraded to enable the detection of minute changes that occur before problems appear in equipment such as brakes and door operation devices. The upgrade is designed to redefine elevator maintenance from a set of discrete points (periodic inspection done by maintenance engineers with the support of the system), into a continuous line (24-hour/365-day maintenance done by the remote intelligent diagnostic system in place of humans).

Adopted in April 2015, the remote maintenance system completely mechanizes 20 function inspection items and thoroughly improves maintenance quality. Fig. 1 illustrates the differences between conventional

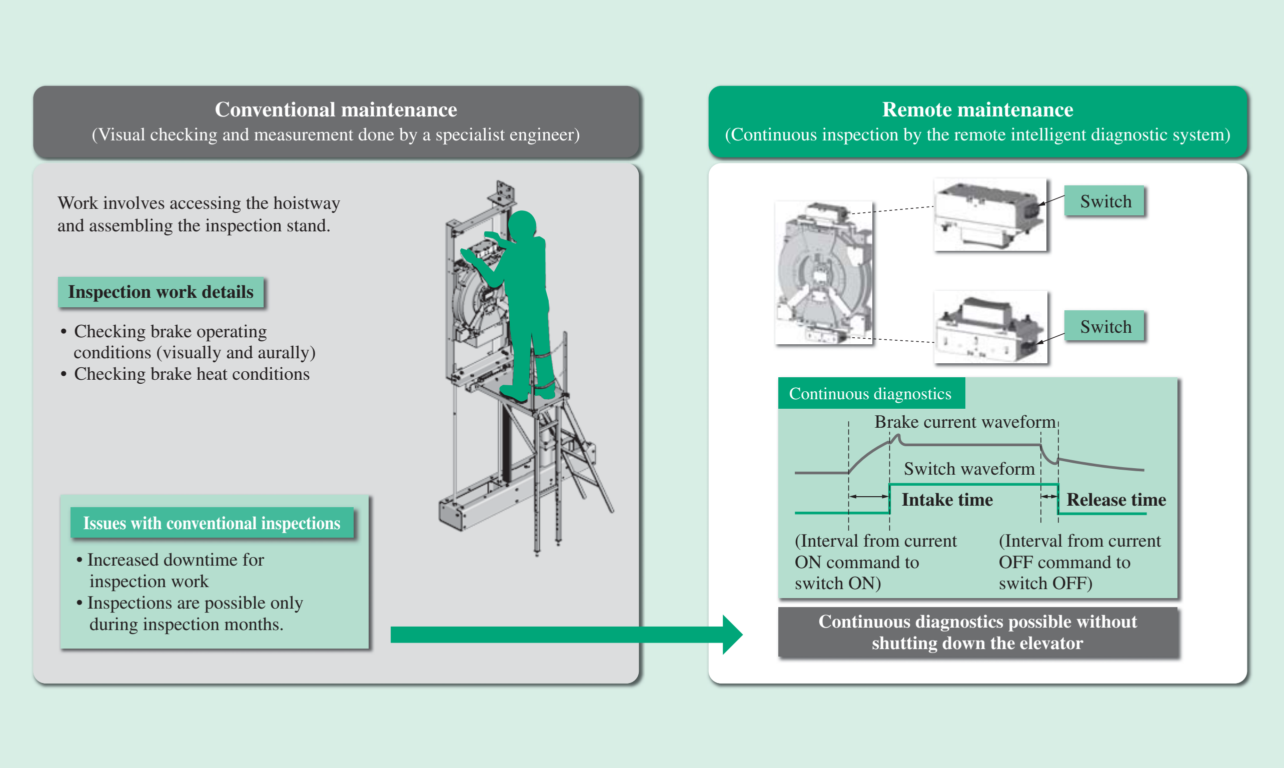


Fig. 1—Difference Between Conventional Maintenance and Hitachi's Remote Maintenance System (Using Brake Inspections as an Example).
Brake inspections are conventionally done manually through periodic visual checks and measurements. The remote intelligent diagnostic system performs the same inspections by monitoring brake operation times precisely and continuously, providing high-quality maintenance service.

maintenance and Hitachi's remote maintenance system, which conforms with "New Government Guidelines for Proper Maintenance and Management of Elevators" announced in February 2016[(2)].

