Newsletter on the Latest Technologies Developed by RTRI

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Railway Technology Newsletter

July 10, 2015 No.51

GENERAL INFORMATION

ARTICLES

R&D for the Future of Railways

Hideyuki TAKAI
Executive Vice President

In its master plan "RESEARCH 2010 - Toward Sustainable Development of Railways," RTRI set up three themes as the mainstays of its R&D: "R&D for the future of railways," "Development of practical technologies," and "Basic research for railways." Specifically, the research concerned with the theme of "R&D for the future of railways" was completed in March 2015 after implementing activities to address the following challenges categorized into five fields: "Safety and Reliability of Railway System," "Innovation of Maintenance," "High-efficiency Energy Utilization," "Sustainability and Development of Railway Networks," and "Construction of Railway Simulators" (Fig.1).

During the period of those activities, in March 2011 Japan suffered "the Great East Japan Earthquake" and a subsequent tsunami as well as the Fukushima nuclear power plant accident. As a result, implementation of countermeasures against massive earthquakes and improvement of energy utilization efficiency became urgent challenges to address immediately and not sometime in the future as RTRI had originally planned. Accordingly, RTRI has publicized results of relevant activities and already brought some of them into practical use. There are also many items for which RTRI's efforts need to be stepped up during the next five years.

RTRI is determined to capture social changes and technology trends ahead of anybody, promote R&D aggressively while bringing its total capability into full play, and convey the outcomes in a timely manner to concerned parties. In this manner, RTRI will continue contribution to the development of railways and to the buildup of an affluent society.

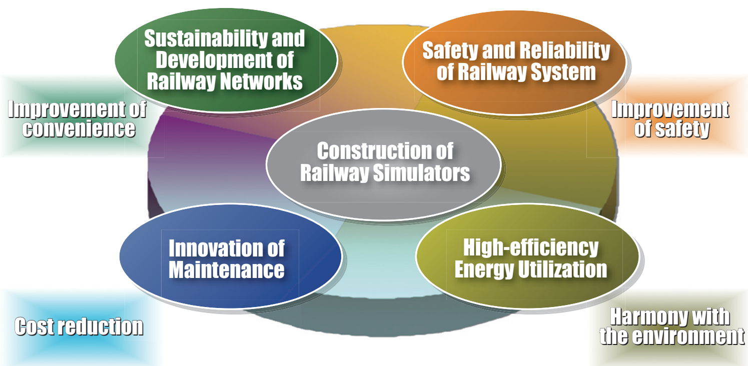


Fig.1 R&D for the Future of Railways (FY 2010 to FY 2014)

President Kumagai Delivered Key-note Speech at the Stephenson Conference

Norimichi Kumagai, President of RTRI, delivered a keynote speech at the Stephenson Conference, an international conference hosted by the Institution of Mechanical Engineers. The Conference was held in London from April 21 to 23. President Kumagai introduced a history of development of railways in Japan and gave a broad view of the contribution of railways to the Japanese society and economy. Specifically he extended his speech to include the contribution of RTRI and its predecessor, the Railway Technical Research Institute of Japanese National Railways, to Japan's railway technology and, especially, the Shinkansen high-speed railway technology.

Taking this opportunity, President Kumagai visited the office of the Rail Safety and Standard Board (RSSB) located in London to exchange views with Mr. Chris Fenton, CEO of RSSB, who also delivered a keynote speech in the Stephenson Conference. One of topics between them was future cooperation between RTRI and RSSB.

President Kumagai delivering lecture at the Stephenson Conference

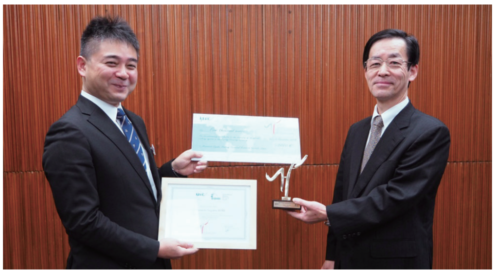
President Kumagai in RSSB office

RTRI's researcher wins UIC Global Research & Innovation Award

RTRI's Dr. Masamichi Sogabe won the UIC Global Research Innovation Award for 2014. He is Senior Researcher in the Railway Dynamics Division, and was given the award in the category of railway safety and security for his research "A Method to Evaluate the Safety of a Train Running on a Sequence of Structures in an Earthquake."

