Track inspection and maintenance process in Japan

Dr. Hirofumi TANAKA

Senior Researcher, Track Geometry & Maintenance Laboratory,
Track Technology Division,
Railway Technical Research Institute
Tokyo, JAPAN

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1. Outline of track inspection set forth in "The Maintenance Standards for Railway Structures (Track Part)"
2. Outline of track maintenance process based on Inspection of track irregularity
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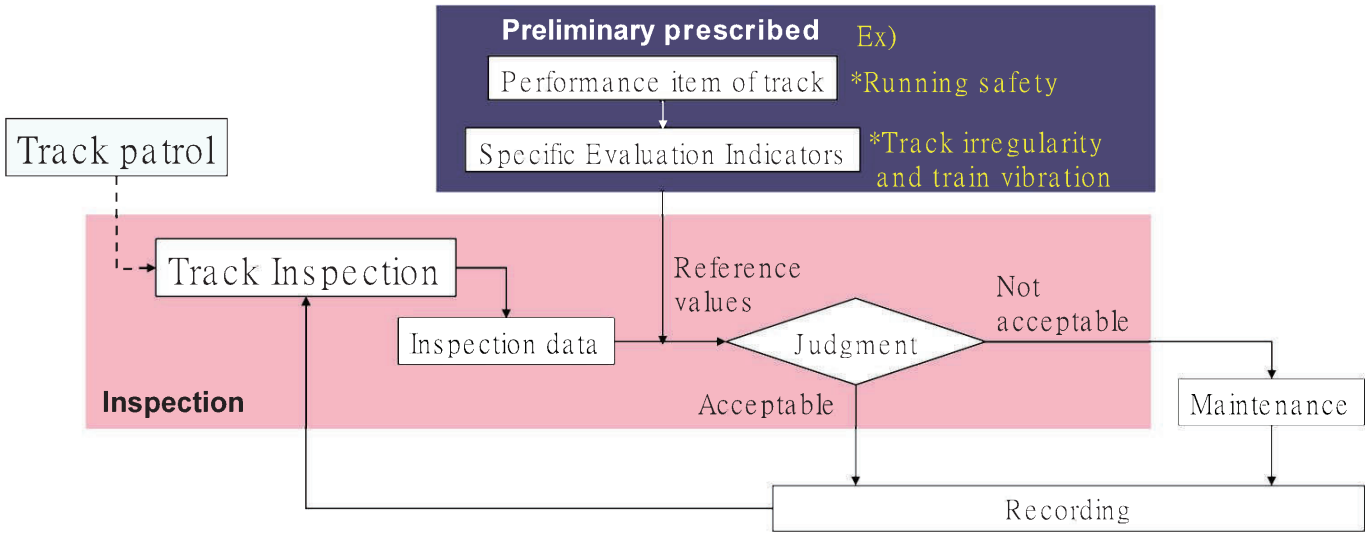
4. Recent efforts

1. Outline of track inspection set forth in "The Maintenance Standards for Railway Structures (Track Part)"

The track maintenance process defined in "The Maintenance Standards for Railway Structures (Track Part)" in JAPAN



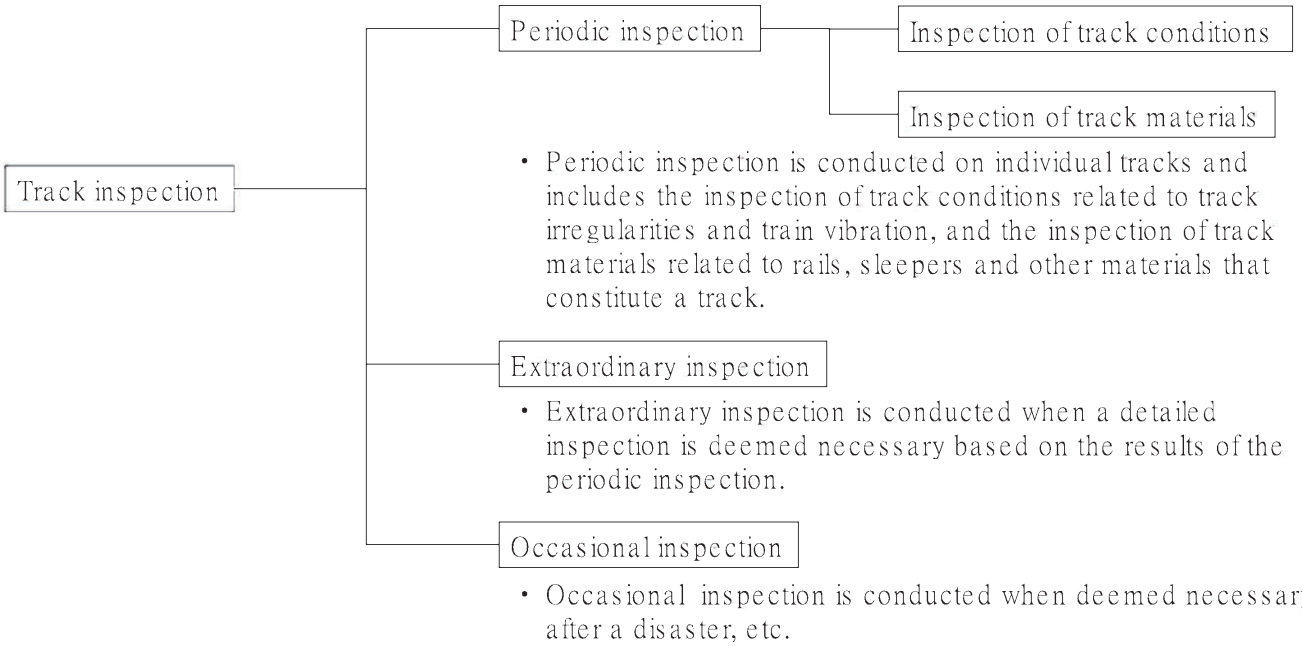
- In Japan, there are more than 200 railway operators, and the conditions of railway lines and train operations vary widely, so the Company standard is determined individually by each railway operator in accordance with their actual conditions.

Outline of Track Patrol Guidelines set forth in "The Maintenance Standards for Railway Structures (Track Part)" in JAPAN

- Track patrol shall be carried out in accordance with the conditions of the line sections and train operations, to ascertain the general condition of the tracks.
- Track patrol is carried out by walking, or by trains, or by motor cars, etc.
- The frequency of track patrols shall be determined according to the importance of the line section and the method of patrol.
- If deemed necessary as a result of track patrol, inspections or measures shall be carried out.

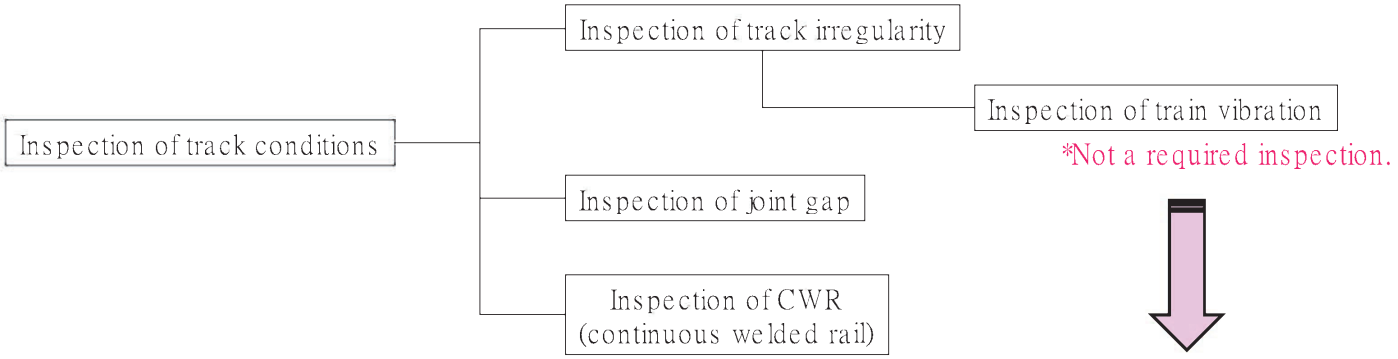
- Specific examples of check items specified in the Commentary of the Maintenance Standards
  - In case of walking patrol
    - Maintenance condition
    - Material condition
  - In case of train patrol
    - Abnormal train vibration
    - Squeaking noise
    - Obstacles to train operations
    - Any other abnormalities

Outline of Track inspection Guideline set forth in "The Maintenance Standards for Railway Structures (Track Part)" in JAPAN



Inspection items of track conditions defined in the Maintenance Standards

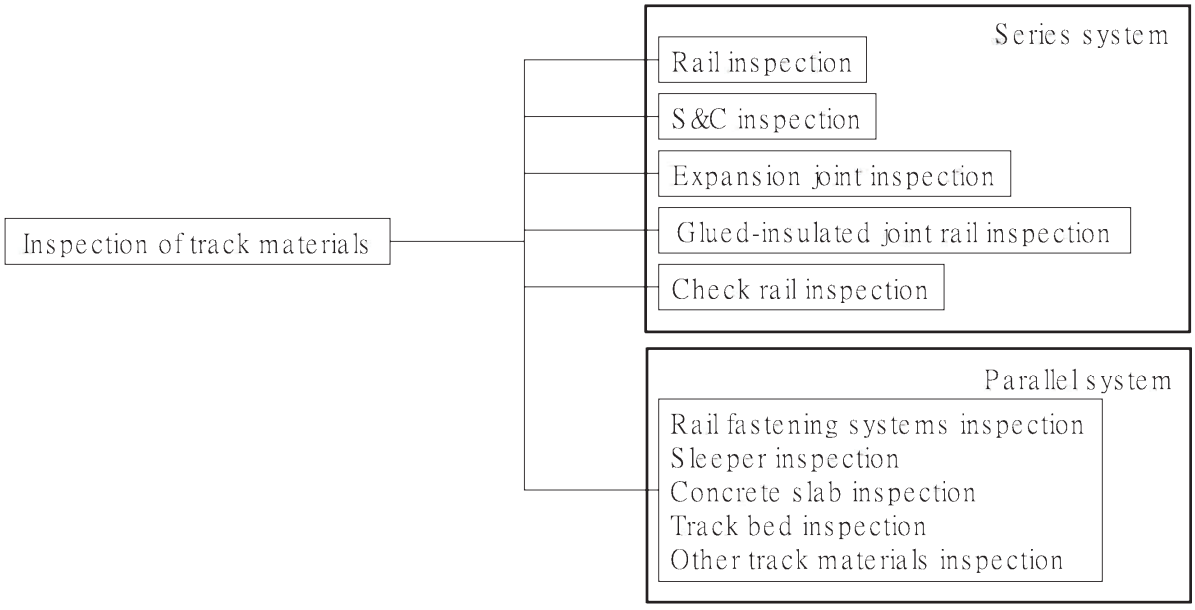
- The inspection of track conditions is intended to ensure the required performance of a track by measuring the track irregularity and train vibration.
- The inspection of train vibration is defined as a complement to the inspection of track irregularity.



