

Development of a Train Approach Alarm System using GPS



Toshinobu Sakamoto*



Tooru Gochou*



Atsushi Sasaki**

* Researcher, Safety Research Laboratory, Research and Development Center of JR East Group

** Principal Chief Researcher, Safety Research Laboratory, Research and Development Center of JR East Group

Abstract

JR East has developed a train approach alarm system as a means to inform maintenance personnel working on the track of the approach of a train. This train approach alarm system can be used even in a section without a track circuit where we cannot use the TC type train approach alarm system used so far. It enables us to grasp the position of a train and the position of the maintenance personnel using GPS.

●**Keywords:** GPS, Train approach alarm System, Track circuit, Traffic Information Display

1. Introduction

The TC type wireless train approach alarm (TC alarm) has been used up to now to help secure safety for workers when conducting track patrols, inspection, and surveys on tracks. However, the TC alarm works by detecting train line occupation using track circuits to output alarms, so it has not been introduced in sections without track circuits.

A mistake resulting in workers not leaving the track when a train passed occurred in 2008 on the Suigun Line without track circuits and where the TC alarm was thus not introduced. As a countermeasure against such incidents, we started work on a train approach alarm system (train approach alarm system that uses GPS) that can be used in sections without track circuits, with actual introduction starting in fiscal 2016.

This paper gives an overview of this system and outlines development for putting it into practical use.

2. Overview of Train Approach Alarm System Using GPS

The train approach alarm system for sections without track circuits differs from the TC alarm in that alarms cannot be emitted using track circuit information. For that reason, location information obtained from satellites (location information measured by GPS) is used to emit alarms. The train approach alarm system for sections without track circuits is composed of the devices shown in Fig. 1, and the major functions of the individual devices are as follows.

(1) Onboard device for train alarm

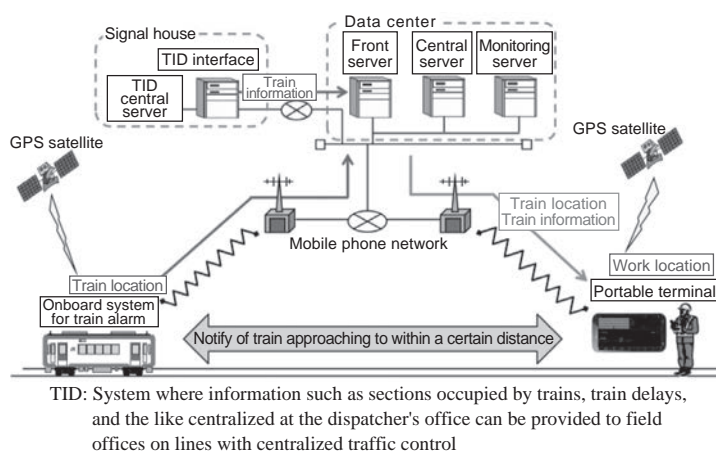
Obtains vehicle location (latitude and longitude information) by GPS and sends that to the front server in the data center by mobile phone network.

(2) TID interface

Sends train line occupation information received from the train operation information distribution system (TID) to the front server.

(3) Front server

Receives train location information from the onboard device for train alarm and train line occupation information from the train TID interface and sends that to the central server.



TID: System where information such as sections occupied by trains, train delays, and the like centralized at the dispatcher's office can be provided to field offices on lines with centralized traffic control

Fig. 1 System Configuration

(4) Central server

Compares train location information and train line occupation information received from the front server and converts that to line kilometrage. It then sends that to portable terminals by mobile phone network.

(5) Portable terminal

Obtains own location (work location) by GPS and converts that to line kilometrage. Also calculates work location and train location from train location information received from the central server and emits a train approach alarm when a train approaches to within a certain distance.

(6) Monitoring server

Monitors operating status of the individual servers.

3. Mechanism of Train Approach Alarm

3.1 Worker Location Detection

Work location is obtained by the GPS function built in to mobile phones (smartphones). Coordinates are obtained once every 1 second, and those are converted to track kilometrage by railway GIS (geographical information for converting latitude and longitude information to track kilometrage) to become work location.

