IRSC 2022
INTERNATIONAL RAILWAY SAFETY COUNCIL

DATA-BASED SMART RAILROAD TECHNOLOGIES FOR PREVENTIVE SAFETY MANAGEMENT

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Contents

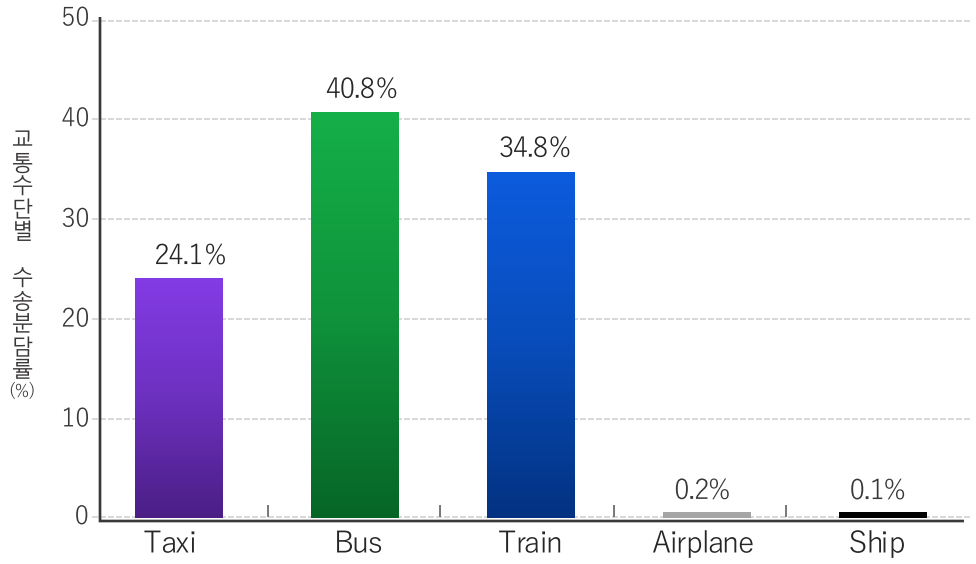
The Size of Railway in Korea

5 billion users per year, meaning 50 million Korean citizens use railway over 100 times a year.

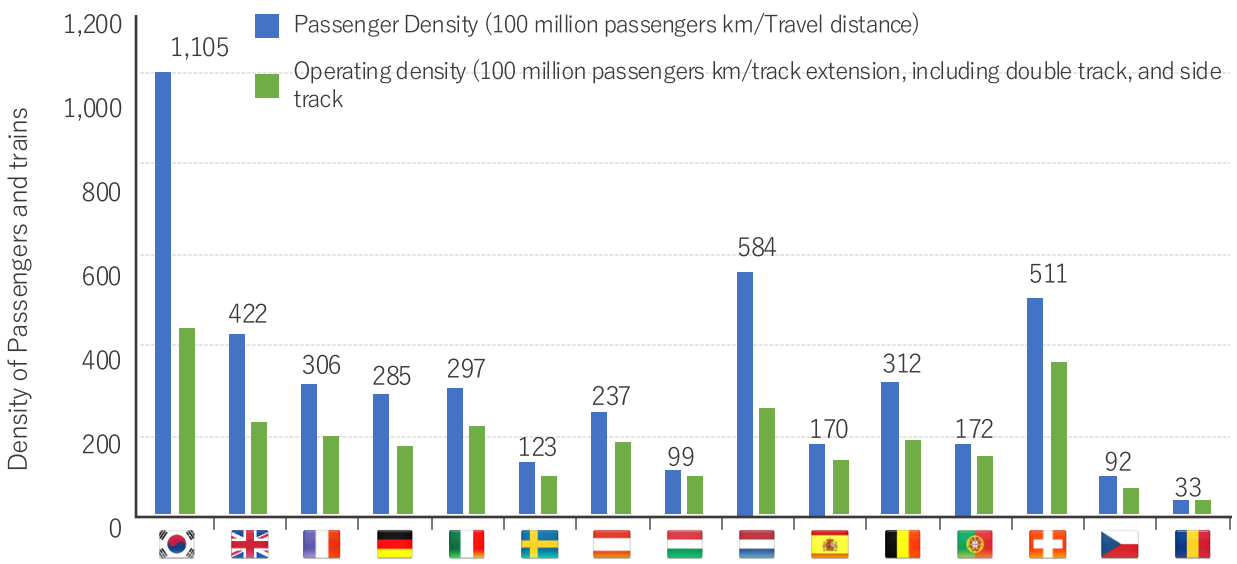
- The ratio of railway transportation is 35% of the entire public transportation (Trains, bus, taxi, airplane, ships)
- The density of passenger and train operation is one of the highest in the world (2~3 times higher than other countries such as UK or France)

