



Mr. Naoki Mizukami
Director,
Head of Human Science Division

The Human Science Division is currently conducting research and development (R&D) on human factors. We aim to enrich and support the education and training of railway workers to enhance their safety, as well as station and on-train environments to enhance passenger safety, convenience, and comfort. We are capitalizing on digital techniques to perform various tasks more effectively and efficiently and are advancing our R&D efforts by cooperating with other research hubs. In this document, we report the results of our recent R&D activities.

Human Science Division

Introduction

The Human Science Division aims to solve various human-related problems in railway systems and devise countermeasures to ensure passenger safety, convenience, and comfort. Consequently, it is essential to understand “people” and “the relationship between people and railroad systems” to elucidate their psychological, physiological, and behavioral phenomena and employ the knowledge and technologies accumulated thus far.

Our division initially comprised four research laboratories (Safety Psychology, Ergonomics, Safety Analysis, and Biotechnology). However, in April 2022, it was restructured and now comprises three laboratories (Safety Psychology, Ergonomics, and Comfort Science and Engineering)

to enhance the efficiency of R&D, with the aim of improving the environment surrounding railways and satisfying the requirements related to passenger safety, security, and comfort.

Major R&D efforts of the Human Science Division shows our major R&D efforts thus far. To provide appropriate education, training, and support to drivers for ensuring safety, we are focusing our R&D efforts to minimize human errors, unsafe behaviors, and workplace accidents; improve workplace environments; and implement driver-support systems. To prevent transport disorders, we are developing guidance measures to be implemented during abnormalities and preventive measures for accidents at level crossings and train–deer collisions. To evaluate and improve user environments and the work done thus far,

our R&D efforts are focused on developing ergonomic designs for internal accommodations, barrier-free solutions, enhancing onboard passenger comfort, and evaluating and improving sanitary conditions. We are working in conjunction with other research divisions, including the Information and Communication Technology Division, and considering cost reductions to solve the issues identified thus far and employ digital technologies to address them.

Here, we introduce the latest examples of our R&D efforts based on digital technologies for developing advisory techniques for drivers that monitor changes in their physical and mental states, enhancing pedestrian safety at level crossings, and developing low-cost and efficient weeding techniques.

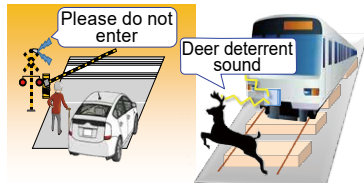
Appropriate education, training, and support measures for ensuring safety

Including minimizing human errors, unsafe behaviors, and workplace accidents, and improving workplace environments, human factor analysis, and support systems



Measures to prevent transport disruptions, including

Guidance measures to be implemented during abnormalities and preventive measures for accidents at level crossings and train-deer collisions



Safety

Convenience
Passenger comfort

To evaluate and improve user environments and work done

Including the development of ergonomic designs for internal accommodations, barrier-free solutions, enhancing onboard passenger comfort, and improving sanitary conditions



Understanding "human beings" and "the relationship between human beings and railway systems," elucidating the various phenomena considering human psychology, physiology, and behavior

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Using the knowledge and technologies accumulated thus far



Solving various human-related problems in railway systems and proposing countermeasures