Overview of the Remote Maintenance System

Fig. 2 shows the overall configuration of Hitachi's remote maintenance system. The system connects the remote intelligent diagnostics unit mounted on an elevator or escalator to a customer center via a communication network, providing 24-hour operating condition monitoring and diagnostics.

When an equipment problem occurs, the system notifies the customer center automatically. The customer center periodically gathers measurement data indicating operation performance and equipment statuses from the remote intelligent diagnostics unit. The gathered measurement data is analyzed at a data center based on analytical methods for big data. The analysis results are applied to part life assessments and inspection/repair plans, and used to create work instructions for maintenance engineers, enabling highly precise preventive maintenance.

REMOTE MAINTENANCE PROVIDED BY UPGRADED REMOTE INTELLIGENT DIAGNOSTIC SYSTEM

For remote monitoring, the remote intelligent diagnostic system was upgraded by improving the precision of its measurement functions, reducing equipment problems through better usability, and optimizing maintenance cycles.

Improving Measurement Function Precision

Elevator door equipment is some of the most problem-prone equipment, so improving diagnostic precision for door-related problems greatly helps reduce elevator equipment problems.

The previous version of the remote intelligent diagnostic system used the operation timing of switches that detect door open/closed positions to calculate door operation speeds, and diagnosed operation states from speed changes. The upgraded version continues to provide this function, and also measures the rotation pulse output of the motor used to drive the door, enabling detection of door operation states in 0.1 mm

