Streamlining and Optimization of Track Maintenance Work by Utilizing TRAck Maintenance System (TRAMS)

Ken Horigome
East Japan Railway Company, Tokyo, Japan

1. Introduction

East Japan Railway Company (JR East) is the Japan’s largest railway operator, providing metropolitan and inter-city transport to cover whole eastern Japan with its network of conventional lines in 67 line sections for 6,473.9km and Shinkansen lines in 3 line sections for 1,134.7km. By utilizing this large railway network, JR East accommodates customers of 16.68 million on a daily basis. One of departments supporting safety and stability of JR East's railway transport is its track maintenance department. Employees of the track maintenance department are realizing daily safe and stable transport without causing a major traffic disturbance by conducting appropriate inspections of track facilities on a timely basis and taking preventative measures in early stages for locations where problems are expected.

Therefore, to manage a variety of track facilities and keep the safety and stability of railway transportation, it is absolutely imperative to streamline and optimize track maintenance work by a track maintenance work support system. There is a track maintenance facility management system, called TRAMS (TRAck Maintenance System), at JR East. By utilizing this system, we achieve efficient and appropriate management of our track facilities with a few maintenance workers. In this paper, I will provide a brief overview of this system (TRAMS) and its functions, with a special emphasis on characteristic functions for track maintenance work for Shinkansen lines.

2. JR East's track maintenance work support system

2.1 History of JR East’s track maintenance work support systems
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JR East’s track maintenance work support systems have a long history in their development at our track maintenance department and have been playing a major role in our track maintenance work. With these systems, JR East has been preventing human errors in track maintenance work and has been achieving appropriate executions of track maintenance work on a timely basis with a high degree of precision in various maintenance works. Especially in Shinkansen department, a system called SMIS (Shinkansen Maintenance and Information System) had been used since Shinkansen started its operation in 1982. And later years, due to the advancement of information processing technologies, as a system with drastic additions to its functions and improvement in operability, a system called EWS (Engineering Work System) was developed in 1995. As its operating system (OS), the EWS employed UNIX. Furthermore, in 2001, a system called TRAMS21 (TRack Maintenance System for 21th century) was developed, later becoming a foundation for the current TRAMS. This system employed Windows NT as its OS and aimed to improve stability of the system. Additionally, it can be said that the TRAMS21 was nearly incorporated with major functions of current TRAMS.

In February 2009, our current track maintenance work support system, TRAMS, was finally put into practical operation. Major differences between TRAMS and its precedent systems were that TRAMS employed a web format for its system screens and introduced a central server instead of traditional servers installed at locations for system terminals. With these improvements, integrated network management at the company was achieved, resulting in reduction in material and human resources such as reduction in server facilities and maintenance work.

2.2 JR East’s Track maintenance work and relations with TRAMS

At JR East, track maintenance work is conducted in a cycle of repeating “See”, “Plan”, “Do” and “Check” as shown in Figure 3. Aiming to manage various works required in each stage with a single system called TRAMS, the structure and functions of the system are installed. The system consists of “subsystems” for each stage of the maintenance work for efficient execution.

Additionally, JR East reviewed its work execution system in 2001 and positioned its facilities department as “a group of professionals in facilities management”. On the other hand, for further promotion of efficient maintenance work, JR East promoted outsourcing of inspection and track.
repair work on this occasion and currently these works are entrusted to our partner companies. Partner companies can be largely divided into: companies specialized in inspection work and those specialized in track repair work. The relationship between JR East and a partner company in track maintenance work is as shown in Figure 4.

2.3 The subsystems of TRAMS
The whole system of TRAMS is divided into several subsystems aiming at the promotion of efficient maintenance work, composed of a cycle of repeating “See”, “Plan”, “Do” and “Check”. Each subsystem is corresponds to each stage of this cycle, and the outline of these subsystems is shown below.