- For this reason, some railway operators do not conduct the inspection of train vibration.
- Small regional railway operators often skip this inspection for their low-speed lines.

Inspection items of track materials defined in the Maintenance Standards

- The inspection of track materials is intended to ensure the required performance of a track by checking the strength and function of materials.



Inspection cycle of track

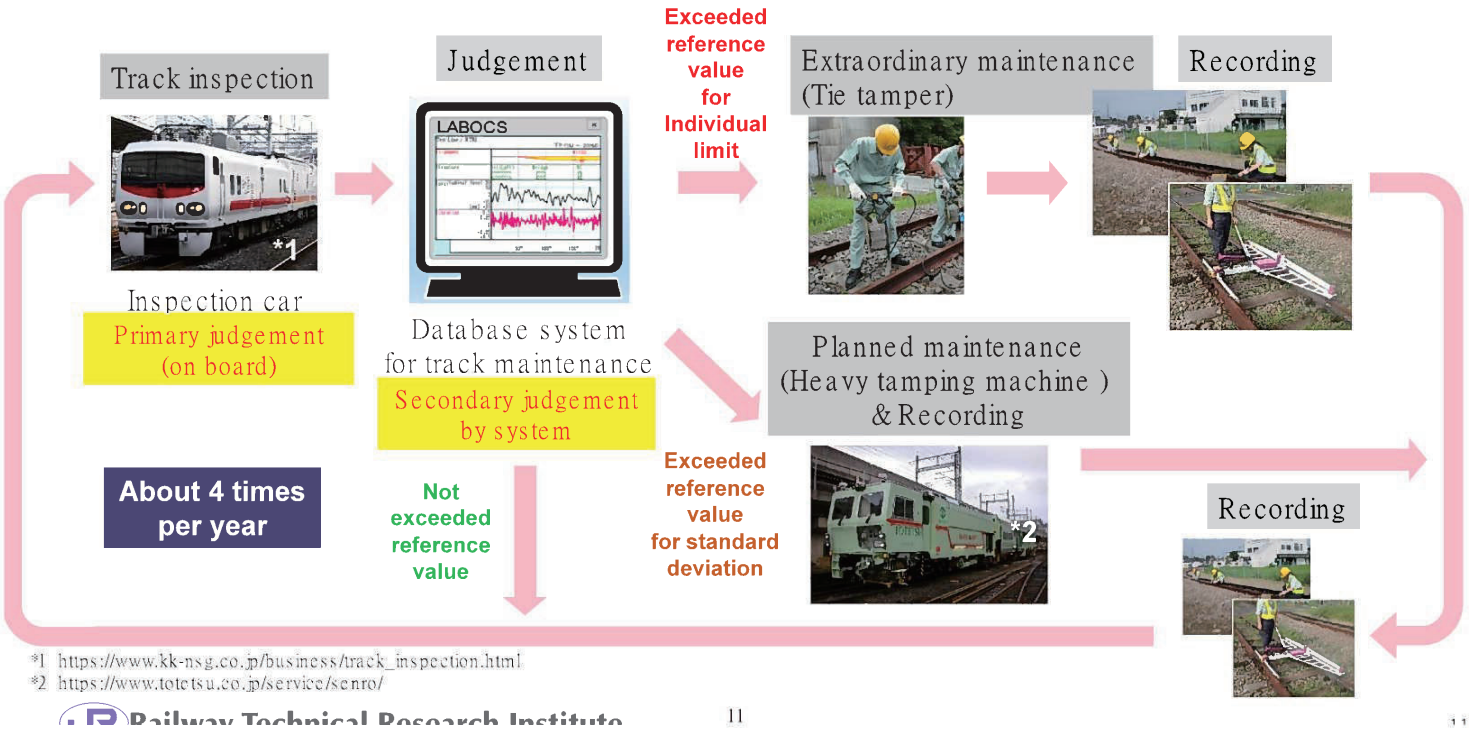
Type of Railway	Shinkansen		Railway other than Shinkansen
Facility type	Track irregularity	Track (Other than Track irregularity)	Track
Base Period	2 months	1 year	1 year

Examples of inspection cycle and methods of inspection of track irregularity

	Shinkansen	Conventional railway (JR)	Conventional railway (other than JR)	Conventional railway (other than JR, local railway)
Implementation standard	60 days	1 year	1 year	1 year
Company regulation	10 days	2 to 4 times/year	1 year	1 year
Inspection method	Track inspection car	Track inspection car	Track inspection car	Track inspection trolley (LWT)

2. Outline of track maintenance process based on Inspection of track irregularity

The track maintenance process in conventional lines



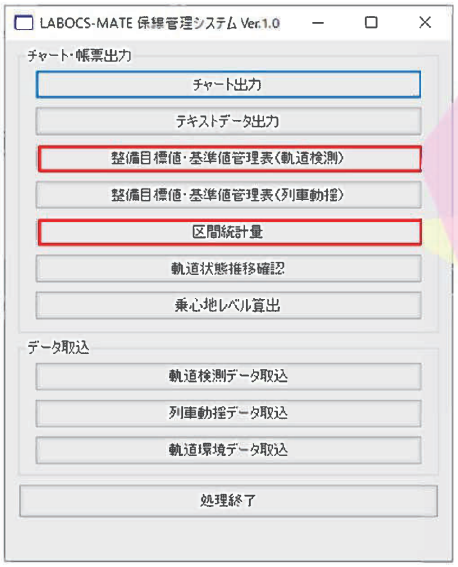
*1 https://www.kk-nsg.co.jp/business/track_inspection.html
*2 https://www.totetsu.co.jp/service/senro/

Outline of LABOCS, Database system for railway track maintenance

- LABOCS can handle various time-series data for data processing and analysis
- LABOCS was developed by RTRI, and dedicated in processing track inspection data

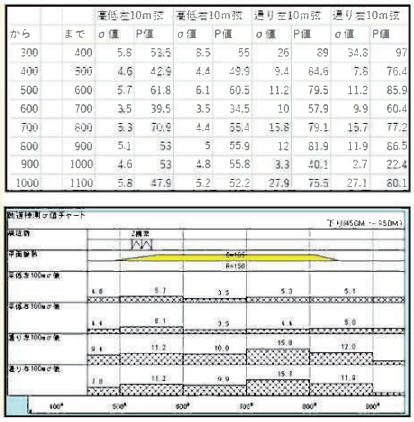
Outline of track management system based on LABOCS

- LABOCS-MATE, packaged system required for inspection of track condition



Main windows

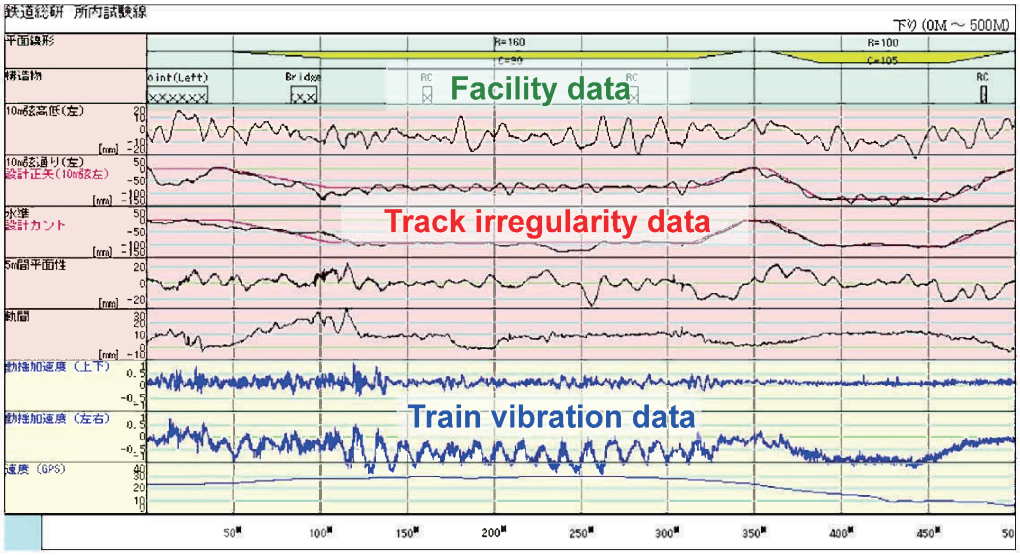
Exceeded list of target and limit value



Interval statistics (Standard deviation)

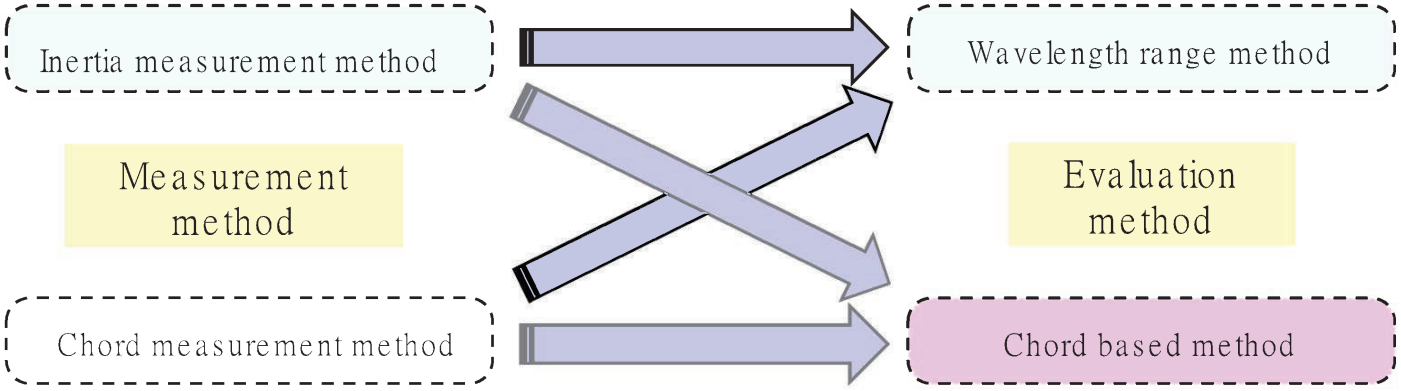
Correlation analysis between track irregularity and train vibration using LABOCS

- Simultaneous chart plotting of track irregularity data (distance axis data) and train vibration data (time axis data)
- Simultaneous chart plotting with facility data for visual understanding



3. Measurement method and evaluation method of track irregularity

Measurement method and evaluation method of longitudinal level and alignment



- Either inspection method can be converted to waveforms both evaluation methods.
- In Japan, the evaluation method uses the 10 m chord based method.
- The chord based method is not specified in the EN standard (EN 13848-1), but in the ISO standard (ISO 23054-1).
- Technical report of the chord based method (ISO TR 8955) is currently under development.