Major R&D efforts of the Human Science Division



Data from each sensor is recorded at a terminal via Bluetooth

⇒ Driver drowsiness levels are measured

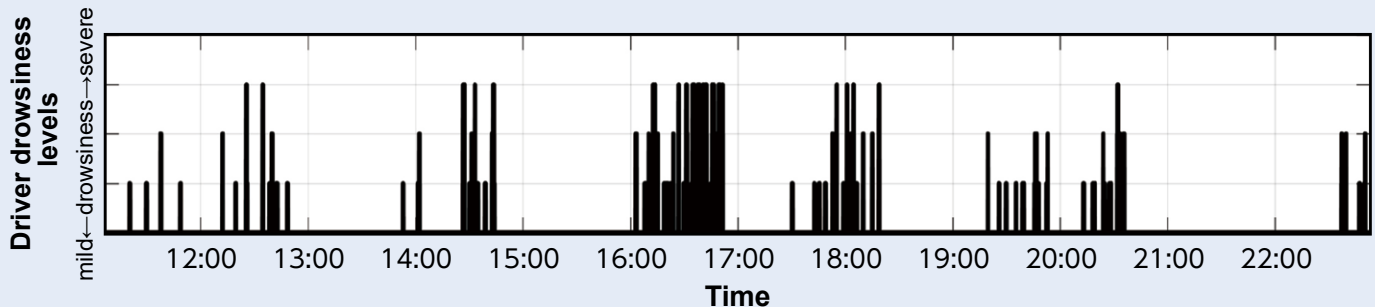
⇒ Sounding a voice alarm if required

Driver-support System by Monitoring their Physical and Mental States

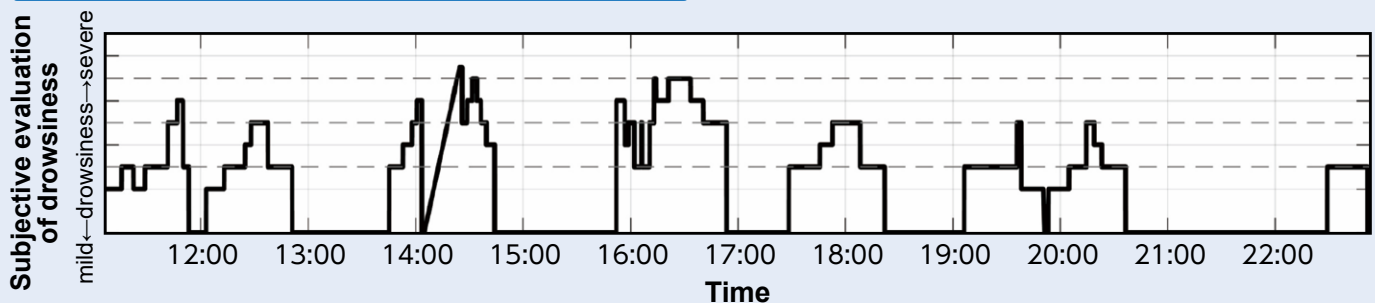
We are developing a system that monitors the physical and mental states of drivers and sounds an alarm in case drowsiness is detected to prevent errors and accidents owing to lowered attention, i.e., drowsiness. There are two major approaches for detecting drowsiness: photographing the driver's face and employing image-analysis technology to detect drowsiness, and physiologically measuring drowsiness using wearable sensors. The Railway

Examples of systems for monitoring changes in the physical and mental states of drivers

Driver drowsiness levels detected by the proposed system



Drivers' self-evaluation of their drowsiness



Examples of driver drowsiness levels detected by the proposed system (above) and those obtained by the drivers' self-evaluations (below)

Technical Research Institute (RTRI) is parallelly researching and developing both approaches to satisfy the various requirements of railway operators. The following paragraphs elucidate the approaches for conducting physiological measurements of drowsiness.