* Source: National Transportation Statistics (2018), Private vehicle data not included

Transportation Share Ratio by Transportation



Comparison of Passenger Density and Train Density by Country



5,949 km	1,672 Stations	59,601 People	71.8 %	25,072 Trains	Approx 25,000
Distance of train traveled	Number of Stations	Number of railway workers	Rate of electrified railway	Number of Trains	Number of train components

The Scope of Korean Railway Safety Management

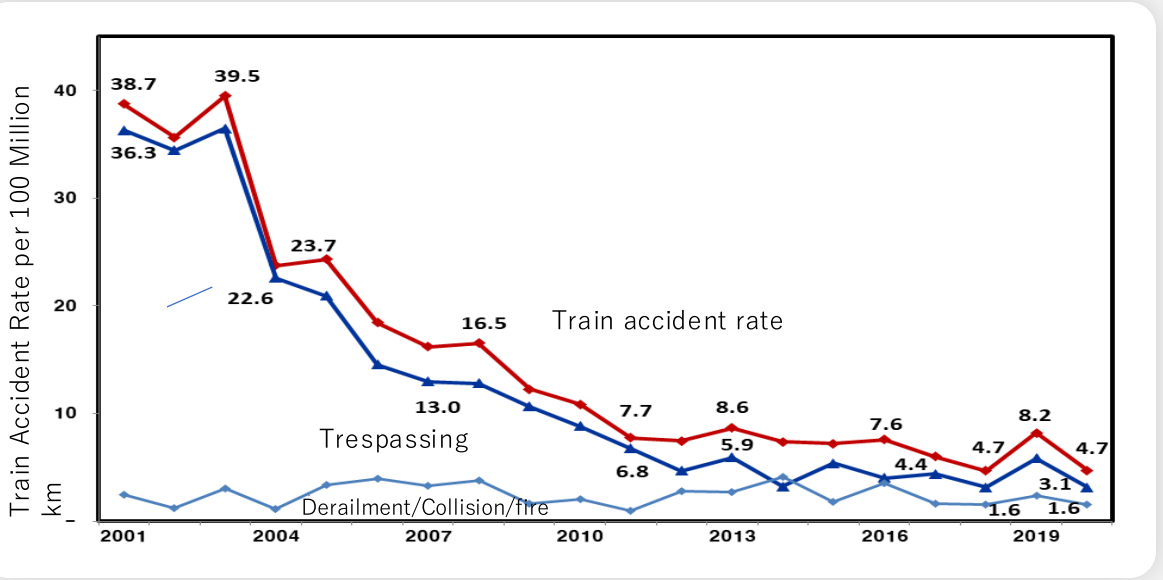
Railway Safety Management consists of Railway Safety Management System, Railway operation System and maintenance system