Loaded and unloaded inspection of track irregularity

- Loaded inspection; track inspection by track inspection train with train load on

https://www.kk-nagoo.jp/business/track_inspection.html

- Unloaded inspection; track inspection by light-weight trolley or manual without train load on track

- The reference values for unloaded inspection are set lower than those for loaded inspection because train load is not applied.
- Loaded inspection is better suited for more accurate track conditions.

Example of reference value (ex. JNR)

- Each JR company sets its own reference values based on these values.

（昭和 47 年 4 月制定　日本国有鉄道軌道整備基準規程）

種別	乙修繕整備基準値				丙修繕整備基準値				仕上り基準値	
線別 / 変位種別	甲線	乙線	丙線	丙線中簡易線	甲線	乙線	丙線	丙線中簡易線	各線別とも共通 一般区間	各線別とも共通 コンクリート道床区間
軌間	＋10 (＋6) － 5 (－4)				R＞600　20（14） 600≧R＞200　25（19） 200≧R　20（14）				(＋1) (－3)	(0) (－3)
水準	11 (7)	12 (8)	13 (9)	16 (11)					(4)	(2)
高低	13 (7)	14 (8)	16 (9)	19 (11)	23 (15)	25 (17)	27 (19)	30 (22)	(4)	(2)
通り	13 (7)	14 (8)	16 (9)	19 (11)	23 (15)	25 (17)	27 (19)	30 (22)	(4)	(2)
平面性					23 (18) (カントの逓減量を含む)				(4) (カントの逓減量を含まない)	

- Values outside brackets are loaded values. Values inside brackets are unloaded values.
- Values of longitudinal level and alignment are for value of 10 m chord.
- Values of twist are between 5 m.

- "乙" values are equivalent to the current "maintenance target value", for planned track maintenance.
- "丙" values are equivalent to the current "maintenance limit value", for extraordinary track maintenance.
- "Safety limit values" are also set to prevent derailment. If these values are exceeded, the train operation is stopped.

表 3.4.1　軌道変位限度値

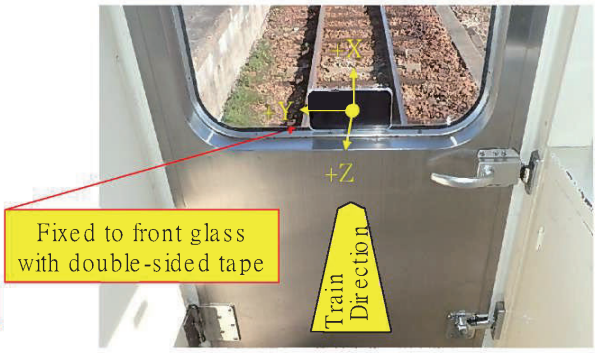
種類	限度値
高低	±40 mm
通り	±36 mm
平面性	±27 mm
軌間	＋43 mm　－13 mm

4. Recent effort
Train patrol support method using smartphones

Our developed smartphone application for supporting train patrols

- "Train Patroller" was developed based on the road application in order to acquire data suitable for railway and for simpler operability.
- This application is not yet available to the public.

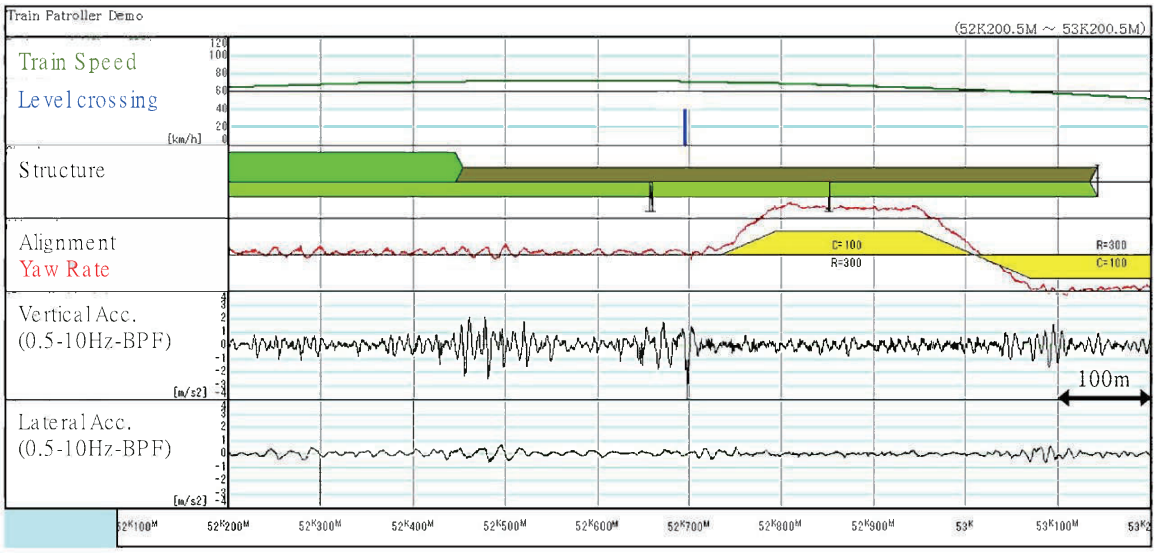
- Run on the Apple iPhone series.
- Can be acquired 3-axis acceleration and angular velocity, sound, video, GPS information, .
- Can be captured video with 4K resolution and 60 fps at the maximum settings.



- Example of smartphone installed on commercial train.
- Basically, installed on the front glass in the driver's cabin.

Measurement example at a regional railway –train vibration

- Measured data is processed by using LABOCS,
- Kilometrage has been precisely added in the waveform data.



Measurement example at a regional railway –front-view video

- Front-view video with subtitle information, such as kilometrage, acceleration and train speed.
- 4K resolution video are clear enough to confirm the track condition.

Track inspection and maintenance process in Japan

Thank you for your attention!

"Human factors leading to railway accidents"

Comfort Science and Engineering Laboratory
Human Sciences Division
Railway Technical Research Institute

Takashi Kyotani

Recommendation to focus on human factors

Unraveling the history of railway accidents ...

Regardless of the technical areas,
Many accidents are caused by **human error.**

("Oversight of confirmation items", "Violation of regulations", "Lack of communication", etc.)

Common responses are ...

- There is a tendency to think that the cause of accidents is the carelessness and lack of responsibility of the members involved in the accident.
- Measures to prevent recurrence tend to end with just approach to members involved in the accident.

The concept of "human error" is misunderstood!

Why do we need to understand human factors?

What is "human factor"? ⇒ "Various background factors"

<examples of human factor>

- Human behavioral characteristics
- On-site environmental conditions and management conditions
- Workplace culture

1. By understanding **human factor**, it can help to investigate the **"essential cause of accidents"** that is the background factor of **human error**.
2. From **a human science point of view**, You can learn hints for recurrence prevention measures.

Relationship between "accidents and incidents", "human error", and "human factor"

Human error is also nothing more than a consequential event brought about by the circumstances and causes that induce it.

Human error such as mishandling is the cause of accidents and incidents.

Human factor
Cause

→

Human error
Consequent

→

Accidents and Incidents
Result

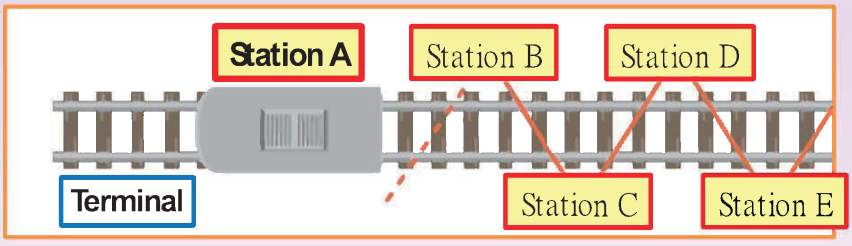
Reduction of causes (Countermeasures)

In order to reduce "human error",
It is necessary to understand the "human factor".

Case study of accident created to consider human factor (fiction)

The driver opened the door on the opposite side of the platform and the passenger fell!

Direction of travel of the train



<Situation of the line>

- One-man operation all day
- The positions of the platforms are staggered, alternating left and right, with some exception.
- **Only Station A**, which is the station before the terminal station, have a platform **on the same side as the previous station (Station B)**, which is an irregular layout.

<Situation of the train>

- About 20 students were on the train as passengers.
- **Most of trains do not have many passengers getting off at intermediate stations before terminal**, and most of passengers get off at the terminal, the nearest station of the school.

The condition and actions of the people involved before this accident occurred

When the concerned driver approached Station A, **he should have checked the station name and platform position by looking at the route slip and "Point and Call checks"**, but **he only called out "Station A, left!"**

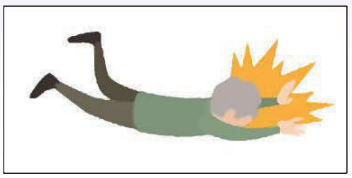
The driver operated the brakes according to the stop sign on the left side of the track.

It was **the driver's procedure to check the platform position after stopping**, but, **after stopping** at the stop sign, the concerned driver immediately pressed the **door open switch on the left side** with that flow.

Immediately after that, he noticed a person approaching from the platform end on the right side of the front, and **he realized that the platform was on the right**.

The concerned driver immediately closed the door, but **the door of the train opened about 80~90cm**.

One of the passengers, who was leaning against the door, lost his balance in a panic when he realized that the door had opened, and fell in the train.



Human errors that occurred in this accident

(Usually‥)

1. **The driver did not confirm the platform position on the route slip.**

(Carelessly‥)

2. **The driver did not check the platform before operating the door switch.**

Human error and the human factors behind it

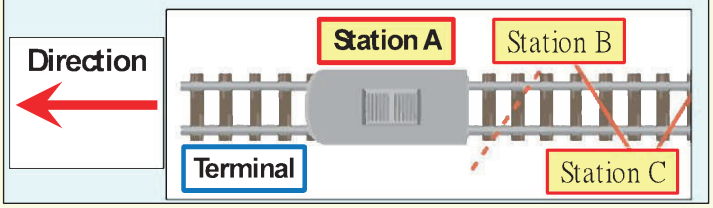
(Example) The driver did not confirm the platform position on the route slip.

