The Safety Research Laboratory was founded on April 1, 1989 as a result of a train collision accident that occurred on the Chuo Line the previous year. That accident on December 5, 1988 led to the death of one passenger and injuries to 116 passengers as well as the death of the train’s driver. On a personal note, the accident occurred the year I joined the company, and I had just been assigned to the same section as the train that was struck. Upon seeing the scene, I felt that we must never again allow such an accident to occur. It has now been 25 years since that accident.

Vice president of the company at the time Shuichiro Yamanouchi stated at the end of a column he presented on science for safety that it was his great wish for JR East, through the Safety Research Laboratory, to create systems, information, and people the company could boast of to society and to the world about in terms of safety. While we have not made leaps as great as wished in the column, the Safety Research Laboratory is faithfully going forward with R&D that contributes to increased railway operation.

Meanwhile, the area that the Safety Research Laboratory is responsible for is separate from such specialized fields. As shown in Fig. 1, it is taking the initiative in “understanding phenomena”, “development of systems and methodologies”, and “improvement of rules and standards”. This is done while taking into consideration, from a preventive safety perspective, human scientific knowledge (human factors) based on engineering and social evaluation of risks, with a goal of increasing railway safety.

We have been promoting from fiscal 2014 our sixth five-year safety plan—“JR East Group Safety Plan 2018”. In that, we put emphasis on preventing reoccurrence of accidents where the cause lies in the JR East Group and that can be prevented by improvement of systems for railway operation and maintenance, especially on preventing reoccurrence of “incidents requiring attention” that occur due to the same causes as before. We are thus putting efforts into R&D on prevention of reoccurrence of those.

At the inception of the Safety Research Laboratory, research included that on observation methods and operation control to reduce damage from natural disasters such as earthquakes, wind

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**Mission and Recent R&D Themes of the Safety Research Laboratory**

**Kenji Horioka**

Safety Research Laboratory, Research and Development Laboratory of JR East Group

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The mission of JR East’s Safety Research Laboratory is to create excellent systems and professional persons we can be proud of all over the world.

The following are some examples of R&D themes we are currently engaging in accordance with “Group Safety Plan 2018”, the safety master plan of the JR East Group.
gusts, rainfall, and snowfall. That field of study was spun off and enhanced as the Disaster Prevention Research Laboratory as a result of the December 25, 2005 derailment accident on the Uetsu Line.

3 Current Specific R&D Efforts

3.1 Human Factors

The Safety Research Laboratory has conducted R&D from a variety of perspectives such as safety evaluation, wayside maintenance work, and rolling stock, as is covered later in this paper. However, human factors stand as the foundation of those, and we have adopted polices for appropriately evaluating and researching from a human factors perspective in overall research for prevention of accidents related to railway operation. Areas we are currently focusing on include “improving employee abilities and skills”, “improving safety abilities for the front lines by improving the organization and systems”, and “building safety systems taking into consideration human-machine interfaces”. Examples of successes are introduced as follows.

As previously mentioned, of the issues shown in “Group Safety Plan 2018”, “incidents requiring attention” that repeatedly occur make up around half of all incidents, with passing stop signals recklessly, exceeding the speed limit, improper track-closure procedures, and the like occurring. To keep those incidents from happening, it is important to learn lessons from incidents experienced by other workplaces, thinking of one’s own workplace or one’s self in same situation as others. As many people say that it is difficult for the front lines to effectively learn from incidents experienced by others, the Safety Research Laboratory created a “support tool to learn lessons from incidents experienced by others”, which can be used for workplace Challenge Safety Campaign activities and the like (related paper on page 25). This tool starts with analysis of an incident, followed by classifying results as one of the four typical error types of railway accidents, classifying by the six background elements inducing errors, then applying to examples at one’s own workplace, and finally discussion on examples and countermeasures.