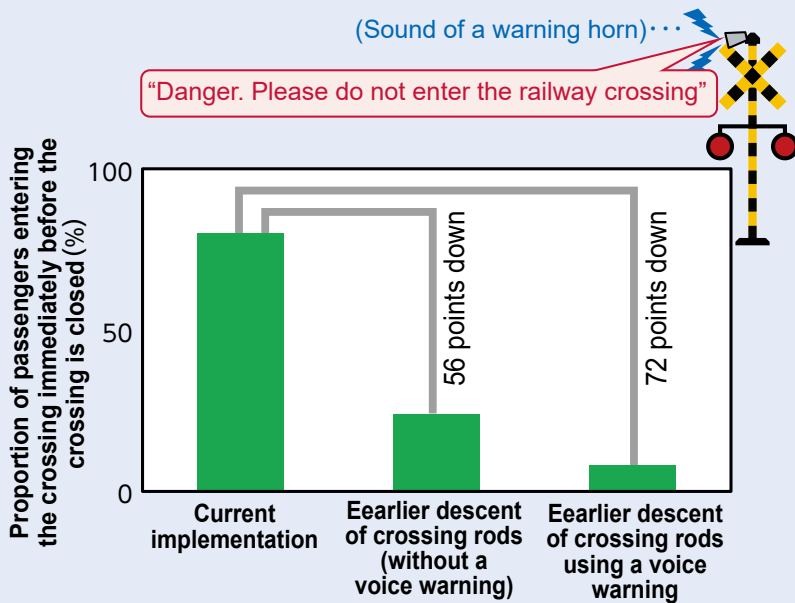
We are studying heartbeat-based (i.e., pulse wave-based) and respiration-based techniques from a practical standpoint, given the simplicity of their measurements for monitoring a wide range of physical and mental states, from low to high arousal¹⁾. The actual deployment of these systems involves accurate and real-time

measurements using wearable sensors that do not cause discomfort to drivers.

We built a prototype measurement system using commercially available wearable sensors (*Examples of systems for monitoring changes in the physical and mental states of drivers*) that is currently being tested on drivers during operation. *Examples of driver drowsiness levels detected by the proposed system (above) and those obtained by the drivers' self-evaluations (below)* shows an example of the drowsiness levels of drivers detected by this system and the results of the drivers' self evaluations²⁾. The onset and dura-

tion of drowsiness detected by this system, as shown in *Examples of driver drowsiness levels detected by the proposed system (above)*, substantially matches those felt by the drivers, as shown in *Those obtained by the drivers' self-evaluations (below)*.

Through close cooperation with the Data Analytics Laboratory, a subdivision of the Information and Communication Technology Division, we plan to not only acquire more data and provide more accurate monitoring but also develop systems that are easy to use by the drivers and their supervisors.



Preventing pedestrians from entering the railway crossing immediately before it is closed by earlier descent of crossing rods and sounding a voice warning



Steam-weeding technique

Enhancement of Level-crossing Safety³⁾

The number of level-crossing accidents involving automobiles has recently declined, whereas those involving pedestrians remain unchanged⁴⁾. According to one study, approximately three-quarters of level-crossing accidents involving pedestrians are caused by pedestrians entering the crossing while the warning is sounding (immediately before the crossing is closed)⁵⁾. We are currently working on preventing such occurrences.

A survey of pedestrians using level crossings showed that approximately 60% of those who experienced fallen barrier traps by entering the crossing while the warning was sounding had misunderstood the meaning of the warning to be “Caution” instead of its intended meaning of “No entry⁶⁾.” To prevent this, we propose sounding a voice message stating “No entry” during an active warning, as well as blocking entry to the railway crossing earlier (hereinafter referred to as earlier descent of crossing rods). We employed multiple types of messages, including “Danger. Please do not enter the railway crossing.” The crossing rods on the entry side descend quickly when the descent starts before slowing down, ensuring that the barrier descent completes within the same time as that in the current setup.

We also conducted an experiment by simulating a level crossing to verify the effect of blocking access to the railway crossings earlier. The participants were shown an image of an alarm sounding when approaching the railway crossing and selected whether to stop or enter the railway crossing. The results, presented in *Preventing pedestrians from entering the railway crossing immediately before it is closed by earlier*