- Inspection Judge Subsystem (See)
This subsystem deals with general matters about track inspection. Some functions are included in this subsystem such as the plan-making of track inspection, the display of inspection results, the extraction of exceeding point of target value for maintenance, the follow-up of inspection. Track inspection is done by various methods such as inspection vehicles, inspection machines, and human eye. And the data inspected by vehicles or machines is registered automatically on-line and judged whether reference values are exceeded its threshold for maintenance. We’ve achieved stricter checkup of inspection cycle in set rule, as well as drastic efficiency in follow-up of inspection by utilizing this subsystem.

- Work Planning Assistance Subsystem (Plan)
In this subsystem, points where maintenance is necessary are picked up from the threshold exceeding points, and then maintenance work plan is made. Also this subsystem employs the function of request of budget or materials necessary for maintenance work, along with the function of notification of request for track maintenance work executed by Partner Companies. This subsystem has reduced much routine and complex works done by human hand previously, and achieved drastic efficiency in work planning.

- Work Performance Result Subsystem (Do)
Work performance planned by inspection subsystem and work planning subsystem are managed by this subsystem. Results are inputted by operation persons and registered through this subsystem on-line with information about date, point, specifics, and so on. In addition, employees of JR East track
maintenance department can refer and count performance results on each work easily by operating TRAMS and achieved drastic efficiency as “a group of professionals in facilities management” in their work.

- Track Condition Management Subsystem (Check) *for Shinkansen lines only

This subsystem has a function which displays a track condition chart inspected by special vehicle for Shinkansen General Electric and Track Inspection Car (East i), calculates the amount of transfer for track repair work. This subsystem is indispensable for Shinkansen track management, processing a great deal of track condition data inspected once per about 10 days and utilizing these data for track maintenance work.

- Work Notification and Inspection Subsystem (Check) *for Shinkansen lines only

Shinkansen lines have a number of customers which is an important inter-city transport. We have to keep track condition in a high level to provide a highly safe transportation of the Shinkansen runs at high speed of 300km/h in maximum. For the efficiency of track maintenance work of Shinkansen lines, some of the works concerned with Shinkansen track maintenance is separated and integrated in one subsystem called “Work notification and inspection subsystem”. Details are mentioned in Chapter 3. In addition, other subsystems shown below are concerned commonly with all subsystems.

- Facilities Subsystem

This subsystem manages all facilities composes railway tracks as a ledger, such as rails, sleepers, rail fastening devices, and so on. We can imagine track conditions of the site even in our office by utilizing this subsystem, for each subsystem refers facility data on demand. This subsystem also has a function of drawing track diagrams automatically by loading facility data, and plays an important role in various scene.

- Expenses of Work Subsystem

It is necessary for us to estimate cost when we notify Partner Companies of track maintenance work. This subsystem has a database of unit price of track maintenance work and we can access this database according to the plan for track maintenance. This subsystem achieved drastic efficiency by eliminating documents for cost estimation and systemizing the work of expenses.

- Database Function

TRAMS has a function of downloading data of each subsystem in the form of general text format from the central server managed. We can make the most of these data managed by TRAMS in various scenes through this function.

The relation between TRAMS and each subsystem is shown on figure 6.

2.4 The security system of TRAMS
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The authority on business is different depending on one’s assignment, such as person responsible, head of department, deputy director, and general manager. And in TRAMS, work restriction beyond one’s responsibility is also designated by the terminal name which corresponds to each employee. The work flow of approval in TRAMS system is as follows; firstly the person responsible of Partner Company prepares drafts of work result, secondly a JR East person responsible checks and approves it, next the administrator and finally general manager checks and approves it, and finally the work result is registered with a central server. The whole process is called “electronic approval”.

We’ve prevented the error of missing the predetermined cycle of inspection, and leakage of abstraction where maintenance is necessary. This systemization has made a great improvement in track maintenance work.