The award ceremony was held on December 3, 2014 at the Automobile Club de France in Paris. On behalf of Dr. Sogabe, RTRI's Dr. Munemasa Tokunaga, Researcher in the Structural Mechanics Group, received the award certificate and plaque from IRRB's Chairman, Mr. Boris Lapidus, and Director of the UIC Fundamental Values Department, Mr. Jerzy Wisniewski. Later in Japan, the certificate and plaque were handed to Dr. Sogabe by RTRI's President Kumagai.

Awards Ceremony



The certificate was handed by President Kumagai

The First Annual Meeting Held by RTRI's Center for Railway Earthquake Engineering Research

RTRI established the Center for Railway Earthquake Engineering Research in April 2014 with a goal of making the Center function as a "base site" for railway earthquake engineering, while "integrating" its various applicable research resources. As a forum for introducing past and ongoing activities of the Center and its vision for the future, a first annual meeting was held at the Tokyo International Forum on March 23, 2015. A total of 142 persons attended from the railway operators, government offices and agencies, universities, and companies in various sectors.

At the meeting, the "Earthquake Information System for Railways" was introduced. The distribution of this information is planned to start in April 2015. The system analyzes input data and releases to railway operators the earthquake information as soon as it is obtained from public agencies immediately after earthquake occurrence.

Opening address by Norimichi KUMAGAI, President of the RTRI

Understanding the Wear Mechanism of Current Collecting Materials

Chikara YAMASHITA
Senior Researcher, Current Collection Maintenance, Power Supply Technology Division

1. Introduction

In electric railways, contact wires and pantograph contact strips, which are both current collecting materials, slide in electric contact with each other to supply the vehicles with high power fed from the substation. The lives of these current collecting materials are mainly determined by wear. Therefore, research and development of wear measuring technologies and wear reduction measures are important.

2. Occurrence factor of maximum wear of contact wire

RTRI researchers have worked on the development of a wear tester (Fig.1) capable of capturing the transitional phenomena of wear modes. In order to understand the wear mechanism we think it is better to focus on the transitional phenomena of wear modes, instead of reproducing a wear volume which has been the traditional approach.

We performed a wear test on a combination of a hard-drawn copper contact wire and an iron-based sintered alloy contact strip. The result of the test indicates that there are three distinct wear modes dependent on the contact force and current (Fig.2). This chart shows the maximum wear rate of the contact wire for this test occurs when the contact force is around 10 N. Fig.2 also shows that the wear rate of the contact wire decreases under the condition of arc discharge occurrence (when the contact force is under 6 N in the chart), which traditionally has been considered the cause of maximum wear.

We also have found that, as shown in Fig.3 the wear mode changes when the maximum contact temperature, estimated from the contact voltage, reaches the melting point of each material, i.e., the hard-drawn copper contact wire and the iron-based sintered alloy contact strip. It can be concluded from the above that the maximum wear of the contact wire occurs when only the contact wire melts and forms a “melting bridge” between the contact wire and the contact strip. If the contact strip (Fe) is melted under a certain condition, the wear mode becomes a contact strip melting wear mode, in which case the surface of the contact wire (Cu) has not melted. In this case, the contact wire’s wear rate decreases because the “melting bridge” behavior of the contact wire has been suppressed.

3. Conclusion

In this research, we have found that the increase in the wear of the contact wire is highly dependent on the “melting bridge” phenomenon on the surface of the wire. It has been expected that, in addition to the maximum contact temperatures that we have discussed in this article, there are other factors which affect the “melting bridge” phenomenon. Therefore, we have continued further research into this phenomenon, and at the same time, have been exploring the optimum combination of materials for contact wire and strip, taking into consideration of the other influential factors.