3.2 Train Location Detection

Train location is detected by combination of train location information obtained by onboard GPS and train location information received from TID and the like. The device shown in Fig. 2 obtains latitude and longitude information by GPS in cycles of 1 second and sends the obtained latest location information to the front server in cycles of 2 seconds. Also, train line occupation information obtained from TID and the like is notified to the front server in cycles of 3 seconds via the TID interface. Consistency of train information obtained by GPS and section of line occupied by the train showed by TID and the like is confirmed and location is sent to portable terminals. Quality of location information is thus improved by combining GPS and TID and the like.

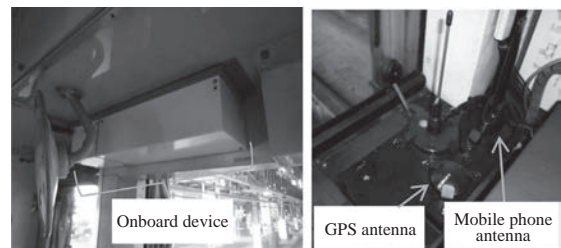


Fig. 2 Onboard Device

3.3 Train Approach Alarm Distance Calculation

Portable terminals emit a train approach alarm when a train approaches to within a certain distance from workers. And when the train passes the work location, the train approach alarm is stopped at an appropriate distance. When no train approaches to within a certain distance from workers, a sound to inform that the system is operating normally is emitted. Alarm operation when a train approaches the work location is as follows.

(1) Train approach caution

When a train approaches at a distance less than 3,000 m from the portable terminal, a caution announcement is emitted.

(2) Train approach alarm

When a train approaches even closer to a distance less than 1,500 m from the portable terminal, an alarm is emitted. The alarm stops when the train is 100 m away after passing the work location.

(3) Normal operation sound

This sound is emitted when the system is operating normally and there is no train in the caution or alarm area.

An alarm will be emitted for the closest train to the workers' location on both the inbound and outbound track.

Fig. 3 shows an overview of alarm operation.

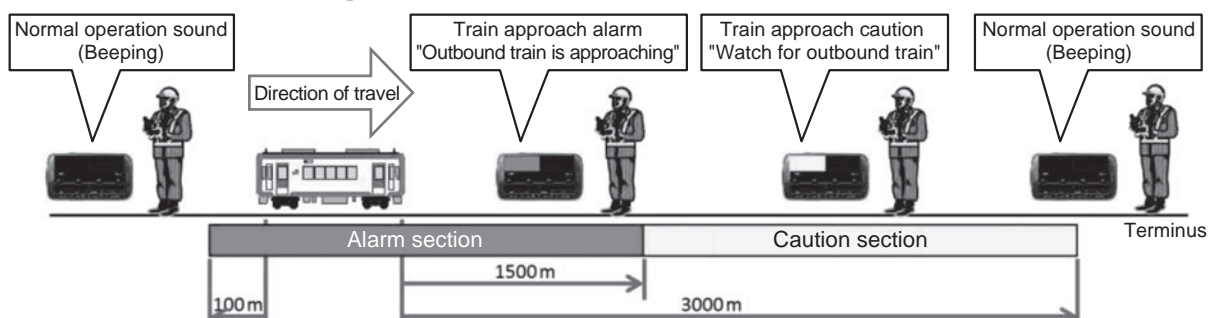


Fig. 3 Alarm Operation

3.4 Screen Display

Portable terminals also use screen displays to notify workers of train information and the like. Display content is shown in Fig. 4, with the following information displayed.

(1) Terminal status information (A)

Battery life, 3G/LTE communications status, GPS positioning status, train alarm operation status

(2) Vehicle information [inbound/outbound] (B)

Train number, section of line occupied, delay time, train speed, approach distance

(3) Graphic display [zoom in/out] (C)

Vehicle symbol, worker symbol

(4) Own location information (D)

Section name, work location kilometrage, current time

When a train approaches the alarm distance, the vehicle information display area shows that train in red (or yellow if train approach caution). Fig. 4 shows that a train on the outbound line has approached to within the train approach alarm range.