Figure 6: The correlation of each subsystem in TRAMS

3. Shinkansen’s check system of track in dynamic state and its relation with TRAMS

As mentioned in chapter 2, in order to keep a high-level of track management especially in Shinkansen lines, TRAMS system for Shinkansen lines equips “Track Condition Management Subsystem” and “Work Notification and Inspection Subsystem” in addition to functions of TRAMS system for...
conventional lines. I’ll explain the method of check system of track in dynamic state for track maintenance of Shinkansen lines in this chapter, in keeping with the construction of this subsystem.

3.1 Abstraction of a point where maintenance is necessary
TRAMS picks up points where reference values of track irregularity or car vibration are exceeded automatically, from the data inspected by East i run by the frequency of once per about 10 days. There are two types of reference value; standard value and target value. The point where exceeds the standard value, with the high urgency of maintenance work, is displayed by red characters in the list of exceeding points. And the related information about exceeding points (tunnels, turnouts, records of the past excess at the same point) are also shown. We determine the priority of track maintenance on the ground of the value of track irregularity or other information by utilizing this information. And the points where track maintenance work is necessary are determined.

3.2 Indication of a chart and decision of method of maintenance
After we decide the point where track maintenance work is necessary, we can show the chart of track condition linking from the list of exceeding point of target value. First, we determine the range for track maintenance work on the chart, considering the shape of chart and the local track condition. After that, the necessary amount of transfer is calculated to bring it close to linearity of original by the amount of transfer calculation function equipped in a system of TRAMS.

3.3 Notifications of track maintenance and execution
The amount of transfer calculated by this process is output by the form of the table which indicates “the point of xxxKxxxm should be transferred how many millimeters in which direction”, for the designated range in every 1 meter. Partner Companies are notified of this table of the amount of transfer, and they execute track maintenance work according to this instruction. The machines for maintenance (MTT, Track Liner, etc.) are used in track maintenance work. This has made a great improvement in efficiency.
of work, and track maintenance work is done automatically by machines, only loading the data of transfer directly calculated by this system.

* Track Liner is a machine by which track lining is executed of slab track of Shinkansen lines in JR East area. This machine consists of loosening and fastening machines called “Auto Power Wrench” (APW) and track lining machine in corresponding to the calculated amount of transfer called “Track Liner”.

3.4 Comparison of track condition before and behind the track maintenance and confirmation of finish

Confirmation of whether track irregularity is improved within the finished standard value must be done. Confirmation is always done twice; the first confirmation is to check the condition just after the maintenance work finishes, and the second confirmation is done about two weeks after the work finishes. The reason why the second confirmation is done after a set period of time is that we can finally recognize the real track situation after the initial settlement of ballasts eased by tamping.

In the case of Shinkansen line of JR East, the second confirmation is done by the data inspected by East i runs for the first time after track maintenance work aiming at recognizing the track condition in a state of train running.

In the second confirmation, whether track irregularity inspected by East i is repaired within the finish standard value (from -4mm to +4mm on 40m-chord by both longitudinal level and alignment level in dynamic state) is checked. If the track irregularity exceeds the finish standard, readjustment must be done.

The second confirmation which is judged automatically by this system from the data inspected by East i made it possible to achieve high level of track condition management, as well as to reduce labor in terms of human resources and time. This systemization of a series of flow about track maintenance work has contributed to keep a highly good state of track (Fig.12). A series of flow like this is indicated on figure 13.
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4. Conclusion
In JR East, TRAMS has made it possible to systemize a series of track maintenance work and achieve streamlining and optimization of work. As in Shinkansen line, we’ve achieved a high level of track condition effectively by using method of check system of track in dynamic state. We will continuously and effectively keep high level of track condition by utilizing TRAMS system, and all employees of track maintenance department increase efforts so that customers feel comfortable to use railways continuously.

Figure 12: The transition of numbers where exceed target value of car vibration (per one run of Tohoku Shinkansen Line)

Figure 13: Cycle of dynamic check system of instructions of track maintenance for Shinkansen