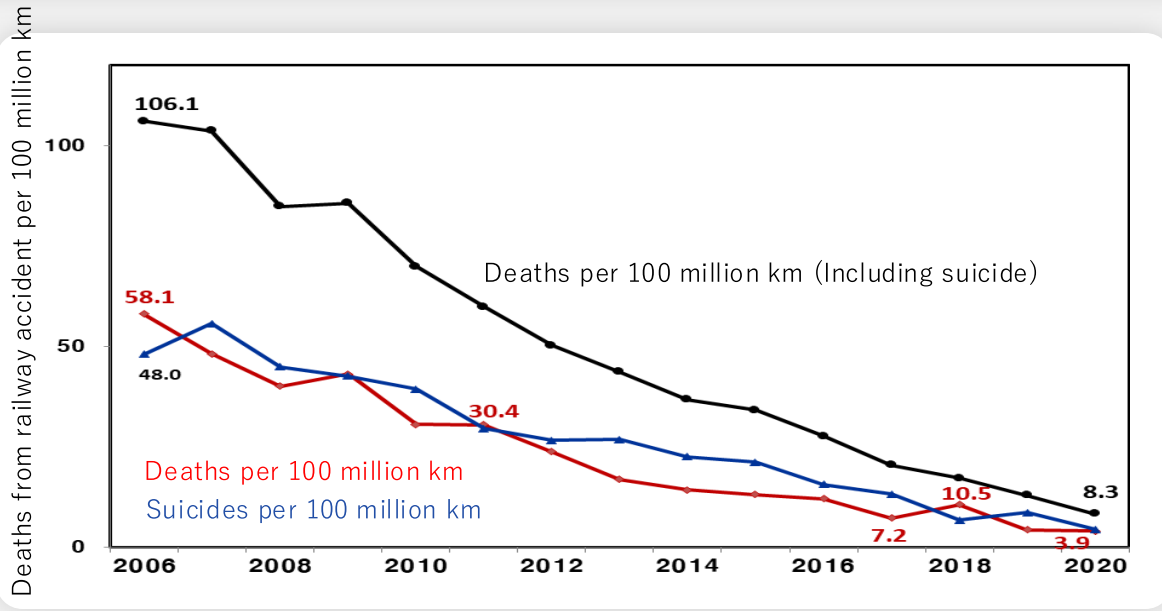
- Railway Safety Management System is an organic system of safety management to implement systematic and preventive railway safety management activity