In the March 11, 2011 Tohoku earthquake and tsunami, many trains suffered tsunami damage along the coastline of the Tohoku region. Thanks to the judgment of crews as well as the cooperation of passengers familiar with the local geography, appropriate evacuation guidance was given and human suffering was avoided. This has provided important lessons for us to use in the future.

Safety is maintained in railway operation by personnel following set rules, and training is conducted regularly on emergency response to deal with transport disorders. Such response is a “single path” where set procedures are executed without error. In the tsunami, decision and response in a rapidly changing situation were demanded, demonstrating that ability to respond flexibly is extremely important. For that reason, the Safety Research Laboratory developed a role-playing type of “image training for abnormal situations” with “forks” where decisions are made on selection in abnormal situations (Fig. 2).

In the area of human-machine interface, we are currently developing an “electronic checklist” to enhance support for emergency response when rolling stock experiences a failure during train operation. This is based on an emergency support concept adopted by the airline industry in the 1990s. The system has functions such as for displaying information on a driver’s cab monitor screen indicating a failure has occurred and the details of that failure, and it also has alarm support for when incorrect operations are done. That way, crews do not make errors in dealing with urgent situations on railways. Into the future, we will continue to brush up the system so as to implement its successes to JR East rolling stock.

3.2 Safety Evaluation of Railway Systems

Railways are both statistically proved and socially perceived as being safer than other modes of transportation. But if an accident does occur, the damage and repercussions are tremendous. JR East has thus been making capital investment in improving safety since the company’s inception.

The Safety Research Laboratory is continuously evaluating safety of railway systems from various incident data gained in railway operation, and we intend for that evaluation to lead to proposals for evaluation methods taking into account passenger trust and values. We are also studying by information exchange with European railway operators methods of risk assessment for quantitatively evaluating cost vs. effects gains from investment that are in common use in Europe. We intend for those studies to lead to safety evaluation within JR East in anticipation of future globalization (related paper on page 17).

In points of contact between railways and society, accidents at level crossings are a major issue that has been brought up. Results of surveys in recent years reveal that approx. 60% of incidents where trains and automobiles impact at level crossings happen after the barrier arm was closed. Trains approach level crossings after barriers close, and it is difficult to stop them by existing safety measures. For that reason, possibilities for accident prevention measures utilizing “collision mitigation brake systems (CMS)”, which have come to be employed on automobiles in recent years, are being studied to prevent drivers from unintentionally entering the level crossing after the barrier has closed.

3.3 Improving Safety of Wayside Maintenance Work

Safety measures in maintenance work for wayside equipment are generally taken in a way where they do not interfere with train operation (such as separation of train operation and maintenance work by line closure). However, much of those safety measures rely on human information, and workers making errors in interpreting rules could lead to trains colliding with construction vehicles and heavy machinery or even more serious incidents where workers are struck by trains.

For that reason, we are developing a system to give warnings...
when, due to incorrect instructions or handing, construction vehicles or heavy machinery are about to deviate from the work area or accidentally enter locations where work cannot be done.

In measures to prevent accidents where workers are struck by trains, introduction of a new train approach alarm is a current issue to be dealt with for sections were existing train approach alarms using train line occupation information from track circuits (TC train approach alarm) cannot be introduced. In other words, a new alarm is needed for sections where we currently rely on the attention of train lookouts. Specifically, we are developing a train approach alarm for locations where five or more lines run in parallel in dense sections of the greater Tokyo area and one for regional transport lines and other lines without track circuits and for sections with long track circuits (related paper on page 37).

A common issue in such technical development is technology for accurately and quickly identifying the location of construction vehicles and heavy machinery or workers. To overcome that, we are going forward with development utilizing the latest GPS technologies.

Line closure and other handling required in maintenance and inspection work is computerized in areas covered by the Autonomous Decentralized Transport Operation Control System (ATOS) in the greater Tokyo area, but handling is done by telephone communication between dispatchers and wayside personnel in other areas. In fact, handling mistakes due to oversights in confirmation dialogs have repeatedly occurred in safety incidents, so there are calls for computerization centering on regional trunk lines. For that reason, the Safety Research Laboratory introduced a “track closing procedure support system” to the Shinoi Line and Chuo East Line (west of Fujimi) in 2001 in advance of other lines. We are currently working to improve functionality and making efforts ahead of future expanded deployment of the system.

