Interpretive article

Efforts at the Safety Research Laboratory

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Abstract
In this article, I will outline the main research and development being done by the Safety Research Laboratory related to safety in the four fields handled by the laboratory. This R&D follows that covered in past issues of JR EAST Technical Review. Before that, however, I will take another look at the word "safety". Finally, I will end by describing new safety viewpoints and ideas related to "safety-II".

●***Keywords*:** Safety, Human Factors, Safety-II

1. Introduction

When did the word "safety" first come into use? The Japanese word for safety, *anzen*, is said to have been created as a translation for "safety" when foreign concepts were introduced to the country in the late 19th century Meiji Restoration, but it actually appears in the 13th-century epic "The Tale of the Heike". The dictionary meaning of *anzen* is "absence of danger, or tranquility and peace".[1]

Words expressing basic concepts as with *anzen* are used as if with a common recognition of their meaning, but the meaning of words that have been around for a long time may become diverse due to modern circumstances. *Anzen* as a translation for "safety" also being applied as a translation for "security" is an example of this.

"Safety Research Laboratory", the English name for our laboratory, uses "safety" to mean *anzen*. One international definition for safety, and consequently *anzen*, is found in ISO/IEC Guide 51: 2014 (which JIS Z 8051: 2015 is based on) as "freedom from risk which is not tolerable".

At the Safety Research Laboratory, we work on more than just efforts to prevent accidents from happening due to risk which is not tolerable, with efforts that go beyond that (see chapter 3). The mission, history, and recent developments of the Safety Research Laboratory are covered in past issues of JR EAST Technical Review[2),3)]. So chapter 2 will describe major R&D since that in line with the four fields handled by the laboratory.

2. Major Recent R&D at the Safety Research Laboratory

2.1 Human Factors

At JR East, we are gradually introducing equipment and systems to improve safety of train operations, and areas handled by humans are decreasing with that. However, there are situations that require human judgment in all tasks, and it is not easy to computerize or mechanize those. Therefore, there is still room for human error to occur, and it is fundamentally impossible to reduce that to zero. In light of that situation, we see human factors as a priority issue at Safety Research Laboratory and are consequently working on that issue.

Various traits that differ by individual are reflected in human behavioral patterns. Of those, we selected as "safety traits" four that are deeply related to safe behavior in duties and created a support tool with which personnel work on tasks to identify tendencies in their own safety traits and make use of that knowledge in their duties. A characteristic of that tool is that it is configured to emphasize tendencies in safety traits shown to personnel by the tool so that they work to better those strengths with confidence and active use them for safe behavior (covered in detail in related paper of this issue of JR EAST Technical Review, P. 19). Currently the diagnostic tool for safety traits that allows one to know his or her strengths in safety is available on the company's intranet safety portal site, and we are encouraging personnel to use the tool at their own initiative.

The aforementioned safety portal site previously only allowed one-way communication where the site administrators put out information on safety. However, we later set up a "safety bulletin board" on the safety portal site for information to be more effectively used. With the bulletin board, interactive communication is achieved where viewers can promote their own efforts and give opinions and comments to those from others (related paper of this issue of JR EAST Technical Review, P. 23). That way, information such as on efforts and training for accident prevention carried out at individual workplaces can be applied throughout the company, and that can provide hints and opportunities for personnel who have obtained that information to think about efforts related to safety for their selves and their workplaces.

Skills necessary in executing duties are more than "technical skills" of specialized knowledge and abilities. There are also "non-technical skills" that complement those, such as "situational recognition" and "decision-making". Crews who secure safety in rapidly changing situations constantly need to appropriately recognize the situation, make decisions, and take action. To prevent human errors that occur in such situations, we gather and organize knowledge and innovation on that by means such as interviews mainly of veteran crews. And we are studying how to build a mechanism for sharing knowledge and innovation based on the findings obtained by interviews so that crews promptly notice appropriately and respond to hazardous situations that may occur and situations where human error easily occurs.

2.2 Risks and their Relation to Society

As noted in chapter 1, the definition of "safety" includes the phrase "risk which is not tolerable". In ISO/IEC Guide 51: 2014, "tolerable risk" is defined as "level of risk that is accepted in a given context based on the current values of society". Therefore, safety is not something decided by the operator, and it depends on how society perceives it. We are thus continuously investigating and analyzing awareness of safety of people using railways (related paper of this issue of JR EAST Technical Review, P. 27).