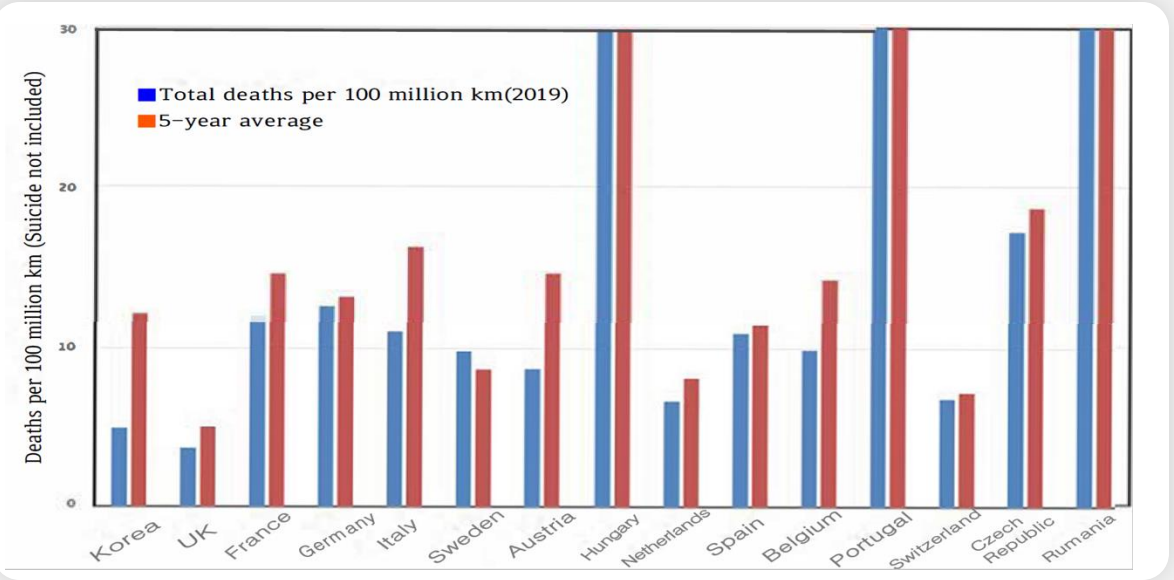
Railway Safety Management

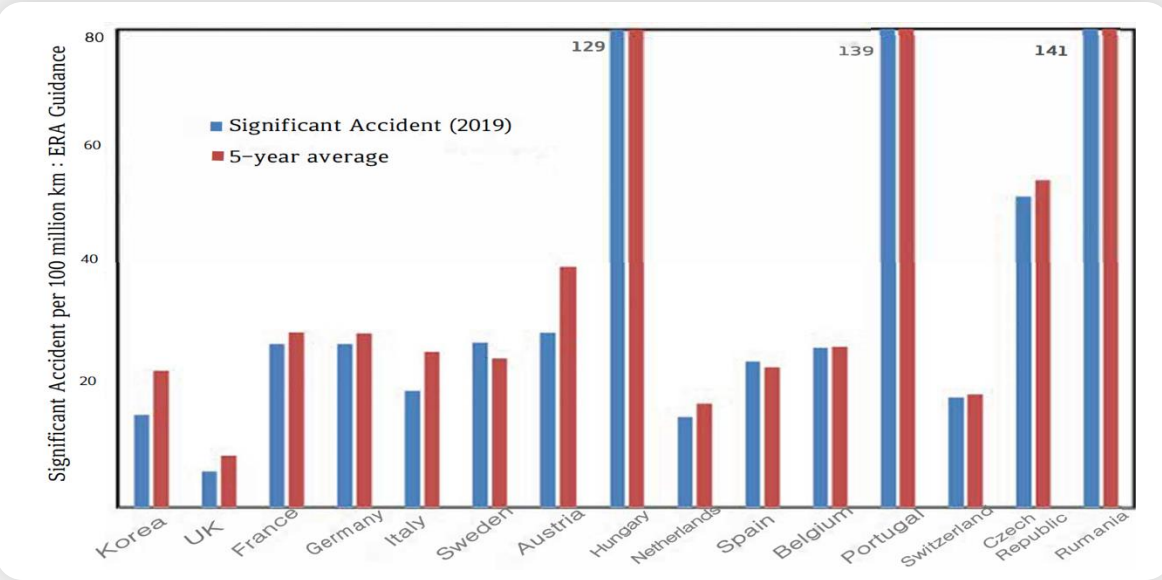
Railway Safety Management System	Train Operation System and Plan	Train Maintenance System
Railway Safety Administration	Train Operation System and Plan	Maintenance
Internal Inspection	Train Operation Plan	Maintenance Methods and Procedures
Documentation	Railway Control	Maintenance Record Management
Emergency Response	Railway Protection and Order Maintenance	Maintenance Facilities and Equipment
Risk Management	Train Operation Record Management	Maintenance components
Education Training		
Compliance with requirements		
Safety Information		
Accident Investigation and Report		
Safety Culture		