3.4 Improvement of Safety Where Rolling Stock and Track Meet

Issues at the area of contact between rails and wheels are covered in a field that is highly specialized even amongst railway-specific technologies, and physical phenomena there are still not completely understood. As a result of the flame climb derailment accident at a turnout in the yard of Ooku Station on February 23, 2008, we started research on a running safety evaluation method for sharp curves and turnouts in station yards (related paper on page 21). There area still many unknowns in the mechanisms leading up to derailment, and running tests using actual track and rolling stock are assumed to be necessary to identify phenomena, so we built a test line using a line out of service and performed repeated running tests there. As a result, we confirmed that leeway in the derailment limit became smaller when running repeatedly in the same sharp curve immediately after wheel turning (friction coefficient between wheels and rails increases and derailment limit coefficient lowers). We also confirmed in running tests that installing derailment prevention guards and lubricating wheel flanges are effective in preventing the decrease in the derailment limit. As we were able to identify from running tests how much the friction coefficient increases in such conditions, we will apply those results in proposing a formula for quantitatively assessing running safety on yard lines.

In the December 25, 2005 derailment accident on the Uetsu Line, a limited express train received a localized gust of wind, derailing and overturning the train and causing many casualties among passengers (five dead, 31 injured) as well as injury to two crewmembers. JR East is working on preventive measures so such accidents never occur again, and R&D personnel are reviewing detection and measurement of gust occurrence and methods of operation train control in strong winds. The Safety Research Laboratory performed on-site verification of the Detailed Equation proposed by the Railway Technology Research Institute (RTRI) as a method of assessing in detail overturn resistance of vehicles in strong winds, and JR East has introduced operation control rules utilizing that method on some lines in advance of full-scale deployment. The RTRI Detailed Equation is an extension of the existing assessment formula (Kunieda formula) with the addition of knowledge gained in recent years. It allows accurate assessment taking into account the influence of winds that change due to landscape or structures and the influence of wind that the car body receives by the train running. Therefore, we will be able to quantitatively assess locations where there is risk of easily being affected by wind and to flexibly set operation control thanks to ability to compare and assess both wind speed and train speed as rules for operation control. However, under some rarely occurring conditions, calculation results show the need for more strict operation control, resulting in need to stop trains at slower wind speeds, and we are considering proposal of effective operation control rules for future expansion of application of those rules.

The Safety Research Laboratory has gone forward with R&D centered on the company’s medium-term safety vision, which is updated every five years. This flow will for the most part remain unchanged, but we will probably have to deal with various new issues that will affect safety. Such issues include changes in how we work in anticipation of a declining birthrate and aging population and lack of available personnel as well as passing down technical skills from the pre-privatization generation to the current JR generation over the gap due to the control of hiring at around the time of privatization, an issue intrinsic of JR.

In R&D, we intend to objectively identify changes involving railway operations and brush up our sensitivity to and ability to act on proposing use of research results that meet the needs of society in an appropriate and timely manner. For that reason, we believe ability to actively utilize ICT and to effectively analyze an enormous volume of data gained from railway operations and raise questions from that analysis are necessary.

At the same time, there are various issues in highly specialized fields for railways, such as preventing derailment/overturn and train collision, countermeasures against earthquakes and meteorological/geological disasters, and human factors. We have received much support from RTRI on those over the years, and we intend to further our coordination with RTRI in the future. As a railway operator, we intend to verify technologies and knowledge proposed by RTRI in the actual fields where they are used and to promote systems and rules provided for actual railway operation.

This paper has introduced recent efforts as the Safety Research Laboratory approaches its 25th anniversary. From a perspective of our mission as in-company research facility, we are still in a growth phase, and we would very much appreciate the feedback and encouragement of readers.