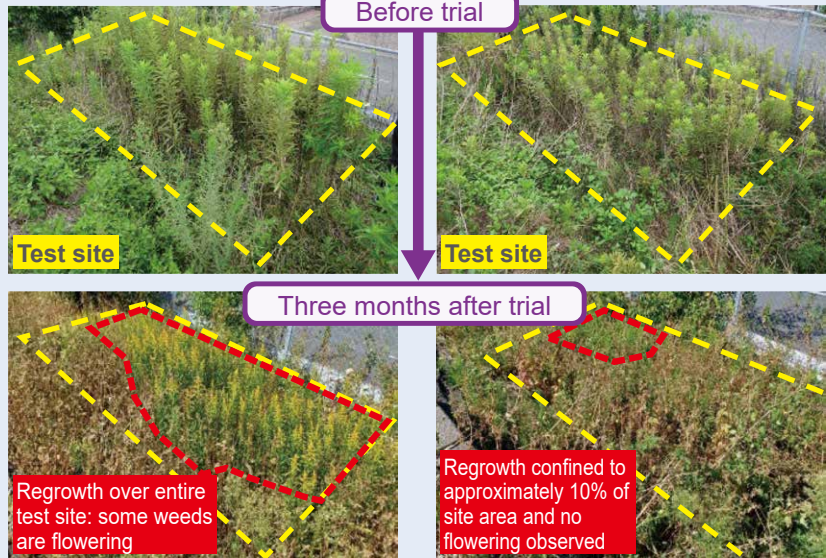
Tests conducted at a site covered with thick growth of large weeds



Solidago altissima
Removing large weeds commonly found along railway lines

Slashing using a bush cutter

Steam weeding



Comparison between steam weeding and slashing using a bush cutter

descent of crossing rods and sounding a voice warning, earlier descent of crossing rods, or a combination of both resulted significantly reduced the proportion of passengers entering the crossing when the warning was sounding compared to the current implementation. Based on these results, we conducted verification experiments using actual systems.

Low-cost and Efficient Weeding in Railways⁷⁾

Weeding in along railway lines requires considerable workforce and time, demanding higher work efficiency. The Human

Science Division has developed a steam-weeding technique with weed-controlling effects and usability based on our accumulated knowledge of weed control in conjunction with the Track Technology Division.

Herbicides can be used to efficiently control weeds growing outside the tracks within the railway-property boundaries. However, to avoid impacting the residential and agricultural areas along the line, it is necessary to limit the locations where they are used. For this, bush cutters, which can rapidly remove weeds, are widely employed. However, during the summer, weeds grow back quickly. Moreover, workers must use bush cutters for relatively

short periods to avoid adverse health impacts such as injuries from rebounding rotary blades and vibration-induced upper-limb disorders. Furthermore, because signaling and communication cables are installed along the railway lines, employing extreme caution is crucial to avoid cutting these cables.

Therefore, we focused on a method used in agricultural fields: steam spraying to denature proteins and wither weeds. Conventional steam-weeding methods require large boilers and considerable quantities of water. Because obtaining large amounts of water in railway areas is challenging, we developed a handheld nozzle array composed of steam-spraying tubes and a cover,

which uses less than one-tenth of water than conventional steam-weeding systems while providing sufficient heat to wither weeds. We confirmed that excellent steam diffusion can be obtained by improving the shape of the steam-diffusion pathways inside the cover and weeds caught within its frame can be withered through a 5-s spray by improving the shape of the ejection opening. In addition to this, a general-purpose steam cleaner and small generator are required for generating the steam (*Steam-weeding technique*).

Trials conducted at a test site covered with a thick growth of large weeds demonstrated that compared to slashing by the

bush cutter, less than 10% of the weeds regrew after three months, and less than 70% regrew after one year using this method (*Comparison between steam weeding and slashing using a bush cutter*). Additionally, it is approximately 30% faster than slashing using bush cutters and reduces the required work force by 60%.

This system is already available on the market and we are also developing more effective weeding techniques to remove weeds growing on the tracks.

Conclusions

This report introduces the Human Sci-

ence Division and the latest R&D efforts for addressing the challenges faced in railways, including driver-support systems, level-crossing safety enhancements, and efficient weeding methods. For more information on our other achievements and ongoing research, please refer to the RTRI website (<https://www.rtri.or.jp/rd/division/rd52/>).

The Human Science Division is committed to continuing R&D to develop innovative systems that focus on human behavior, specifically those of railway employees and users, by employing rapidly advancing digital technologies.

References

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