Railway Safety Levels of Korea









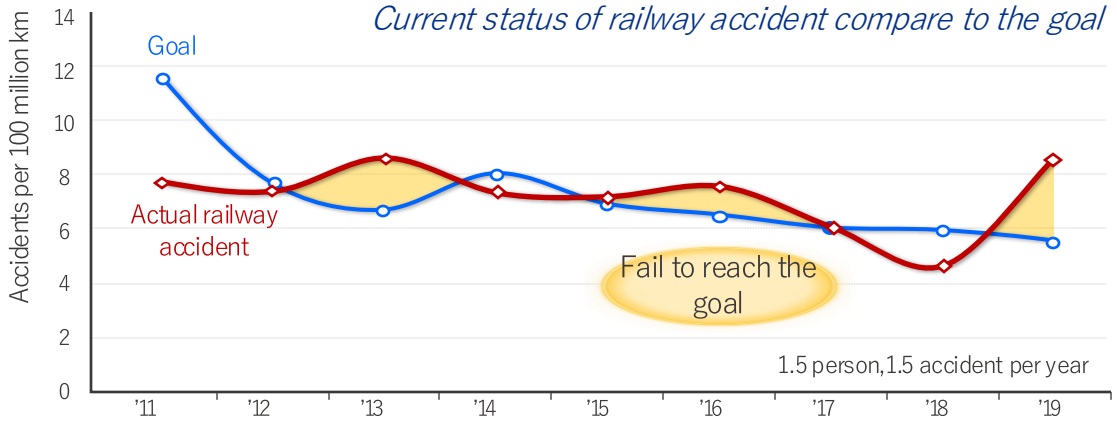
Background of the Project

Continuous and repetitive occurrance of Railway Accident malfunction

Slow decrease of Railway accident malfunction

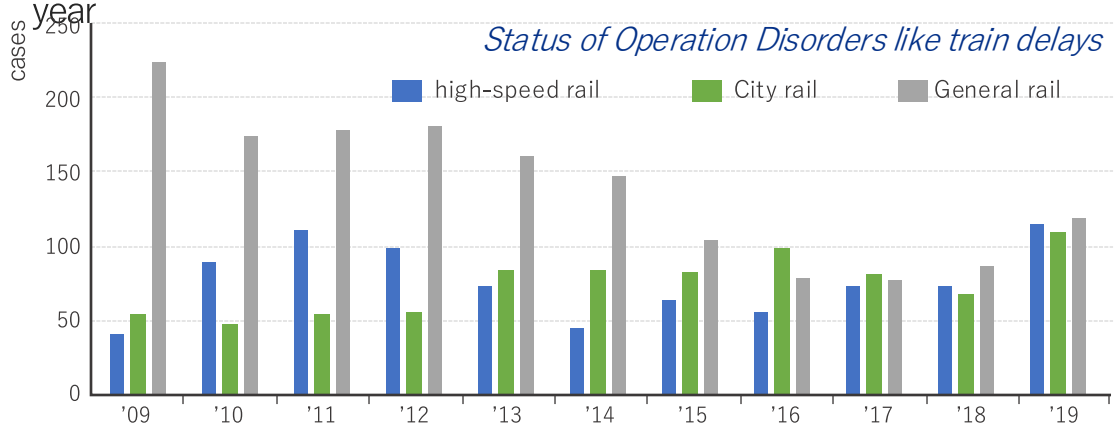
- Fail to reach the goal of railway accident decrease

Current status of railway accident compare to the goal



- Continuous occurrence of operation disorder – about 100 cases per year

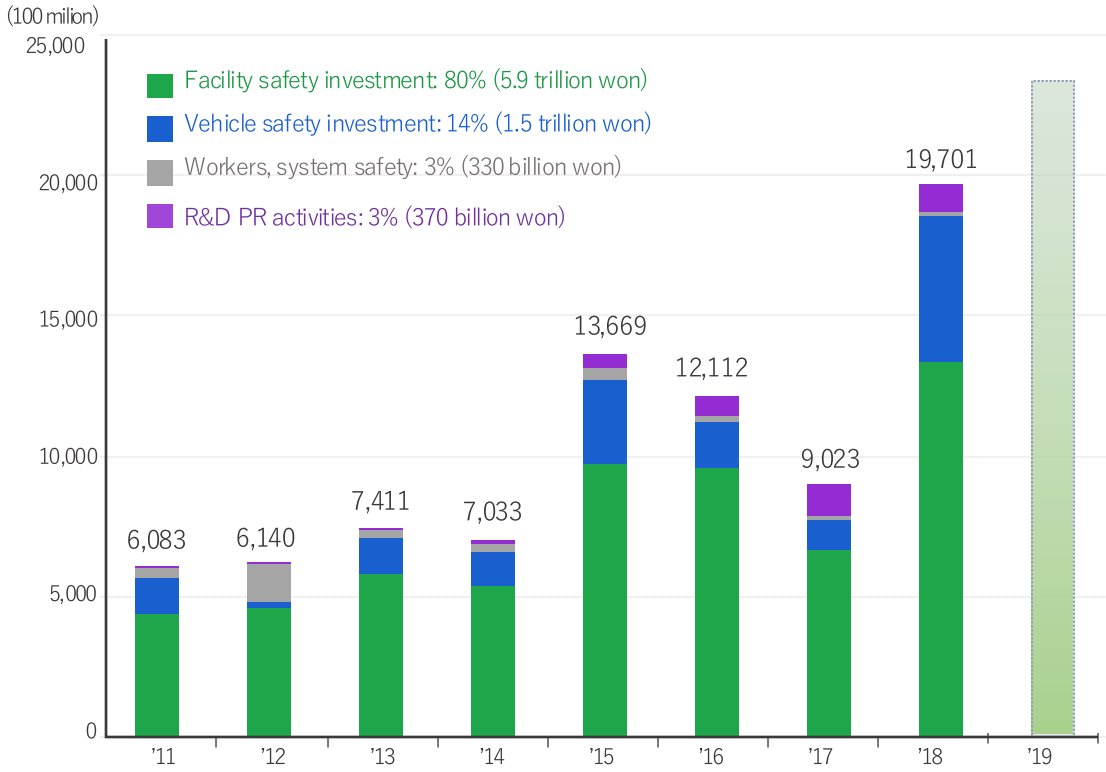
Status of Operation Disorders like train delays



Increase of railroad safety investment budget

- Increase in national investment over 10 years
  - 1.3 trillion won(2015) → 3.2 trillion won(2020)
  - Spend more than 90% on facilities and vehicles