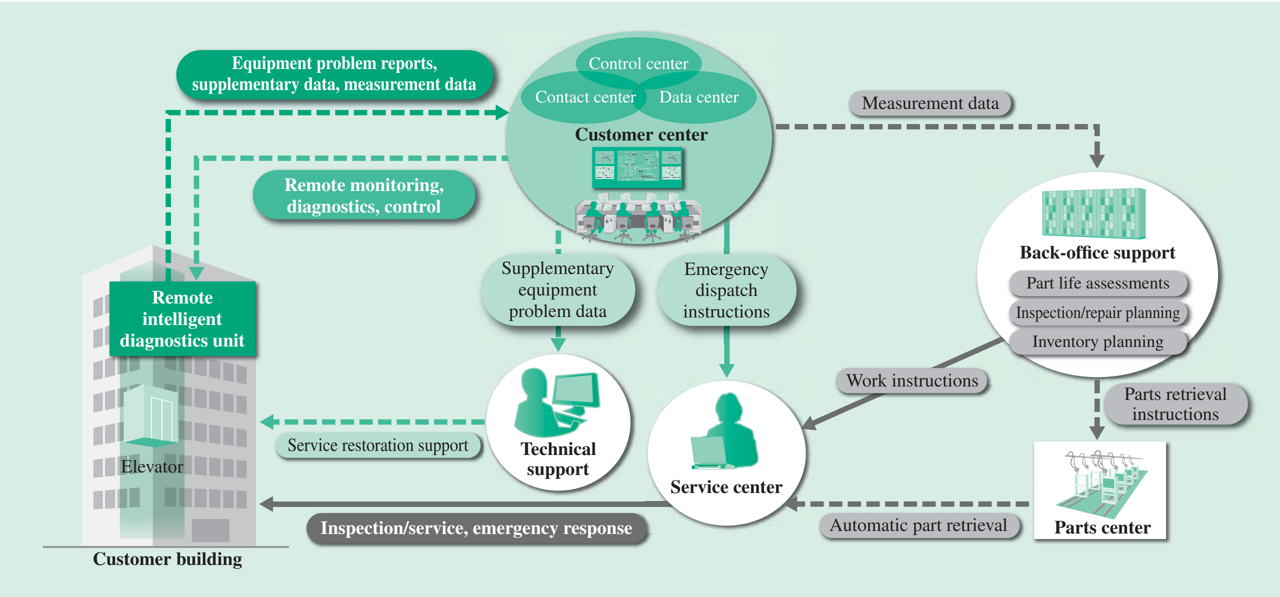
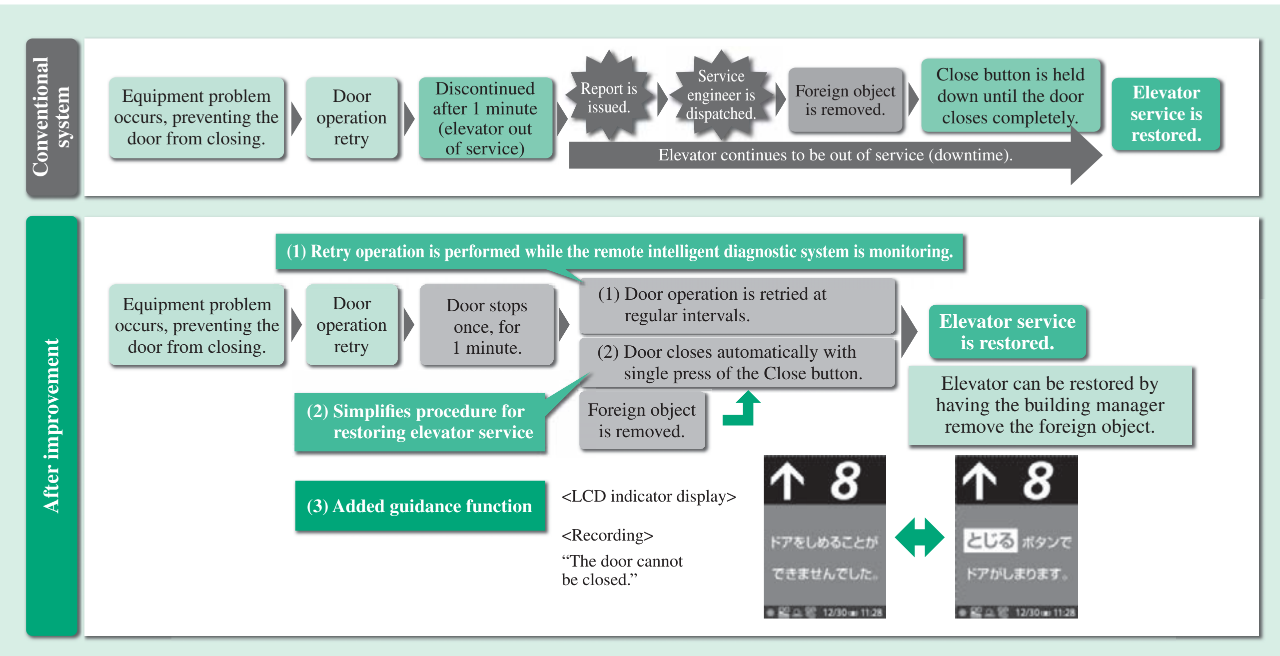


Fig. 2—Overall Configuration of Remote Maintenance System.
The remote intelligent diagnostics unit mounted on elevators and escalators is connected via a communication network to customer centers to provide 24-hour/365-day monitoring of mobility infrastructure and users nationwide. If, by chance, an equipment problem occurs, a maintenance engineer is sent from a service center and rapidly restores service.



LCD: liquid crystal display

Fig. 3—Overview of the Door Operation Retry Function.
This function enables the building manager to restore elevator service and to avoid events that lead to elevator downtime.

increments. This improvement enables more precise diagnosis of door operation states.