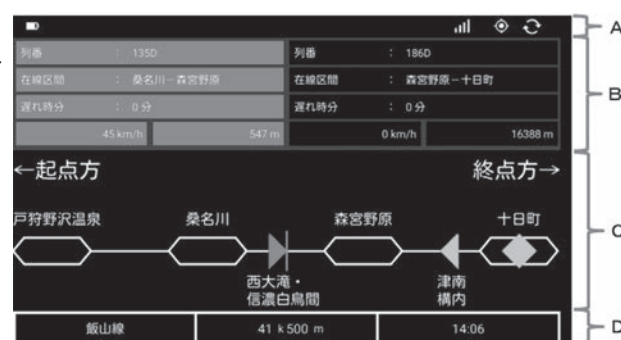


Fig. 4 Screen Display Example

4. Overview of Development for Practical Application

Train location information and train line occupation information are not consistent for tunnel sections, shunting vehicles, or vehicles parked long-term, so the system will judge a failure to have occurred with ordinary processing. In that case, the portable terminal emits a failure alarm and notifies of the details of the failure. Functions to operate on the safe side are thereby achieved, but this creates a problem in terms of usefulness for the user. We therefore studied a method where those are not counted as failures by defining sections where such incidents occur regularly as sections with special circumstances and making special processing on the system.

4.1. Consideration for Tunnel Sections, Etc.

We set in advance tunnels and other sections where GPS signals cannot be received as a database on the central server and portable terminals and performed special processing there. Fig. 5 shows an image of train approach alarm operation in that case.

When a train approaches a pre-set tunnel section and the like (when a train is moving outside the tunnel, etc.), ordinary operation is performed (Fig. 5, top). When the train enters the set section, it is assumed to be occupying the line on the exit side of the section and an approach alarm activates if workers are in the alarm range measured with that location as the start point. The actual train is farther away than the assumed exit-side train location, so alarm activation on the safe side can be achieved. The system returns to normal operation when the train exits the tunnel, train location is re-obtained by GPS, and train location information and train line occupation information match. Train approach alarm operation and processing differ from ordinary in the set sections and train location cannot be obtained due to inability to catch GPS or mobile phone signals, so those sections are assumed to be sections where use of the system is prohibited.

In processing on the server, sections where ordinary positioning by GPS is possible (judgment sections A and B in Fig. 6) are set before and after sections such as at tunnels where positioning is not possible, and those are grouped as sections where system use is prohibited and registered to the database. When a train enters judgment section A, train

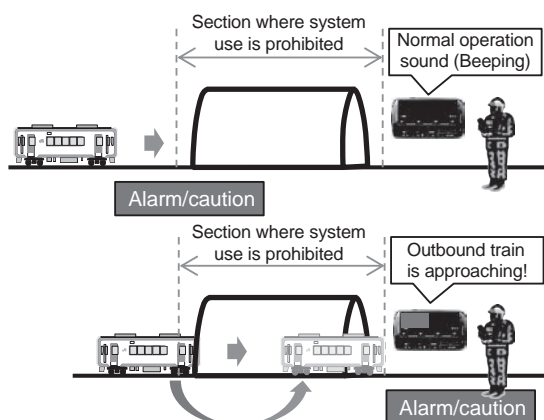


Fig. 5 Operation in Tunnels, Etc.

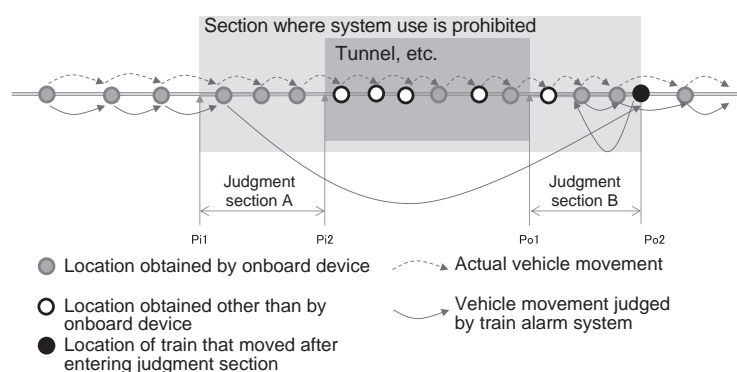


Fig. 6 Vehicle Location in Tunnel Section, Etc.

location is moved from the actual train location to Po2 in the outward-most direction of the section where system use is prohibited, and train location is restored to actual train location when it is detected by GPS in judgment section B in the section from Po1 to Po2.