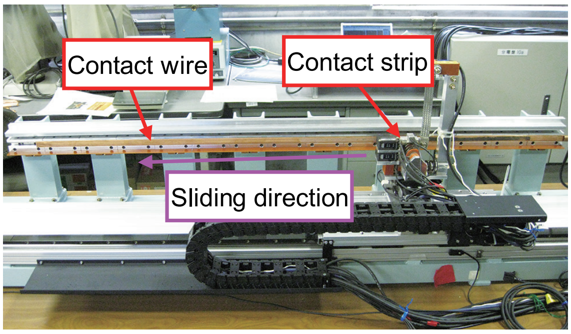


Fig.1 Linear wear test apparatus

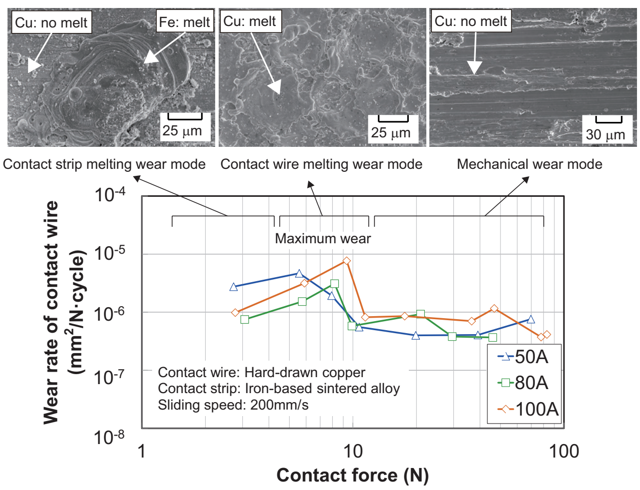


Fig.2 Wear rate and wear surface of contact wire

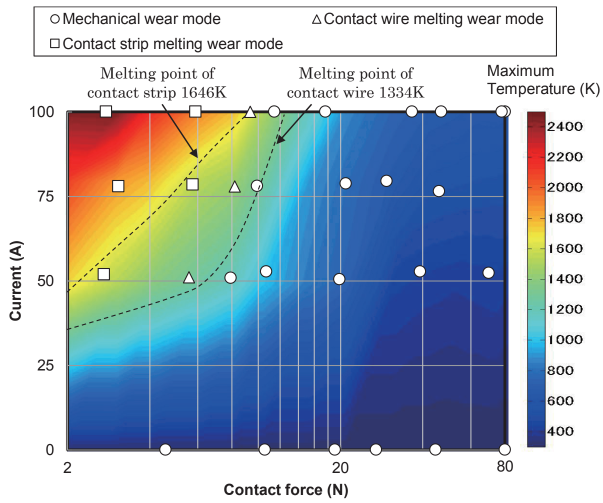


Fig.3 Correlation between wear mode and maximum contact temperature

Development of the Optimal Track Maintenance Schedule Planning Model

Masashi MIWA
Senior Chief Researcher, Laboratory Head, Track Geometry and Maintenance, Track Technology Division

1. Introduction

It is vital to effectively utilize the limited maintenance machinery, budgets and other resources in order to develop an efficient railway track maintenance schedule. Therefore, we have developed a Track Maintenance Schedule Planning Model to process track inspection and other associated data effectively and create a high-quality maintenance schedule. Fig.1 shows the whole structure of this model, which can be categorized into four major components of (1) Track Condition Diagnostics, (2) Track Maintenance Scheduling, (3) Evaluation of Maintenance Policies, and (4) Track Condition Forecasting, each consisting of submodels.
The summary of some of the submodels is introduced below.

2. Optimal Track Maintenance Scheduling Model for Track Irregularity Improvement

Many railway business operators are using heavy tamping machines called multiple tie tampers (MTT) to correct track irregularities. Proper operation is required for efficient maintenance of a large area with these tampers. Accordingly, we developed an Optimal Track Maintenance Scheduling Model for Track Irregularity Improvement to predict a future change in track irregularities by using the historical track inspection data and to schedule track maintenance for track irregularity improvement for the following fiscal year.
This model enables us to schedule maintenance according to the concept of "maintaining the track condition of the whole line section as good as possible by providing the total maintenance volume" or "maintaining the target track condition with as small maintenance volume as possible," The model considers track irregularities compared with the usual track condition and accounts for any restrictions in the MTT operation.
Fig.2 shows the changes of track condition and maintenance volume before and after the actual maintenance conducted in accordance with the schedule made by using this model. This indicates that, after commencement of the scheduled maintenance, the maintenance volume has decreased year after year and the track condition has improved.
This model was originally formulated to schedule maintenance for the tracks within the area assigned to one unit of MTT. However, it has been improved recently so that maintenance can be scheduled for more than one unit of MTT. The new model allows us to schedule maintenance for an efficient, wide-area operation of all the units of MTT with consideration of the inspection time and assigned area of each MTT and the losses caused by out-of-service distance.