The following is an actual example of how an equipment problem was prevented by detecting a door operation problem: the remote intelligent diagnostic system detected a change in the operation position of a door when the switch that detects when the door is open (open limit switch, OLS) was triggered. A maintenance engineer was sent to the site and found that dust had accumulated on the open end of the door rail used to guide the moving door. The engineer cleaned the door rail, preventing an equipment problem

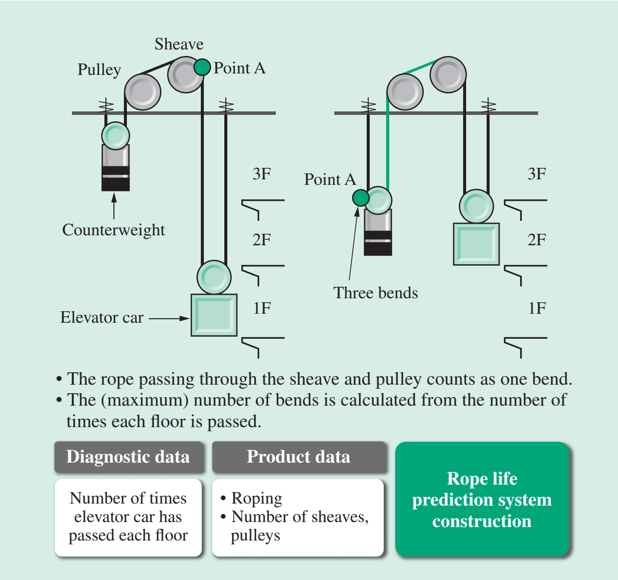


Fig. 4—Example of Counting Rope Bends Using the Remote Intelligent Diagnostic System.
Diagnostic data and product data is combined to enable the proper maintenance cycle to be set for the equipment in each building.

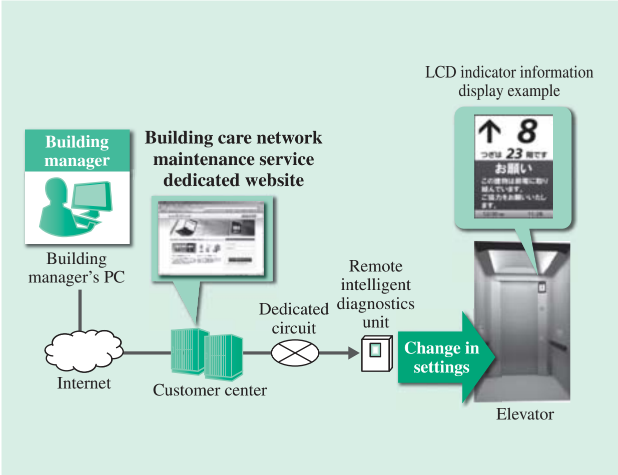


Fig. 5—System Configuration of Building Care Network Maintenance Service.
The system enables building managers to change elevator settings from a PC.

that would have stopped the door from fully opening (open lock).

Reducing Equipment Problems by Improving Door Operation Retry Function

A foreign object becoming stuck in the doorsill of an elevator door can sometimes prevent the door from fully closing, leading to an equipment problem report. The upgraded version of the remote intelligent diagnostic system repeatedly retries the door operation at regular time intervals while continuing to monitor the elevator.

The elevator's status and instructions for restoring it are also displayed on a liquid crystal display (LCD) indicator in the elevator car, enabling the building manager to remove the foreign object and restore elevator operation, preventing the problem from taking the elevator out of service (see Fig. 3).

Using Diagnostic Data with the Remote Intelligent Diagnostic System to Set Proper Maintenance Cycles

The remote intelligent diagnostic system diagnostic data with the remote intelligent diagnostic system from elevators is sent to the customer center and stored in the data center. The stored diagnostic data is used to set the proper maintenance cycle for each elevator. Maintenance cycles are set using test data that was collected during product development along with big data that has been analyzed by research departments such as data in maintenance work records and survey data for returned items.