[Background factors (Human factors)]

<Situation of the stations **(partial excerpt)**>

・When checking the route slip, the concerned driver sometimes **perform the Point and Call checks, which is a basic movement,** and he sometimes do not on a routine basis.

・The concerned driver **lacks the awareness to work reliably** on a routine basis.



<Management factors **(partial excerpt)**>

・The concerned driver has **40 years of driving experience**, but he had just been transferred to the line in question **only two months before.**

・After the transfer, the concerned driver did not receive any further guidance on **why it was necessary to perform the Point and Call checks** when confirming the route slip at the time of on-board training.

Summary

Human factor: Various background factors such as:

- Human behavioral characteristics
- On-site environmental conditions and management conditions
- Workplace culture

- By understanding **human factor**, it can help to investigate the **"essential cause of accidents"** that is the background factor of **human error**.
- From **a human science point of view**, you can learn hints for recurrence prevention measures.

Human factor "Cause" → **Human Error** "Event" → **Accidents or Incidents** "Result"

Thank you for your attention.

RTRI & TRA Seminar
2022.June.13

Safety Education Training

Takayuki Masuda
Safety Psychology
Human Science Division
Railway Technical Research Institute

Outline

1. Recent Topics on Human Science for Railways
2. The educational software for Point and Call Check -SimError-
   - What's Point and Call Check?
   - The effects of Point and Call Check
   - Experiments for validation of those effect
   - Summary of the software(SimError)

Human Science Division

The Human Science Research Department consists of three laboratories, "Safety Psychology," "Ergonomics," and "Comfort Science and Engineering," and is responsible for all research and development related to human factors that contribute to the improvement of railroad safety and comfort. It also provides technical guidance on driving aptitude testing and support for safety activities by utilizing the findings of human science.(https://www.rtri.or.jp/eng/rd/division/rd52/)

Laboratories

Safety Psychology

- Aptitude test for train driver operation staff
- Safety educations as prevention of accidents with human errors by employees
- User Safety

Comfort Science and Engineering

- Evaluation of air-conditioning environment
- Vibration and ride comfort in trains
- Barrier-free measures
- Sanitary environment including infection prevention, magnetic field environment evaluation
- Measures against deer impact accidents and plants

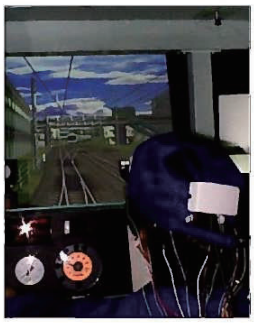
Ergonomics

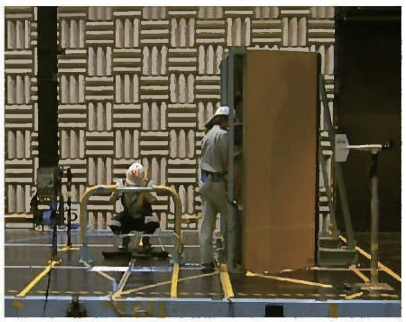
- Vehicle safety
- Equipment usability for passengers
- Work environment
- Education and training systems for employees

Human Science Division

Our Objective

- **Understanding of the people who use and operate railroads**
- **Conducting research and development aimed at improving the safety and comfort of railroad systems, based on a it.**



Major R&D topics

Human error and accident prevention

- Decision-making skills assessment methods
- Driving information record analysis
- Driver simulator training methods
- Prospective Calling method
- Crew Support System
- Risk Analysis Method
- Accident Interviewing Method
- Human Factors Analysis
- Point and Call

Workplace accidents and incidents

- On-track safety training methods
- Hazard perception training

Transportation disturbance

- Level crossing accident
- Train-deer collisions
- Guide Information Provision Method

Safety

Convenience

Comfort

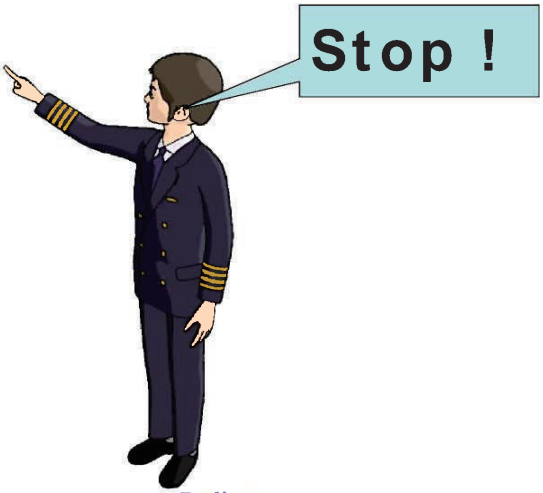
Environment for users

- Sanitary environment
- Barrier-free
- Improvement of vehicle safety
- Magnetic field environment
- Thermal environment

What's Point and Call Check?

What's Point and Call Check?

Point to target and call its state loudly



The situation of Point and Call check in railway

Train Drivers

- -Traffic light
- -Time table
- -Clock
- -Air brake indicator
- -The speed meter

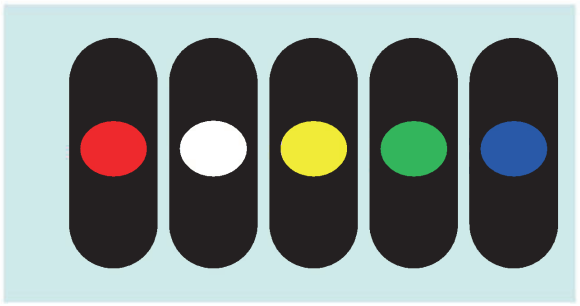
etc.

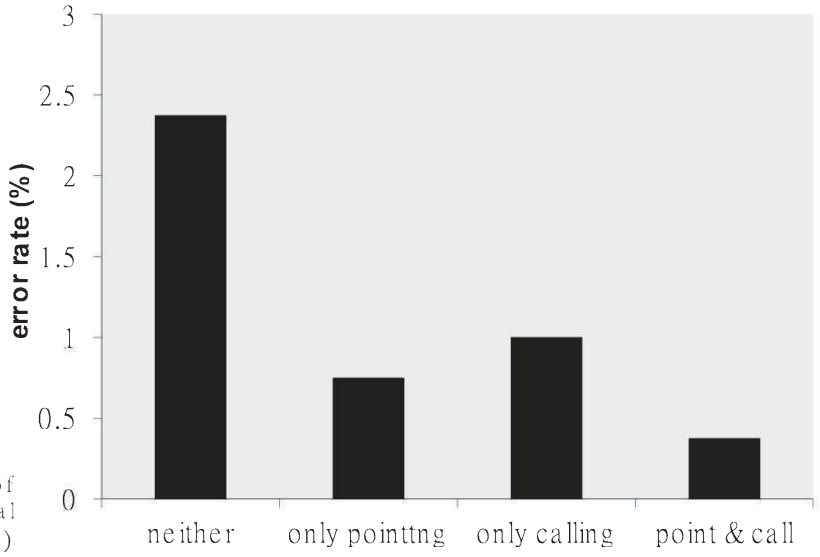
Why do they check in this way?

- For safety
  - -To prevent
    - Human error
    - check error
  - -To protect
    - passengers
    - themselves

The effect of Point and Call check

Participants were required to press buttons ,according to color in the monitor.





Shigeru Haga et al., Japanese Association of Industrial Organizational Psychology Journal 1996, Vol.9 , No.2, 107-114. (in Japanese)

Why don't they check in this way?

Point and Call Check is trouble some

- Require to movie one's arm and hand
- Require to take more time
- Require to speak loudly

Hard to feel the effect of pointing and calling

- Works are very easy and familiar to them

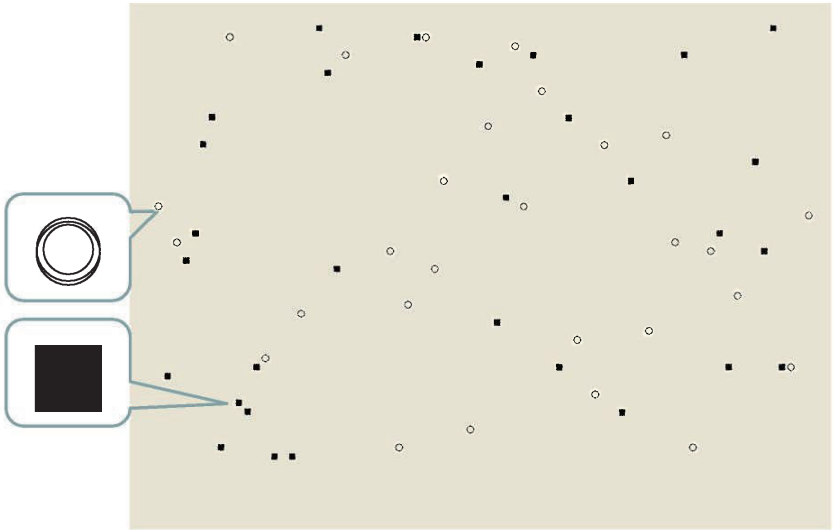
The effects of Point and Call Check

Five effects

Factor of Point and Call Check	Effects of preventing error
Pointing	Fix eyes on the check object accurately
	Impulsivity suppression
Calling	Memory enhancement
	Error detection
Pointing and Calling	Keeping up of arousal level

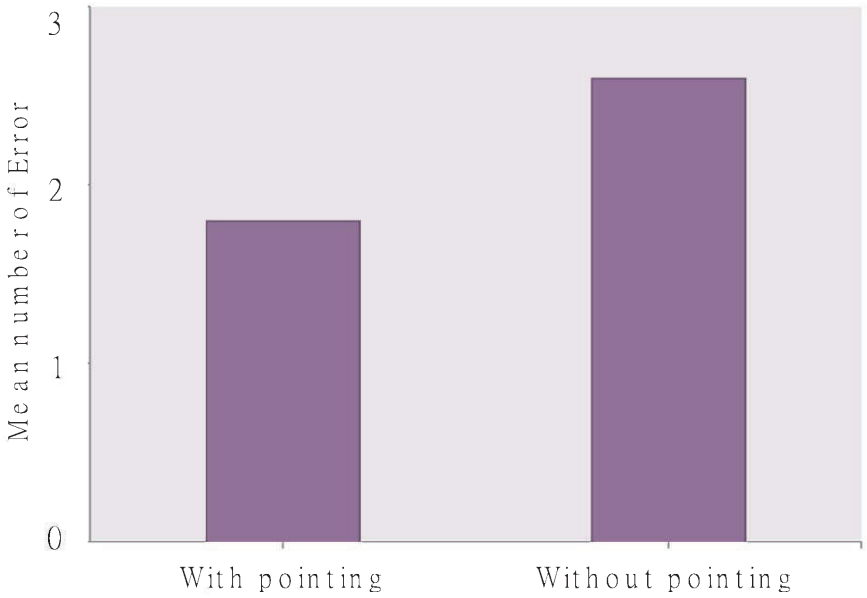
Experiments for validation of those effects