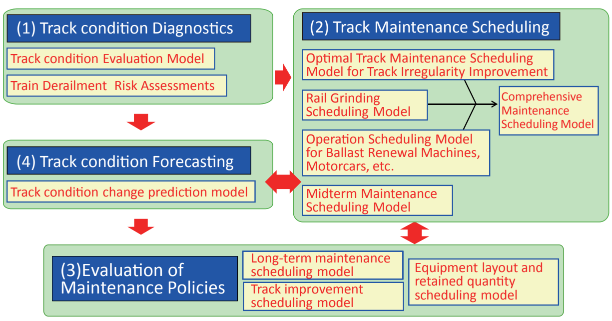


Fig.1 Optimal Track Maintenance Schedule Planning Model

3. Track Condition Evaluation Model

The Track Condition Evaluation Model enables us to choose the locations to be maintained frequently due to track irregularities; evaluate the condition of rail and/or ballast and choose the locations of quick growth of track irregularities by referring to the track inspection data; and propose appropriate maintenance methods according to the evaluation results. Generally, increased rail roughness will cause wheel load fluctuations to increase, which eventually will cause the growth of track irregularities to increase. If the ballast deteriorates, the growth of track irregularities will increase and improvements resulting from correcting track irregularities will decrease. Such a condition requires increased costs to correct track irregularities. Therefore, we chose locations where this model will turn out to be very effective in reducing the frequency of track irregularity improvement from mid- and long-term perspectives as shown in Fig. 3, and propose suitable maintenance methods to be employed accordingly.
Currently, several railway business operators are using some of the submodels.

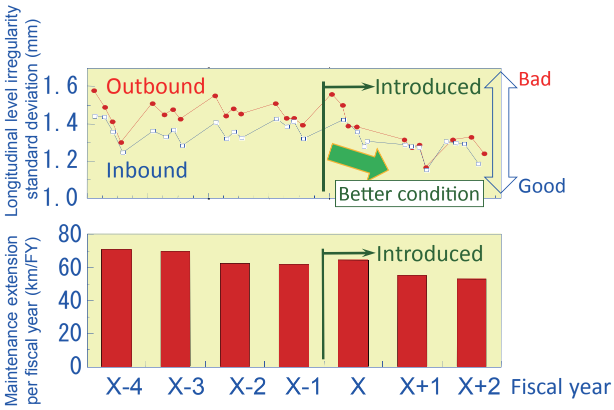


Fig.2 Track Irregularities and Maintenance Volumes Before and After Model Introduction

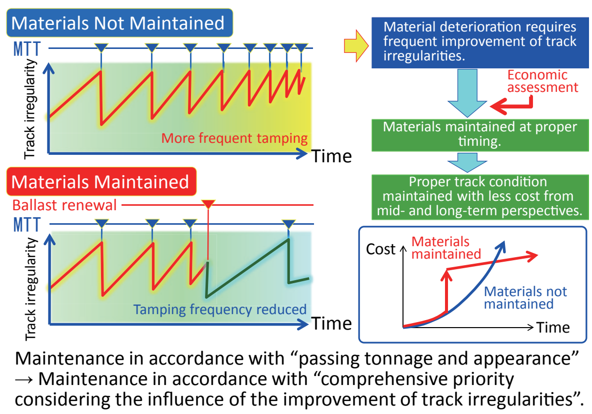


Fig.3 Choice of Maintenance Method in Consideration of Long-term Economics

Rockfall Hazard Map Using Digital Elevation Model

Takuya URAKOSHI
Assistant Senior Researcher, Geology, Disaster Prevention Technology Division

1. Introduction

We have developed a method to make a rockfall hazard map, using the digital elevation model (DEM). This method enables mapping a "reach probability," that is, the probability that falling rocks will reach railway facilities. This hazard map will be helpful to screen rock outcrops and to plan measures against a potential rockfall disaster.

2. Hazard mapping

This hazard mapping method consists of three components as shown in Fig.1: an estimation of the distribution of rock outcrops, an analysis of the pathway of a falling rock from each rock outcrop, and an evaluation of the reach probability using rockfall simulation. In this method, these estimations and evaluations are carried out using DEM. The DEM is raster data where analysis area is divided into squares, namely cells, with each cell consisting of an appropriate elevation value. The width of a cell, i.e. spatial resolution, is up to one meter when it is created from airborne light detection and ranging (Lidar) data.