Railway safety investment budget



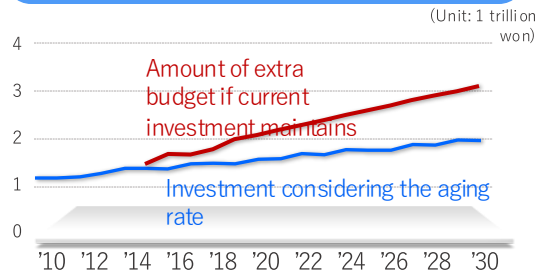
Various potential risk factors due to the changes of railway operating environment

- Necessity of preemptive response to the potential risk factors that can cause the railway safety accident

Condition evaluation of aging railway

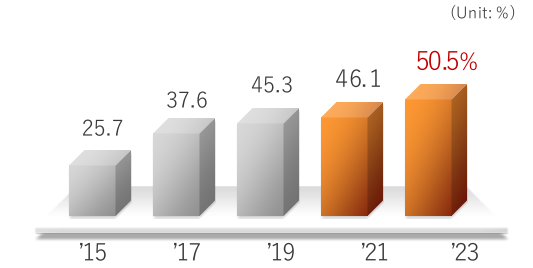
- Due to the limited budget, the aging of vehicles/facilities continues
- Need to develop technology to reduce railway system maintenance cost for safety

infrastructure maintenance investment prospects



Source : Current state of SOC maintenance Investment & required financial resource

Current state of old trains & Prospect (Older than 20 years)

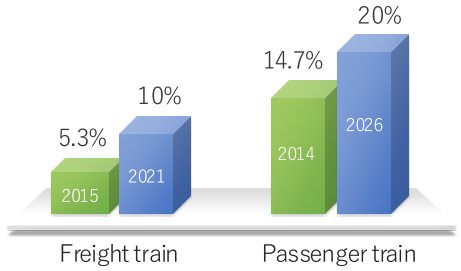


Source : 2019 Railroad safety implementation plan, MOLIT

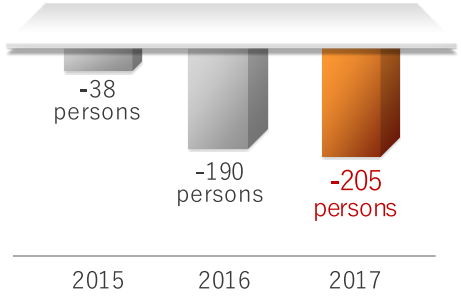
Railroad network increase, Maintenance budget/personnel decrease

- Increase from 3,729km(2016) to 5,364km(2026)
- Decrease of train maintenance personnel

The National Railway Network Plan



Maintenance personnel



Precursor of abnormal climate change

- Need to detect/diagnose the precursors of damage such as heat waves, heavy rains, and earthquakes.
- Need to preemptive response based on the risk and damage prediction for preparing disaster
- Insufficient emergency response system to prevent spread in the event of an accident

Risk Factors

- Unmanned driving, station/cyber security, increased crime/terrorist threats, etc.
- Need for real-time detection/diagnosis, integrated safety information system