Experimet (eye-fixation effect)



- To count the white dot (○)
- To ignore black squire (■)
- Two conditions (pointing and not)
- Participants performed five trials under each condition (pointing or not)

Ex.1 Result



The mean number of Error was lower with pointing than that without pointing

Masuda et al. RTRI REPORT, Vol28, pp.5 -10, 2014 (in Japanese)

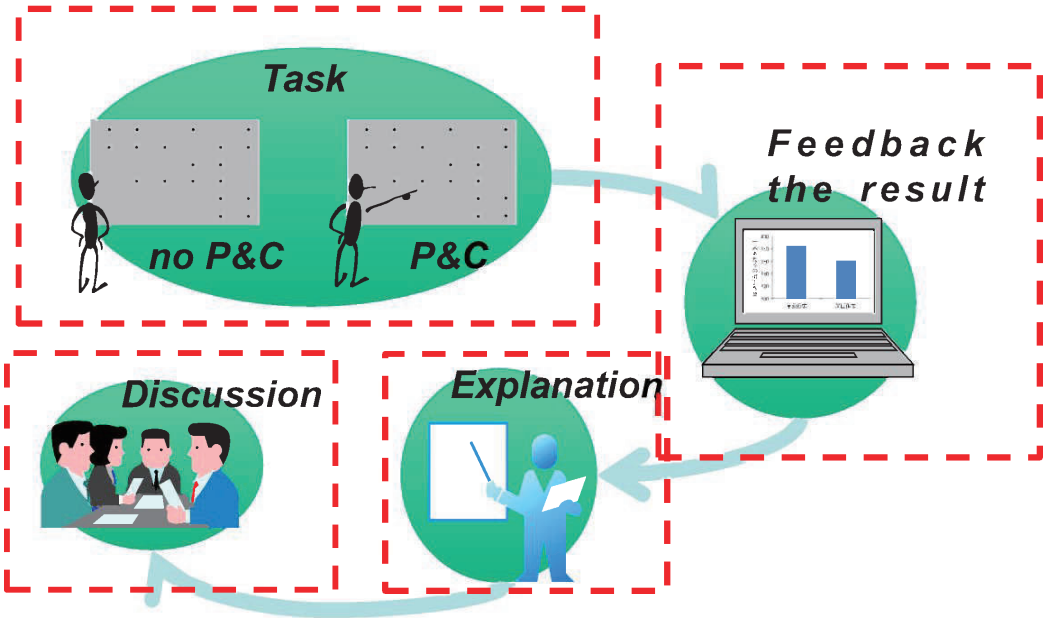
Software to Experience the Effects of Pointing and Calling
SimError for Pointing and Calling

Summary of the software (SimError)

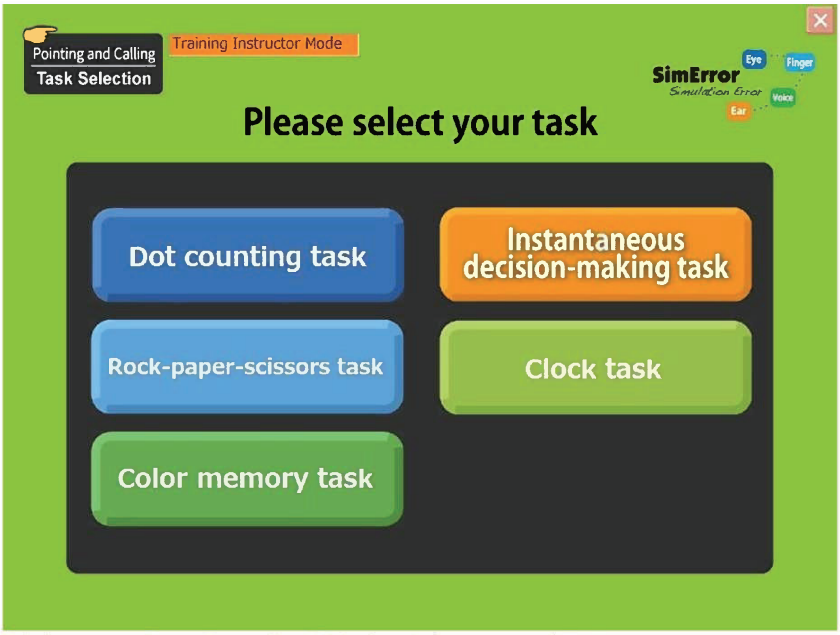
Purpose of SimError

- Let them feel the effect of Point and Call Checks
- Let them know the effects experientially

SimError Overview



Tasks in SimError



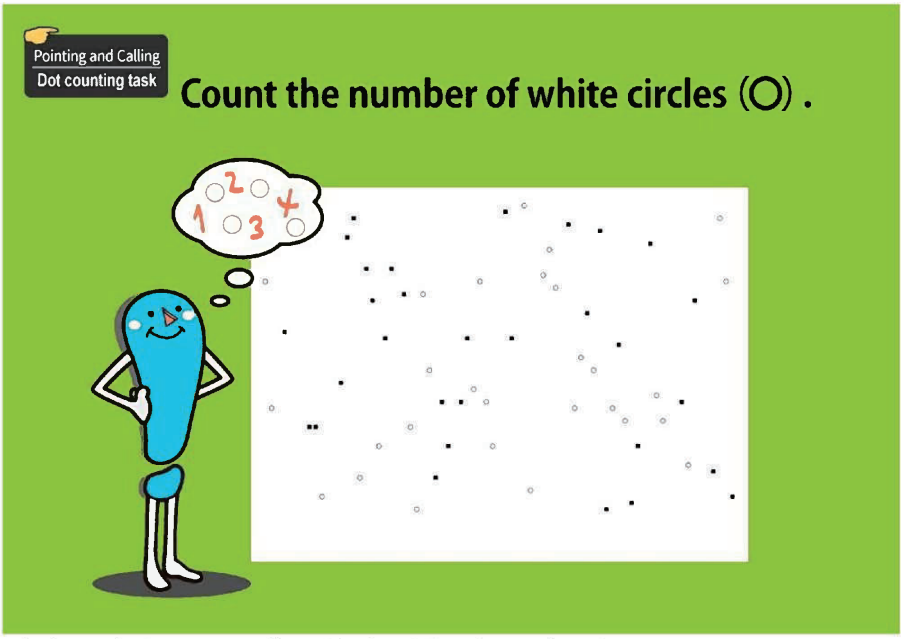
Software to Experience the Effects of Pointing and Calling
SimError for Pointing and Calling

Effects and Tasks

Elements of Point and Call Check	Effect	Tasks of SimError
Pointing	Fix eyes on the check object accurately	Dot-counting task
	Impulsivity suppression	Rock Paper Scissors task
Calling	Memory enhancement	Color memory task
	Error detection	Instance decision making task
Pointing and calling	Keeping up arousal level	Clock task

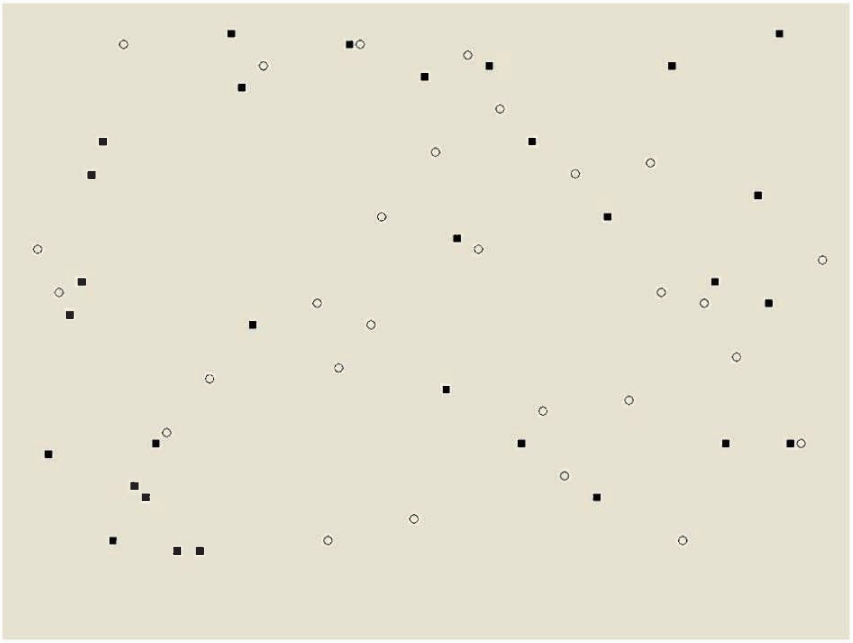
Masuda et al. RRR, Vol74, pp.8 -11, 2014 (in Japanese)

Tasks in SimError : Dot Counting



Software to Experience the Effects of Pointing and Calling
SimError for Pointing and Calling

