Arrival of a Great Turning Point in Maintenance: Smart Maintenance Initiative

Atsushi Yokoyama
Director, Technical Center, Research and Development Center of JR East Group

1 Introduction

Maintenance of railway equipment up to now has centered on time-based maintenance methods with uniform inspection periods, maintenance standards, and the like as guides. Inspections themselves are labor consuming and the data acquired could only be processed in laboratories and other places with mainframe computers. Due to such limitations, inspections periods and maintenance standards simplified to employ the greatest number of common features were thus unavoidable.

Acquisition of large volumes of data, however, became possible thanks to advancement of various technologies and better inspection frequencies. That and ability to process data at the personal computer level at the actual maintenance worksite changed the situation.

Condition-based maintenance (CBM) instead of just time-based maintenance (TBM) will become possible on the front lines of maintenance, allowing streamlined decision-making by individual equipment condition and predictive values for the future. Furthermore, by analyzing large volumes of equipment data and repair data, mid- to long-term maintenance strategies can be formed more specifically to allow for streamlined life cycle management.

In other words, decision-making in maintenance can be optimized based on specific data. That applies for…
(1) Inspection and repair at the maintenance worksite and
(2) Repair strategy across the life cycle.

In fields other than railways, systems such as smart grids and smart cities are being actively built that assume use of currently present real-time data for smarter decision-making.

For railways, too, establishment of smarter systems for smart maintenance can be said to be an urgent issue.

2 Smart Maintenance

Smart grid initiatives are being debated in the area of electric power supply. This is the formation of power girds that control power flow at both supply and demand sides to optimize that power flow.

Such a process of the identifying the current condition as data and making optimal decision according to the situation can be interpreted as using smart techniques.

IBM and others have promoted the “Smarter Planet” corporate initiative. That initiative includes traffic flow optimized by controlling traffic signal algorithm to alleviate congestion in urban areas as well as personalized medical treatment according to the circumstances of the individual instead of standardized medical treatment.

Making maintenance in the field of railways smart too is a smart maintenance initiative. Such work involves analyzing real-time data for “smarter” decision-making instead of the conventional method where the basis of decision-making (mostly inspection periods, maintenance standards, and the like presented in the form of rules, regulations, etc.) is simplified to that with the greatest number of common features from past knowledge and research.

This smart maintenance initiative has two aspects.

One is the method of optimizing day-to-day equipment management by analyzing real-time equipment condition data.

The other is the method of optimizing life cycle management by analyzing and processing (data mining) large volumes of equipment data that has been accumulated.

The following section will cover the two aspects of the smart maintenance initiative using track maintenance as an example.
In the area of track maintenance for conventional lines, decision-making for when and where on the track to conduct repairs is based on data from track inspections carried out every three months in track irregularity control. A guide used in that decision-making is track maintenance criteria. Those criteria are determined by approximate passing tonnage of individual classifications (track category) based on past research. Repairs are assumed to be made if data from track inspections exceeds the criteria, and this is called time-based maintenance (TBM).

Meanwhile, inspection of track irregularity and other situations has become possible using trains in service thanks to advances in inspection technologies in recent years. Data from such inspection can be acquired every day. The decision on when to conduct repairs can thus be decided by analysis and prediction methods using actual data. This is called condition-based maintenance (CBM).

The TBM and CBM concepts are shown in Fig. 1.

By migrating to CBM instead of TBM, guide values for track maintenance are high, but we are determined to aim to establish a new methodology for the maintenance process. Achievement of smart maintenance will transform decision-cycle management based on specific data will become practical. Methods of analyzing huge amounts of data—so-called big data analysis—have come into use in recent years, however, with advancement of computer technologies. Thanks to this, we have been able to comprehend various matters that had hitherto been unseen.

In the example of track maintenance, possible items that may be analyzed for a specific curve include the relationship between rail wear and the type of train passing or alignment. In that case, specifying a curve and analyzing it instead of using average tendencies of many curves with the same radius is important. By understanding the true tendencies of individual parts, the optimum measures for that specific location can be taken.

By combining the data for individual locations, items can be quantitatively identified to a certain extent. An example of this is the relationship of the condition (equipment such as rails, condition of track irregularity, failure rate, vibration distribution, etc.) between specific stations in efforts to maintain that. In other words, the tradeoff in service level (condition of track supporting transport) and costs to achieve that level will become visible, and choices from a management perspective will be possible. If a certain service level is assumed, efforts to reduce costs can be made, or the service level can be increased with costs fixed.

For that reason, a variety of reliability theories will be necessary along with risk analysis methods such as how to define failure rates. But as accuracy increases with the accumulation of data, we will be able to accurately put together long-term repair planning in terms of decades in addition to relatively short-term repair strategies of one or two years.

If a maintenance method can be established where the service level that can be provided and required costs can be proposed together, maintenance will be able to gain a position as an even more important element of the management strategy.

Up to now we have stressed from a standpoint of conducting maintenance that a certain track possession period for that maintenance is needed between maintenance. But it will be an important role of maintenance engineers to make a specific proposal in terms of management strategy to determine how much it would cost to maintain a certain level of maintenance while running trains all night on weekends.

The advancement of ITC that supports such maintenance has been tremendous. Data too has continued to be amassed.

If that data can be applied, extremely accurate equipment life cycle management based on specific data will become practical. Achievement of smart maintenance will transform decision-making from that based on rules, regulations, and the like as done up to now to that by front-line data and judgment of front-line engineers. That will mean a paradigm shift of 180 degrees in the maintenance process.

The hurdles that have to be surpassed to achieve such maintenance are high, but we are determined to aim to establish some of the highest-level maintenance methods in the world.