The estimation of the distribution of rock outcrops (Fig.2(A)) is based on two characteristics, namely the slope angle and the curvature of the ground surface calculated using DEM. We selected these two properties as indices for this estimation based on statistical comparison between the properties and the results of field investigations.

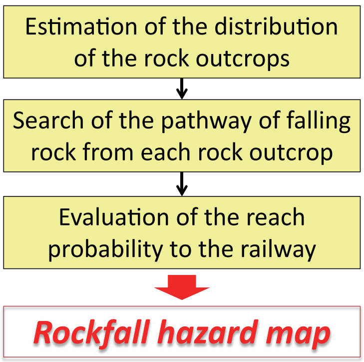


Fig.1 The process of the proposed hazard mapping method

The pathway of a falling rock from each rock outcrop [Fig.2(A)] is analyzed with the assumption that the falling rock moves in the direction of maximum downward gradient, DMDG. The DMDG is determined by comparing slope angles between the cell where the rock exists and the surrounding eight cells.

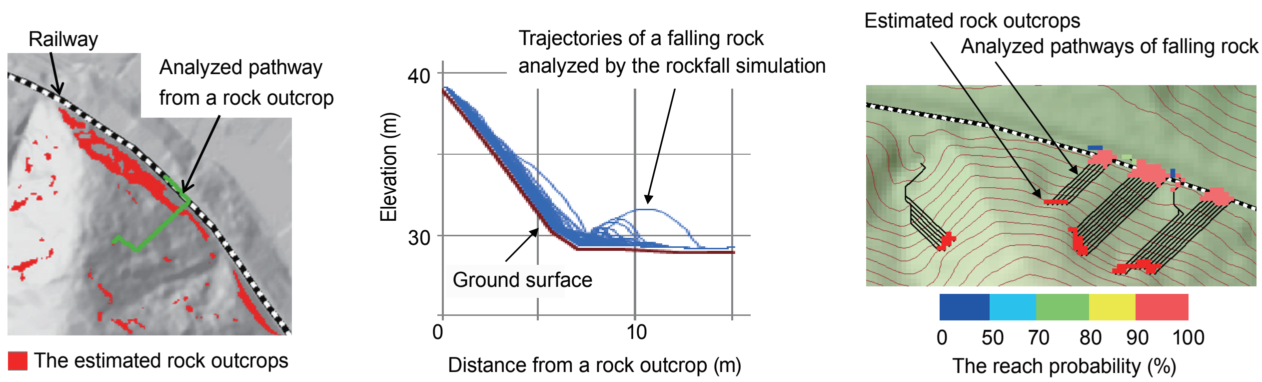
To evaluate the "reach probability", an existing simulation[1] using the Monte Carlo method is conducted (Fig.2(B)). The pathway analysis and the rockfall simulation are implemented for all estimated rock outcrops, and in this analysis, each rock outcrop is regarded as an individual source of rock fall.

Finally, the reach probability is mapped along railway lines using a geographic information system (Fig.2(C)). Additionally, the distribution of rock outcrops and the pathways are also mapped.

3. Merits of the rockfall hazard map

This map can be used as a screening tool to identify rock outcrops to be given high priority in investigation by engineers, among the vast number of rock outcrops along railway facilities. Moreover, this map enables users to find the region where the reach probability is high, which helps users to make a decision where they should prioritize counter-measures.

[1] Yoshida, H., T. Ushiro, H.Masuya and T. Fujii, 1991. An Evaluation of Impulsive Design Load of Rock Sheds Taking into Account Slope Properties, Journal of structural engineering. A., 37A, 1603-1616. (In Japanese with English abstract)



(A) Distribution of rock outcrops and pathway of falling rock
(B) Rock fall simulation on pathway
(C) Reach probability of falling rocks

Fig.2 Examples of estimation results

Performance Evaluation of Communication Network for Train Control System Using Radio Communications

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1. Introduction

As information communication technology matures, practical applications of a train control system using radio communications are being developed for railways. This system allows communications between the ground and on-board devices of control information related to safety, such as train position or the position to stop the train.

An overview of the train control system using radio communications is shown in Fig.1. It is important for a designer of a train control system to use stable radio communications and to fully understand network performance including the effects of loads and delays in transmission of control information between devices. Therefore we have developed a simulator for evaluating such network performance.