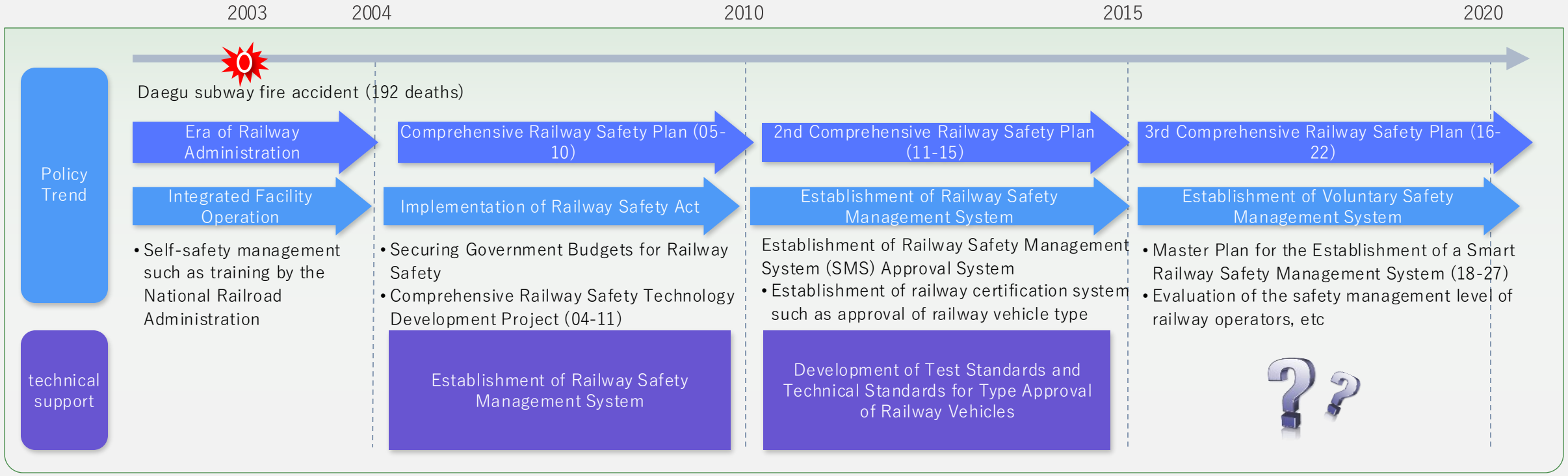
Technology Development Requirement

Technology Development Requirement for on-site implementation according to safety management law/policy

- After 2003 Daegu subway fire accident (192 deaths), Railway Safety Act was legislated
- Establishment of voluntary safety management system and conversion to preventive system by Railway Safety Act and 3rd Comprehensive Railway Safety Plan
- In 2018, Master Plan for Smart Railway Safety Management System was established

→ Lack of technologies required for on-site implementation

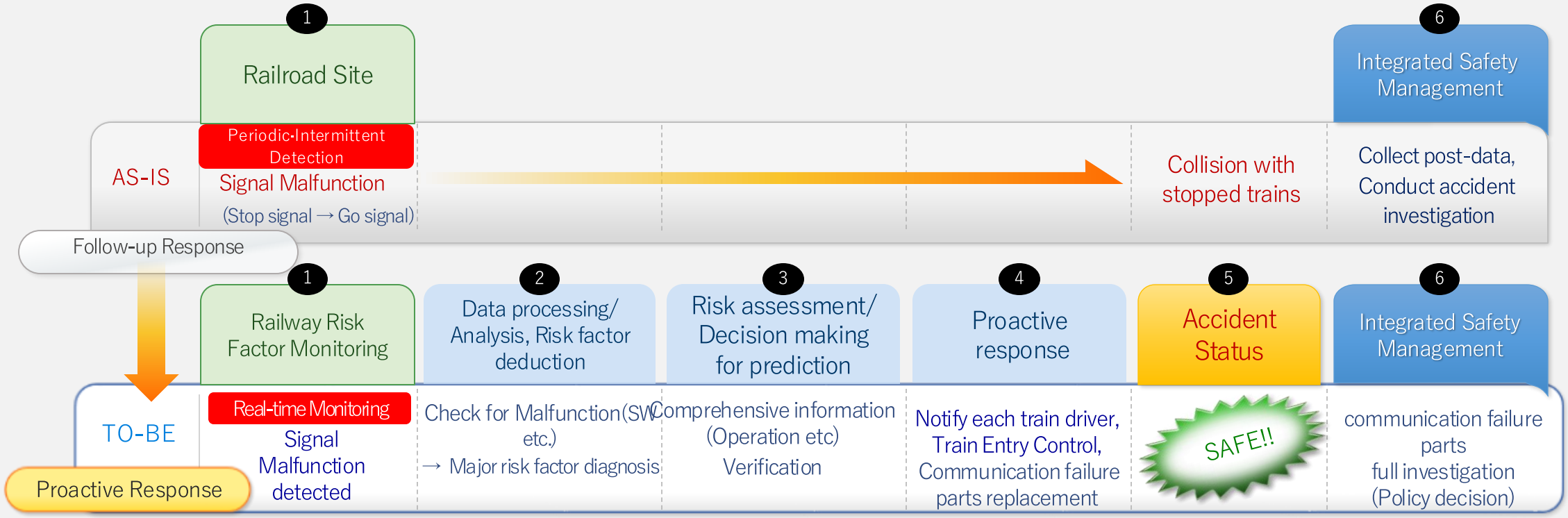
Current status of the policy change in Korea