R&D is currently underway on methods of risk assessment related to train operation that can be applied at JR East. Risk assessment is the part of the risk management process pertaining to identifying risks, analyzing those risks, and evaluating those risks (Fig. 1). For the first part, identifying risks, risks are extracted as preliminary work. However, after the 2011 Tohoku earthquake and tsunami, there has been much debate on "unanticipated risks", and a method of making unanticipated risks easily extractable has been thought up.

That method is a mechanism to make it easy for people who extract risks to notice them by limiting situations where risks are anticipated, taking into account the fact that unanticipated risks are by nature difficult to anticipate.[4] First, elements for the vertical axis and elements for the multiple horizontal axes are decided in order to set situations where risks are anticipated. For example, types of accidents, etc. in railway accident investigations reports by the Japan

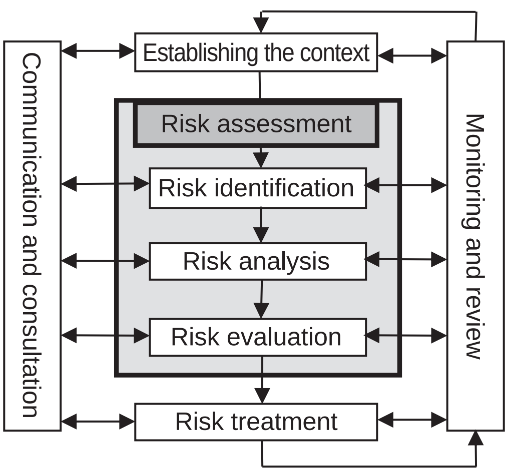

Fig. 1 Overview of Group Safety Plan 2018

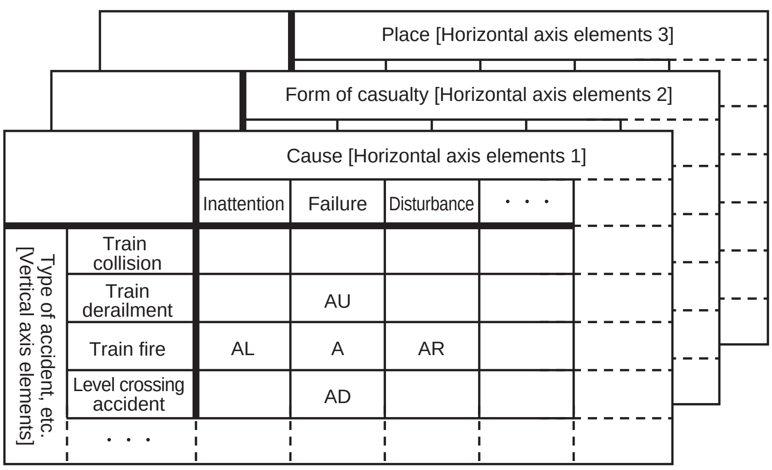

Fig. 2 Trends in Railway Operational Accidents

Transportation Safety Board are set as elements of the vertical axis in order to maintain consistency with past classifications. And "cause", "form of casualty", and "place" are set as elements of the multiple horizontal axes in order to make so risks are noticed easily. Then, the contents of vertical axis elements are combined with each horizontal axis element to form multiple matrixes (Fig. 2). After that, risks are considered limited to situations corresponding to each cell and gradually entered. If risks are not thought of in the first stage, entry is omitted and the next cell is moved to. If there are blank cells (for example, "A" in Fig. 2) after this procedure is done for all cells, risks entered in the adjacent cells ("AU", "AR", "AD", "AL" in the case of Fig. 2) are information related to the blank cell, so opportunity to think of risks corresponding to the blank cell is obtained. By using this method, risks could be extracted in a more comprehensive manner.

2.3 Improving Safety of Maintenance Work

Wayside equipment needs to be maintained in order to secure safe train operation, and maintenance personnel inspect while patrolling along track or they enter the track to perform maintenance work. In order to secure safety in those patrols and work, a train approach alarm system has been put in place to audibly inform of train approach to prevent workers from being struck by trains due to not noticing their approach while patrolling. Also, track closure procedures are conducted to prevent trains from entering related sections so accidents and damage do not occur due to trains and other vehicles being operated in sites where work is underway.

The TC type train approach alarm system used so far detects train location based on information of track circuits installed with track separated into sections, and it outputs an alarm to maintenance workers when a train approaches. It therefore can only be used in sections with track circuits, so there was a need to develop a system that can notify of approaching trains in sections without track circuits. We thus developed a "train approach alarm system using GPS". That system can output alarms without obtaining track circuit information by identifying the location of trains using GPS technology, which has seen increases in precision in recent years (related paper of this issue of JR EAST Technical Review, P. 31). Lines with the system are being gradually expanded in the JR East area.