Tasks in SimError



Software to Experience the Effects of Pointing and Calling
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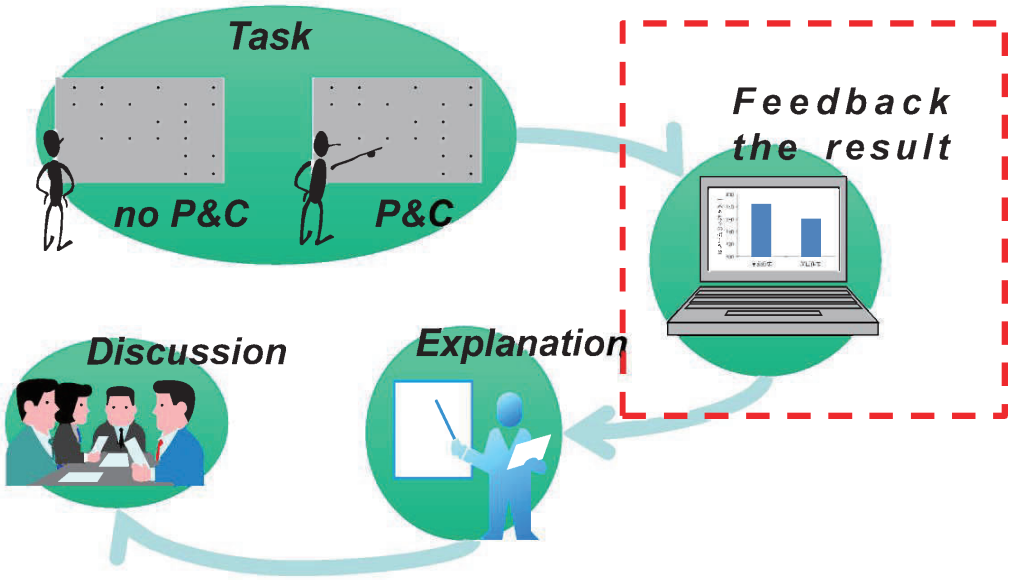
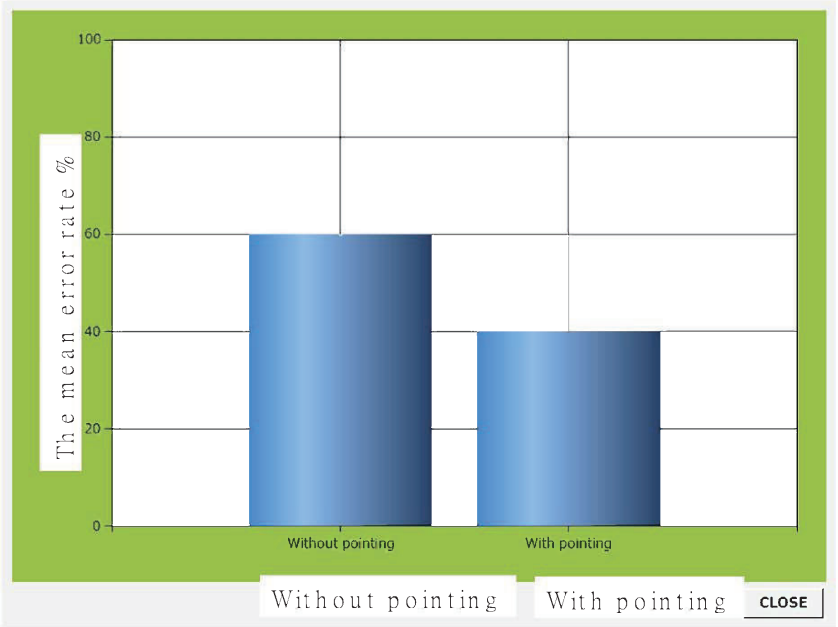
SimError Overview

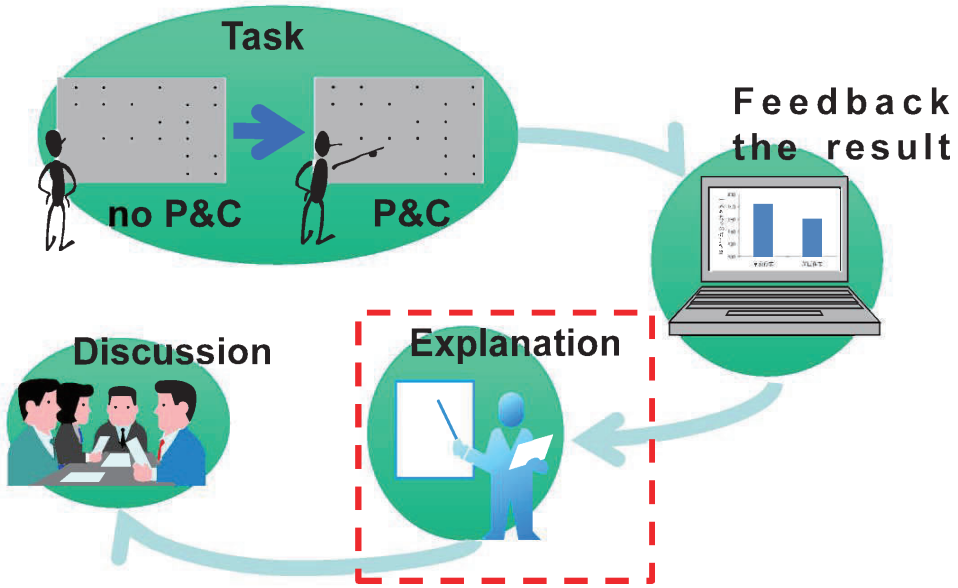


Feedback



Software to Experience the Effects of Pointing and Calling
SimError for Pointing and Calling

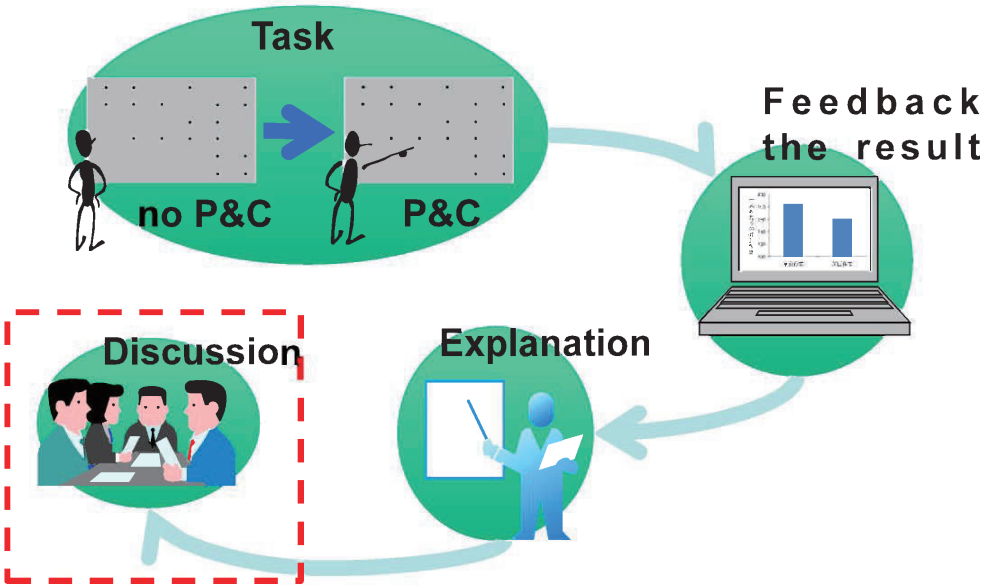
SimError Overview



Explanation

- The meaning of the tasks.
- The effects of Point and Call Checks.
- The relationship between the tasks and their ordinary work.
- The importance of Point and Call Check.

SimError Overview



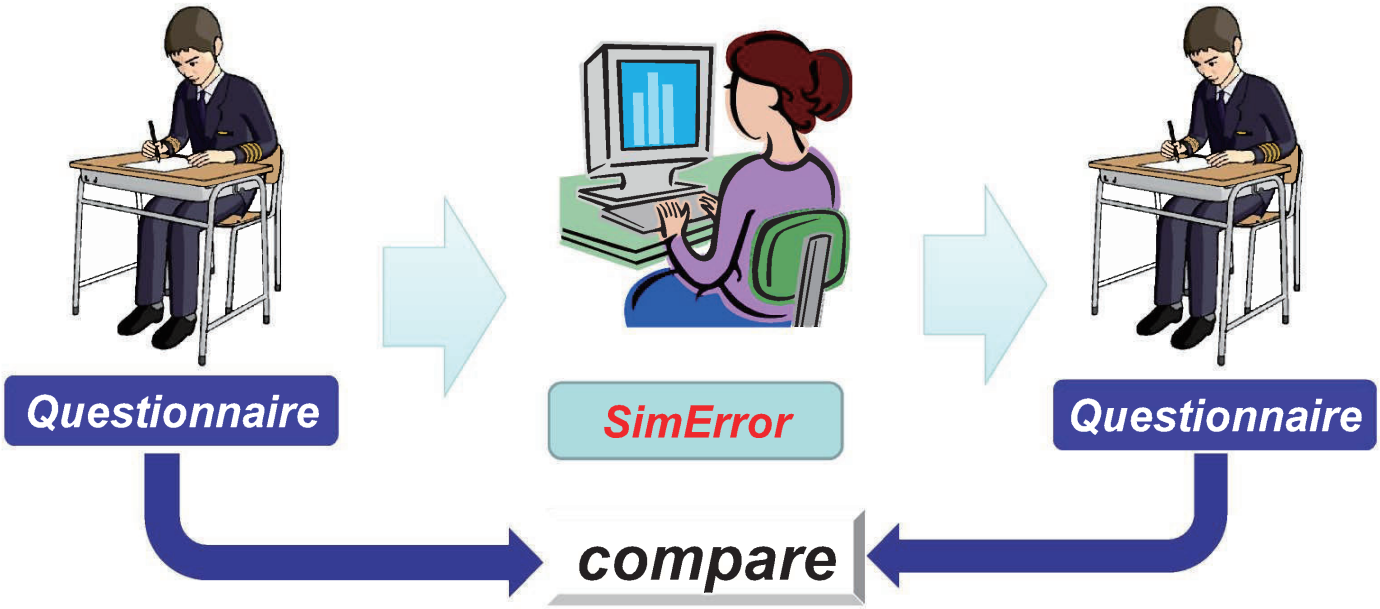
Discussion

Example

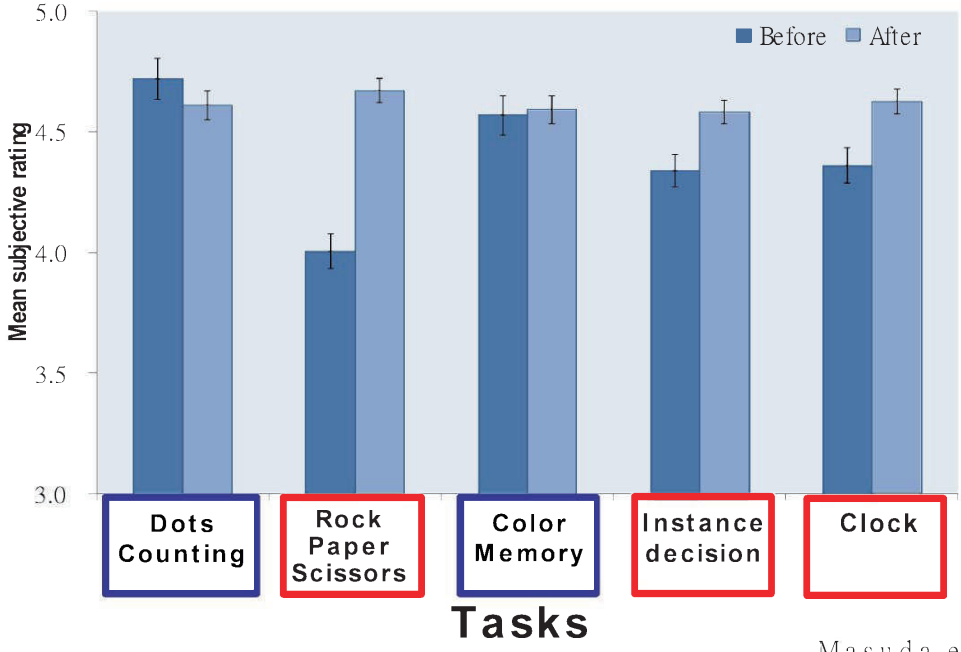
- They talk about making use of point and call check.
- They talk about past accidents or incidents.
- They share their ideas with the colleague.