4.2 Consideration for Shunting Vehicles

Shunting is performed at some stations for coupling and uncoupling of cars. Train line occupation information is not delivered for shunting, so train location information and train line occupation information do not correspond. In this case, special processing must be performed to prevent that being seen as a failure on the system. As with handling of tunnel sections and the like, train line occupation information is cleared on the defined section and this processing is performed when there is train location information obtained by GPS alone. This is done assuming the station yard is set as a section where system use is prohibited, and voice guidance on prohibition of use is given and train approach alarm is emitted. If the case of shunting vehicles, direction of travel may not be clear, so the alarm applies for both sides of the vehicle. Fig. 7 shows the operation in a station where shunting is performed.

4.3 Consideration for Vehicles Parked Long-term

Long-term parking of vehicles with the engine stopped may be done with line occupation information left in basic operation. Onboard device power is linked to vehicle power, so onboard device turns off when the engine is stopped, making it impossible to obtain vehicle location. In this case, train location information and train line occupation information do not correspond, resulting in a failure on the system. For this reason, special processing must be performed.

In special processing with vehicles parked long-term with their engines stopped, as with handling of tunnel sections and the like and shunting, the station yard is assumed to be set in advance as a section where system use is prohibited. When train location information by GPS and train line occupation information do not match, voice guidance and train approach alarm are emitted for train numbers set in advance. Train number and line occupation section are set from the roster for applicable vehicles to identify them. Fig. 8 shows the operation of portable terminals.

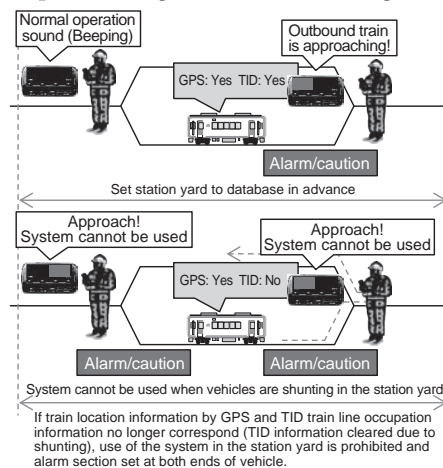


Fig. 7 Operation in Shunting Station

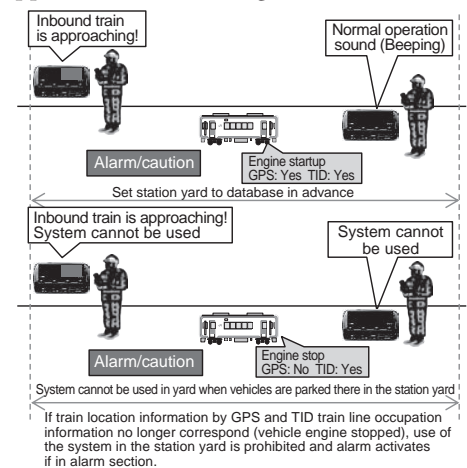


Fig. 8 Operation in Station with Long-term Parking

5. Introduction Plan

Use of the system started in April 2016 on the Hachiko Line and Iiyama line, and it has been introduced to eight lines as of August 2017. We plan to introduce it to sections of lines shown in Fig. 9 where there are no track circuits and where train line occupation information can be obtained.

6. Conclusion

This paper has presented an overview of the train approach alarm system for sections without track circuits and development for full-scale deployment. With its introduction, need for a safety structure depending fully on the attention of lookouts will be alleviated, and we expect that accidents involving workers being struck by trains and mistakes in leaving the track when trains pass will be prevented. Issues for the future such as specifications taking into consideration special circumstances of individual lines have been brought up, but we will push forward with efforts to introduce the system as planned and work to improve the safety of workers.

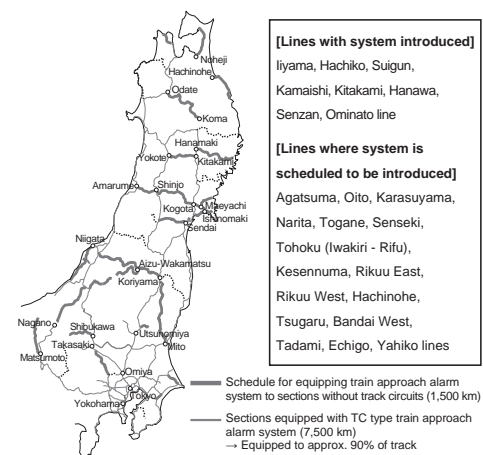


Fig. 9 Sections Scheduled for System Introduction