While the TC type train approach alarm system is designed to be compatible with sections with up to four main tracks running in parallel, the greater Tokyo area handled by JR East has sections with more than four main tracks in parallel (for example, there are 10 tracks in the section between Uguisudani and Nippori). As there are many trains running in such sections, there is a high chance of a train approaching without being noticed if attention allowed to slip for just a short time. There was thus a need to develop a system to notify of train approach in such sections. We consequently developed and confirmed basic functions of a mechanism where maintenance personnel in sections with more than four tracks can select the two tracks they are involved with, and an alarm is emitted when a train approaches on those tracks and the two tracks adjacent to them (maximum of four tracks). Mass production devices for that are currently being developed.

The cause of a train derailment in the yard of Kawasaki Station on the Tokaido Line (Keihin-Tohoku Line) in February 2014 was a road-rail vehicle entering track before track closure and colliding with a deadhead train running there[5]. In light of that, we are installing GPS receivers on road-rail vehicles to identify their locations; and we are also separately developing a mechanism to identify status of track closure start from ATOS (Autonomous Decentralized Transport Operation Control System) for example and emit alarms for road-rail vehicle drivers if those vehicles enter tracks where track closure has not started (related paper of this issue of JR EAST Technical Review, P. 35).

2.4 Improvement of Rolling Stock Safety

Rolling stock is heavy and the steel of rails on the ground is in contact with the same of wheels on rolling stock, so frictional force is small and rolling stock cannot stop fast. So, even if the crew detects an obstacle ahead of a running train and applies the brakes immediately, the train may still collide with that obstacle. And the impact of the collision may greatly affect the passengers and crew onboard the train. For that reason, increasing the safety of rolling stock in a collision will greatly contribute to alleviating human damages when an accident occurs.

In the September 1992 Narita Line Osuge level crossing train derailment accident, an overloaded large dump truck was not able to stop and intruded onto the level crossing closed to road traffic. The approaching train collided with the side of the dump truck, resulting in major damage to the driver's cab of the train. In response to that, we added crushable zones in areas where people are not normally at, such as the front of cars and between the driver's cab and the cabin, as a measure to improve safety against impact. By those areas intentionally being crushed in a collision, energy is absorbed and impact on the passenger cabin is alleviated. We are currently researching the possibility of further improving collision safety by analyzing the behavior at impact in the aforementioned Kawasaki Station yard derailment accident for cars where such collision safety measures were implemented (related paper of this issue of JR EAST Technical Review, P. 39).

Preventing derailments caused by rolling stock too is a major theme for the Safety Research Laboratory. The September 2013 derailment accident in the yard of Sagamiko Station on the Chuo Line was caused by large unbalance in right and left wheel load[6]. We are therefore working on the following two sets of R&D on wheel load unbalance. One is by devices equipped to rolling stock monitoring air spring pressure in order to determine onboard that wheel load unbalance is abnormal[7]. Wheel load fluctuates according to track condition or vibration from running, and a certain amount of unbalance is present in normal conditions. For that reason, we monitor pressure of four air springs per car and combine lateral unbalance with unbalance between diagonally opposing wheel loads in order to determine whether wheel load unbalance is normal or abnormal. Currently, in order to determine the appropriateness of values needed for determining unbalance, we are collecting data in the field. The other set of R&D is for devices installed at the wayside. With those, strain gauges are set on rails where trains run to directly measures wheel load and detect abnormal wheel load unbalance[8]. As data obtained from measurements is affected by track condition or vibration due to running, we discovered that the impact of those could be minimized by measuring while moving the four axles of a car in a certain place. Currently, we are conducing development with an eye to installing the devices on tracks in the yards of rolling stock centers in order to be able to detect unbalance by measuring when putting rolling stock into sheds.

3. Future Efforts

With the decrease in the number of accidents compared to in the past, it is becoming difficult to further improve safety by conventional methods centering on preventing reoccurrence of accidents alone. Authority on human factors Erik Hollnagel calls the conventional view of safety being “avoiding that things go wrong as much as possible” Safety-I and the new view of safety being “ensuring that things go right as much as possible” Safety-II.[9] We have reached the limit to what can be done from a Safety-I perspective and now need to work from a Safety-II perspective as said by Hollnagel.

As noted in paragraph 1 of chapter 2, efforts to better strengths and the concept of non-technical skills probably incorporate this new view in part. We will work to sort out the meanings of the concepts related to the new view and the relationship between the two views in addition to continuing to work on preventing reoccurrence of accidents. And, we believe that applying the new view to actual work will lead to further heightening of safety.

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