They understand the importance of Point and Call Check

Verification the advantage of SimError

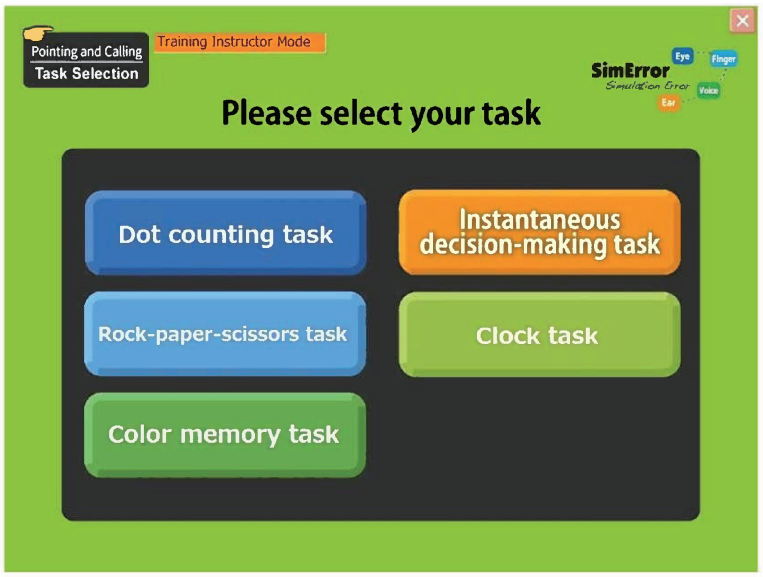


The advantage of SimError



Three tasks made participants feel the effect of point and call stronger.

Masuda et al. RRR, Vol74, pp. 8 -11, 2014



Software to Experience the Effects of Pointing and Calling
SimError for Pointing and Calling

Thanks for your attention

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Seminar

June 13th, 2023

Level crossing with safety measures

Signalling Systems Lab. Hiroyuki Fujita

Signalling and Operation Systems Technology Division
Railway Technical Research Institute

Contents

Introduction

History of level crossing in Japan

When the railway opened

- Block the railway side with gate
- When train passes, the gate is opened, and the road side is blocked

Ordinance of the Ministry of Railways in 1924

- When train passes, block the road side with gate
- Standardization of railway crossing alarms around 1930

Post-World War II

- Significant development of automobile traffic
- Level crossing accidents becoming a social problem

Introduction

History of level crossing in Japan

Road traffic act | Act No. 105 of 1960, Last version: Act No. 76 of 2015

Article 33(1) Before going over a railroad crossing, the driver of a vehicle or streetcar must stop immediately in front of the railroad crossing (or immediately in front of any stop line established by road signs or markings; the same applies hereinafter in this paragraph) and must not proceed until after checking that it is safe to do so; provided, however, that the vehicle or streetcar may proceed without stopping immediately before a railroad crossing when complying with a signal indicated by a traffic light.

Road traffic is obliged to stop in front of level crossing

By Japanese Law Translation https://www.japaneselawtranslation.go.jp/ja/laws/view/2962

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Introduction

June 13th, 2023

History of level crossing in Japan

Order to technical standards for railway | Order of MLIT No. 151 of 2012

Article 39 **Railways shall not intersect at same level with roads.**

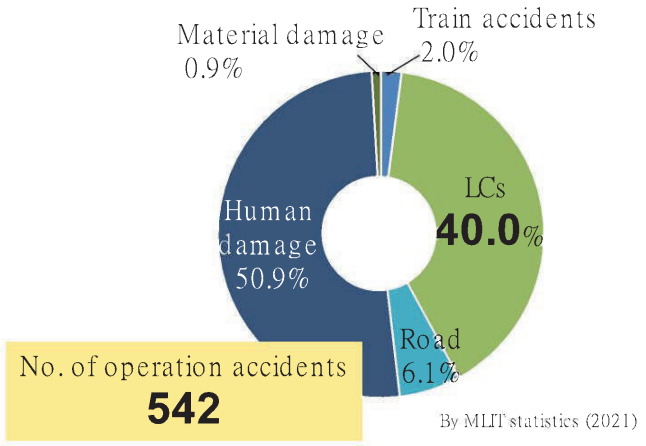
However, this does not apply to railways other than the Shinkansen or railways that operate at a speed equivalent to the Shinkansen, and where the traffic volume on the railway and the roads that intersect with it is low, or where it is unavoidable due to topographical reasons.

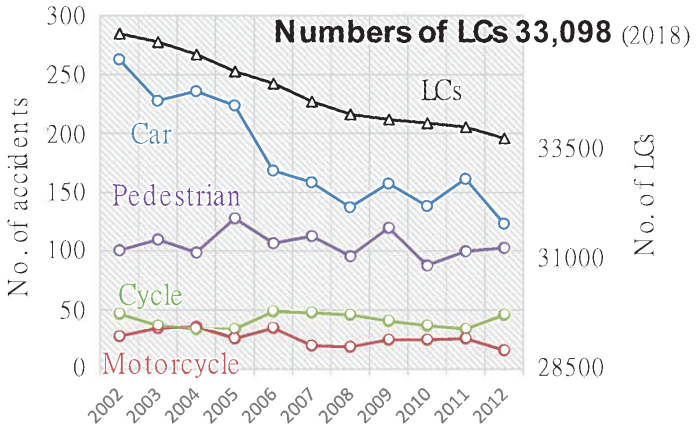
By e-gov (in Japanese) https://elaws.e-gov.go.jp/document?lawid=413M60000800151

Introduction

Accident of level crossing

Accidents of level crossing account for 40% of operation accidents of railway
Numbers of LCs accidents have been decreased, as the numbers of LCs decreases

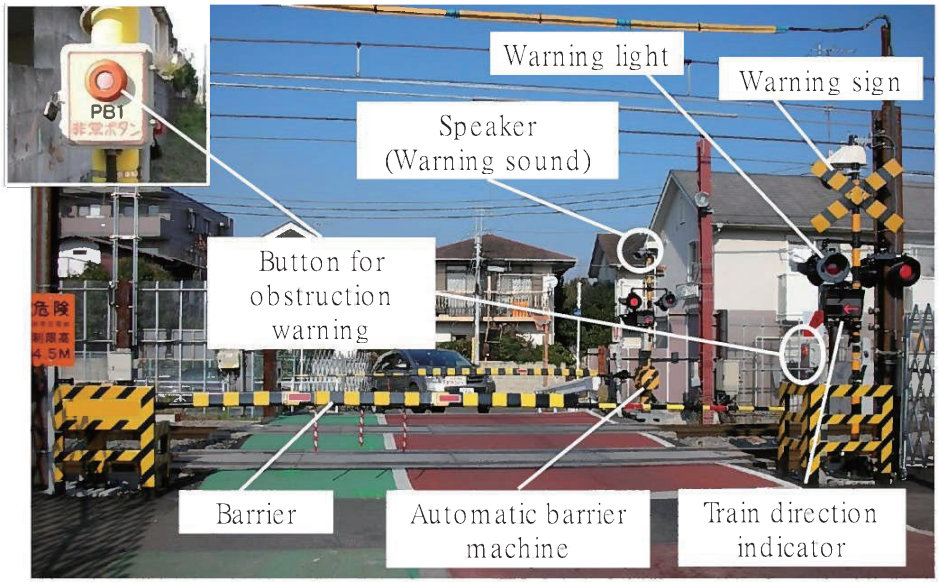




Improvement of LCs safety is important for railway safety

Overview of safety equipment

Level crossing equipment



Grades of level crossing

Grade	1st 90%	3rd 2%	4th 8%
Warning light	Y	Y	N
Automatic barrier machine	Y	N	N

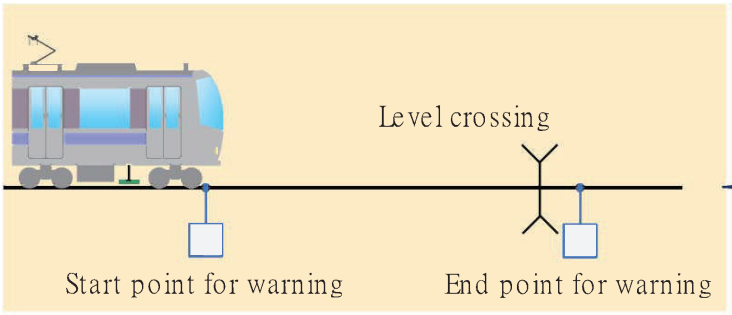
Class 2 level crossing which operator controls barrier at part time, abolished in 1960s at JNR

Overview of safety equipment

Train detector/ control of level crossing

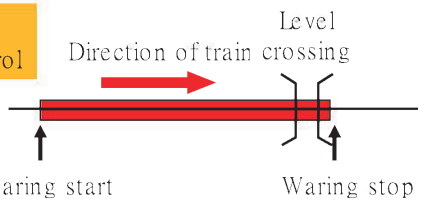
Position of train detector for LC is designed to allow sufficient time for warning and barrier

LC controller is also designed to continue warning if train detector failed

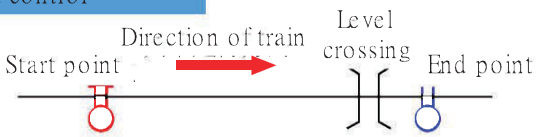


- Maximum speed of trains
- Length of level crossing
- Types of train (passing / stopping)

Track circuit
Continuous control



Electronic train detector
Intermittent control



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Overview of safety equipment