For example, the primary factor affecting the deterioration of the rope (a major elevator component) is the number of times the rope bends as it passes through the hoist sheave and pulleys. The remote intelligent diagnostic system can use the elevator car operating conditions to accurately count the number of times the rope bends at each location (see Fig. 4). Using the big data analysis previously mentioned, the rope's life curve is estimated for the specific applicable factors such as the hoist model and rope type. The proper rope replacement cycle and inspection/service cycle are set from this life curve. During servicing, a proprietary rope tester developed by Hitachi is used for detailed diagnosis of rope deterioration such as broken filaments, to ensure that equipment is always kept in good condition.

NEW MAINTENANCE SERVICE ENABLED BY NEW IoT SERVICE PLATFORM

Building Care Network Maintenance Service

Hitachi has recently started a building care network maintenance service that lets building managers use a PC to tailor their elevators to their needs by specifying some of the elevator functions and control settings, and changing the information shown on the LCD indicators in the elevator cars.

The service is provided via the Internet, and has a dedicated website to let building managers log in and

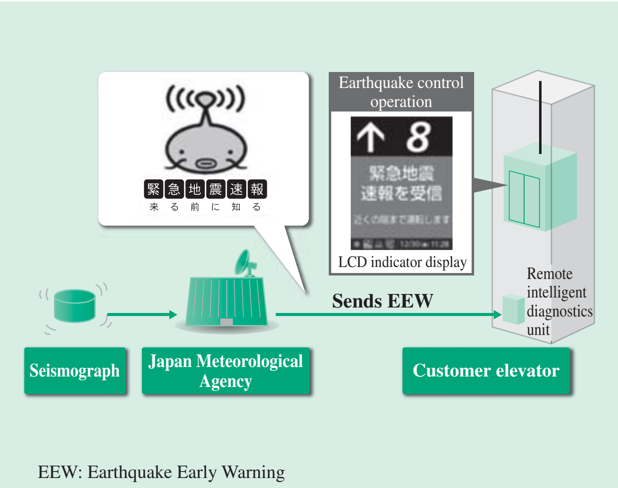


Fig. 6—System Configuration Used for Operation Control Function Linked to Earthquake Early Warnings (EEWs).
The operation control function responds to EEWs by stopping the elevator car at the nearest floor and guiding passengers to safety.

modify the settings needed, such as extending the door opening/closing time or customizing the messages for the elevator car LCD indicators (see Fig. 5).

Operation Control Function Linked to Earthquake Early Warnings

In response to growing concern over natural disasters caused by a recent spate of large earthquakes [of at least level 5 on the Japan Meteorological Agency (JMA) scale], Hitachi has led the industry by creating a function that links elevator operation to Japan's Earthquake Early Warning (EEW) system using congestion-resistant Long Term Evolution (LTE)* communication. When the function detects an EEW sent from the JMA, it stops the elevators that are in service at the nearest floor and provides guidance to enable rapid evacuation of the passengers, minimizing the potential for earthquake casualties (see Fig. 6).

If the earthquake tremors do not reach the elevators, the function restores normal operation after one minute to minimize inconvenience.

FUTURE ACTIVITIES

To expand the use of the diagnostic technologies and algorithms created for the latest standard Hitachi elevator models, Hitachi has also applied its remote maintenance system to its made-to-order elevators and its modernization package for elevators. It is working to expand the system's use by developing technologies to support elevator and the remote intelligent diagnostic system upgrades for both new and existing elevator models.

CONCLUSIONS

This article has discussed the latest elevator maintenance technologies used in Hitachi's remote intelligent diagnostic system, and its new maintenance service.

Hitachi aims to achieve the highest standard of elevator maintenance quality in the world, and will continue to provide service that ensures the safety and comfort of all building users as it expands its new IoT-based elevator maintenance service platform into Asia and other global markets.

* LTE is a Trade Mark of ETSI.

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