2. Simulator development

The simulator we have developed is designed to be operated by combining the models to control the timing of transmitting control information for each of the devices shown in Fig.1. The communication functions are divided in a hierarchical structure, patterned after the Open Systems Interconnection (OSI) Reference Model. The communication functions are classified into two main groups, the control processing section which corresponds to an application layer and the transfer processing section for transferring control information. In this simulator, various types of communications protocols can be used including the Transmission Control Protocol/Internet Protocol (TCP/IP) which is widely used in industries. Therefore, the simulator is capable of comparing and verifying the performances of various communication networks without being affected by the difference in protocol performances.

3. Evaluation of network performance

The simulator we have developed enables us to simulate the communication network of a scale equivalent to the real line section on a computer as shown in Fig.2 and check the delay condition and load tendency of the control information. Fig.3 shows a graph indicating a distribution of the transmission delays between the wayside and on-board control equipment (turnaround time starting with the wayside equipment, proceeding through the on-board control equipment, and finishing with the wayside equipment). We can see from this chart that the delay of control information does not exceed a certain period of time and consequently the simulation can confirm the stable operation of this system.

In the future, we would like to utilize this simulator for designing and evaluating more systems. We also intend to enlarge and strengthen its functions, combine it with other simulators for train operations and passenger behavior, and further develop the simulator so that we can evaluate the performance requirements for communication networks from the perspective of the effects on train operations.

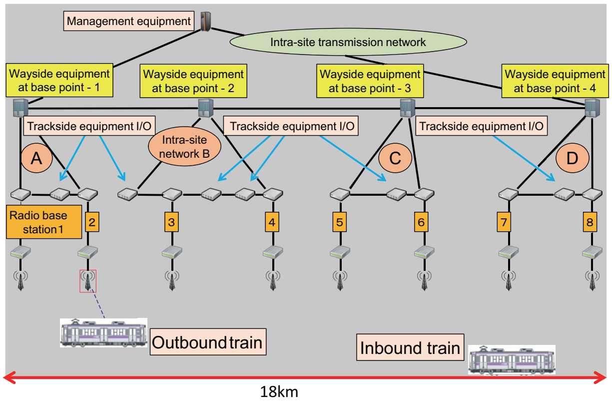

Fig.2 Overview of Network Construction and Simulation

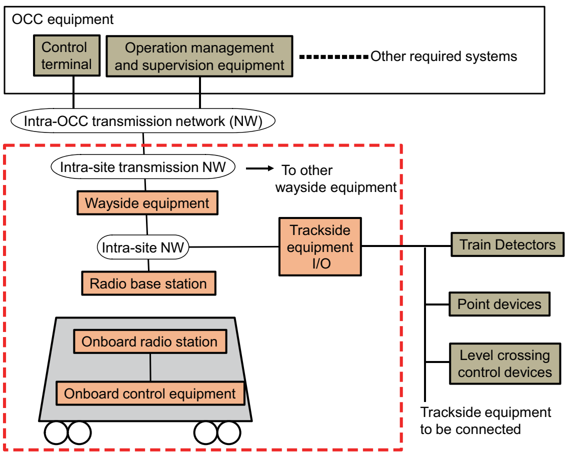

Fig.1 Overview of Structure of Train Control System Using Radio Communications

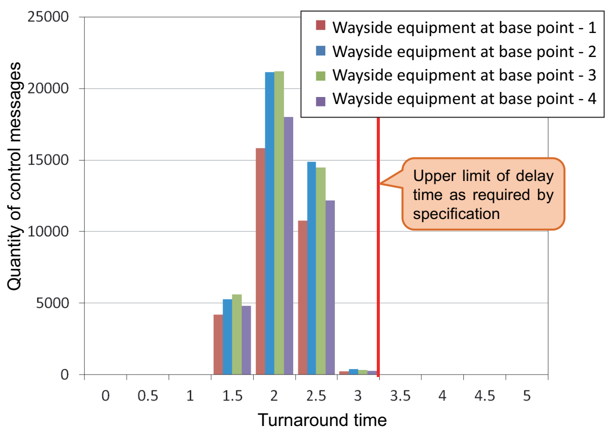

Fig.3 Distribution of Turnaround Time