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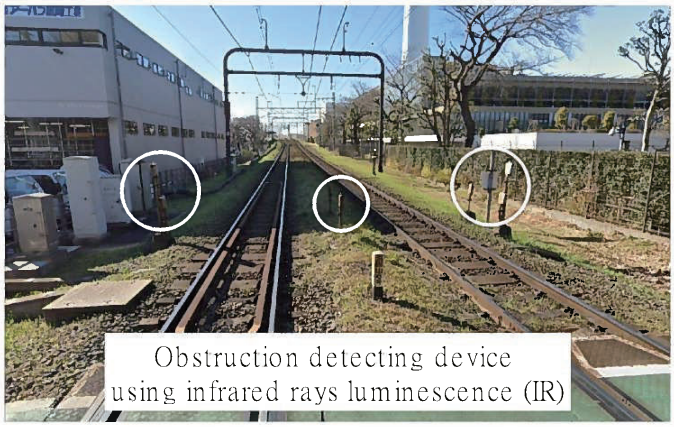
Train detector/ control of level crossing

Electronic train detector/ End point
Intermittent control

Overview of safety equipment

Obstruction detecting device/ obstruction warning signal

Obstruction detecting device is installed to detect automobile and so on
Ex. Using LED, IR, Laser-rader (3DLR)



Obstruction detecting device using infrared rays luminescence (IR)

Obstruction detecting device using laser-rader (3DLR)

By Google map

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Overview of safety equipment

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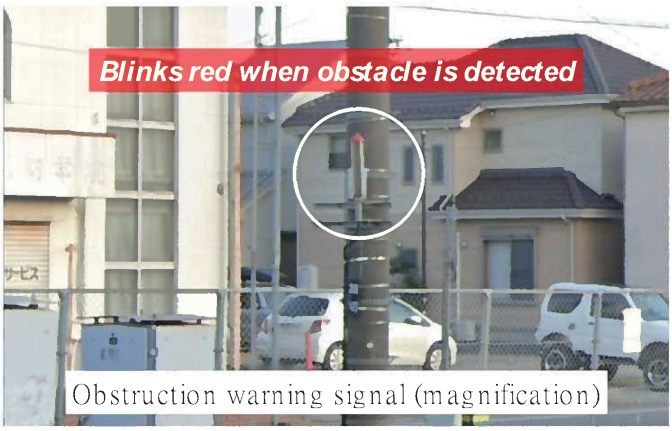
Obstruction detecting device/ obstruction warning signal

Detection result of the obstruction detecting device is transmitted to the obstruction warning signal. When the driver visually recognizes it, brake is applied

Obstruction warning signal



Obstruction warning signal (magnification)

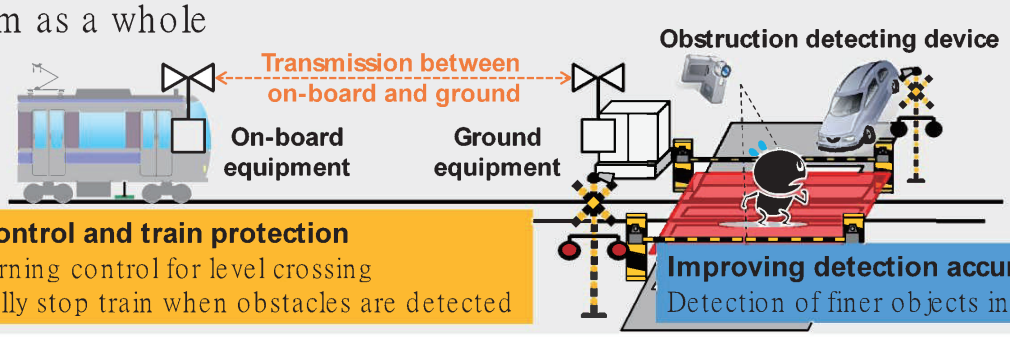
By Google map

Safety measures for reducing accidents

Approach for reducing accidents

Various measures are being implemented by railway operators, such as improvement of the visibility of alarms and installation of obstruction detecting devices that detect obstacles on railroad crossings

On the other hand, while it is important to advance individual elemental technologies, it is also necessary to work on measures for the railway crossing system as a whole



Warning control and train protection
Reliable warning control for level crossing
Automatically stop train when obstacles are detected

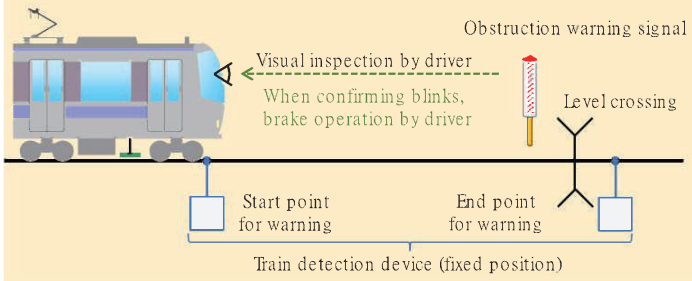
Improving detection accuracy of obstacles
Detection of finer objects in railway crossing

Safety measures for reducing accidents

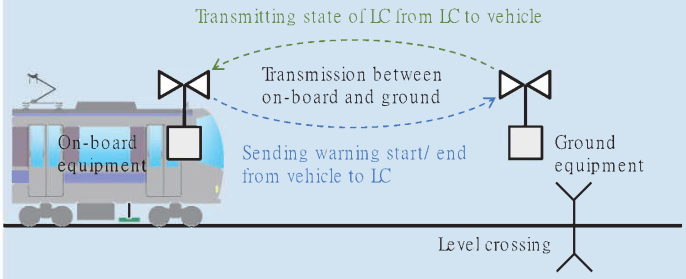
Warning control and train protection

Reliable warning control for level crossing
Automatically stop train when obstacles are detected

Current warning control and train protection



On-board warning control and train protection

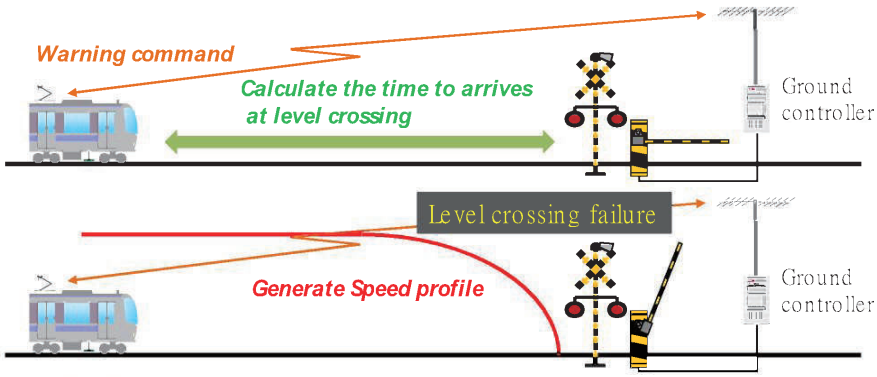


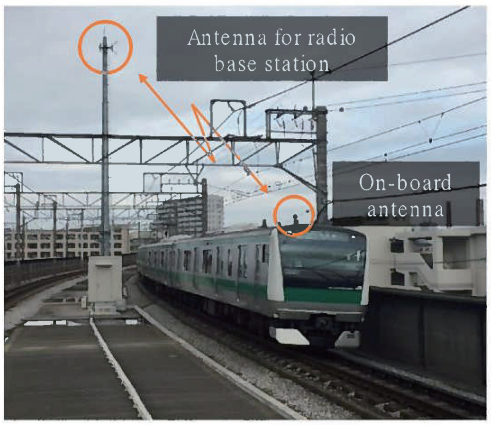
Method using radio communication such as CBTC system

Safety measures for reducing accidents

Warning control and train protection by train control systems | Ex. ATACS

Optimization of train approach warning duration
On-board equipment sends warning command to level crossing controller
In case of abnormality of level crossing, on-board equipment generates speed profile to stop train before level crossing

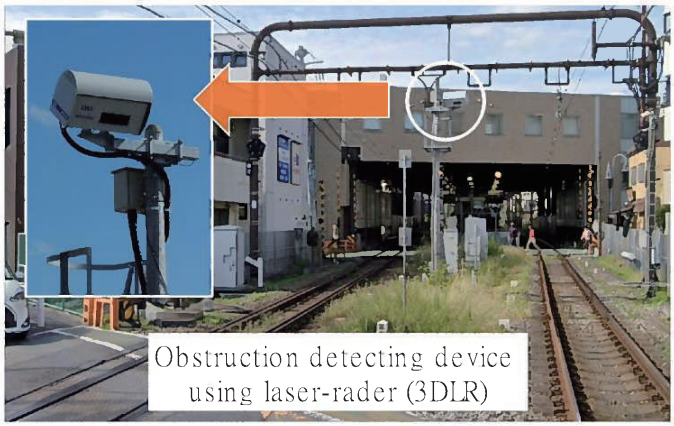




Safety measures for reducing accidents

Improving detection accuracy of obstacles

Detecting objects smaller than automobile, aimed at human detection
Ex. Laser-rader (3DLR), Laser-rader (2DLR), detect by area, not by line

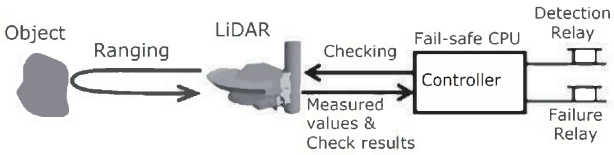


By Google map

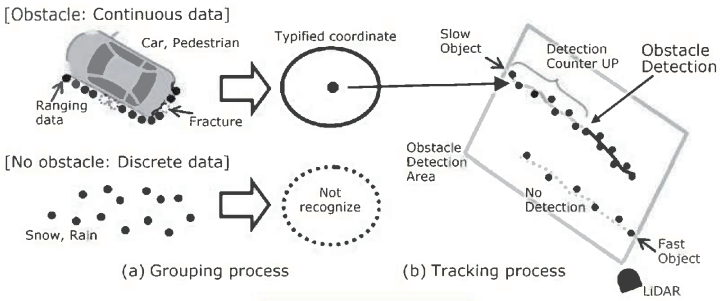
Safety measures for reducing accidents

Improving detection accuracy of obstacles | Ex. 2DLR

Sensing method: LiDAR using TOF (Time of Flight)
Processing method: grouping process and tracking process
In one of them, low-level scanning is being tested wit aim of detecting a person has fallen and is lying flat



Basic system architecture



Filtering process

T. Mae: "Development of MTrader & LiDAR system for level crossing obstacle detector", Japanese Railway Engineering, Vol. 59, No. 2, pp. 6 –7, 2019

Conclusions

Improved safety of level crossing

Reducing number of LCs through elevation and undergrounding
Working on measures for the railway crossing system as a whole

Warning control and train protection
Reliable warning control for level crossing
Automatically stop train when obstacles are detected

Improving detection accuracy of obstacles
Detection of finer objects in railway crossing

Introduction of CBTC is expected to improve level crossing safety

Regarding the issue of railway crossings, which are connecting points of road traffic, we would like to continue to work on it as an issue to improve safety