The Concept of Data-Based Smart Railway Safety Management Technology and Prospect

Smart Technology Development for Preventive System of Railway Safety Management

- Manpower-oriented follow-up response reached the limit → Switch to the preventive system by data-based smart technology



✓ Measurement technology automation
✓ Digitization of risk factor data
✓ Standardization/Data Analysis

✓ Data utilization state-based risk diagnosis
✓ Defect/damage real-time response

✓ Perform rail risk and condition-based analysis, assessment, and forecasting

✓ Mitigation and resolution of risk factors Optimal decision-making

Preventive system using digital safety chain

Digital safety chain unit Prediction of safety accident → Data standardization → Risk level and condition analysis → Accident prediction model → Determination of countermeasures

Railroad site hazards and health monitoring	Railway safety data standardization and Digitization, big data processing	Risk/Condition Based Railway safety analysis/prediction	Forecast basis Decision	Decision base preemptive response
Bogie fever history data data	Big data construction	History pattern analysis → Diagnosis of major risk factors	Bogie frame behavior simulation, Defect cause analysis	Prediction of possible timing and type of derailment and operation failure due to a defect in the bogie suspension system
	Risk and health data	risk and status diagnosis	Accident prediction	Decision making

Suspension replacement

bogie suspension Defect Compensation

Required Area for Technology Development

"Required Area for Technology Development" derived from the contents related to the technology development at SWOT analysis results

SWOT analysis result	
SO	- Accelerate technology development based on well-equipped railway safety management system policies - Efficient railroad safety management with budget investment by utilizing railroad-based technology through prior projects
ST	- Active response to railway operation risk factors such as aging and reduction of professional manpower by shortening the technology development period - Preemptive response and resolution of new risk factors by securing intelligent railroad safety management technology
WO	- Resolving data-based safety management difficulties for each operator through government-led development of safety management technology - Field spread of R&D performance through operation of national integrated data center
WT	- Preemptive response to railway operation risk factors through application of risk analysis-based technology - Resolving the shortage of professional manpower through automation technology development and education and training

Areas required for technology development

SO + ST

of railroad safety management
Integrated
control tower function technology

ST + WT

railroad safety
Prior risk factors
Analysis, prediction, and decision-making skills

WT + WO

Railroad safety information management and
Risk factor proactive response technology

Goals of Developing data-Based Smart Railway Management Technology

Vision

"Implementation of intelligent railroad safety that people can trust and feel safe"

Business Purpose

Reinforcement of safety capabilities and creation of a smart ecosystem
through digitalization of railway safety management and preemptive response to risk factors

Business Goals

Innovation and efficiency improvement of smart railway safety management technology

Through reduction of 60% of railroad accidents and 50% or more of operational obstacles Improvement of railroad safety indicators	Achieved more than 3,000 digital safety chains through processing, analysis, prediction, and decision-making of railway safety risk factor data	Improvement of safety management cost efficiency by reducing railway system maintenance cost by 20%

Focus Field

Focus 1	Focus 2	Focus 3
IoT-based railway site Safety big data construction and smart preemptive response technology	AI-based railway operation safety Analysis/prediction / decision-making skills	Big data-based national integrated railway safety management system technology

On-site safety data / On-site response results ⇌ Immediate response and preemptive response decision making

Prediction of on-site risk / safety management information ⇌ State-led railway safety Precautionary management

Data-based Smart Railway Safety Management Key Technologies

focus Field

1 IoT-based railway site safety big data construction and smart preemptive response technology

2 AI-based railway operation safety Analysis/prediction/decision-making skills

3 Big data-based national integrated railway safety management system technology

Details assign ment

1.1 Human error of railroad workers Big data construction and Smart preemptive response technology

1.2 Railway facility risk factors Big data construction and Smart preemptive response technology

1.3 Railway vehicle risk factors Big data construction and Smart preemptive response technology

2.4 Railroad operation safety digital twin decision-making platform technology

2.1 Big data-based railway workers Human error analysis and prediction technology

2.2 AI-based railway facility risk factors Diagnosis and Prediction Technology

2.3 Smart Rail Vehicle Risk Factors Diagnosis and Prediction Technology

3.1 Smart railway safety national integration System build and test bed operating technology

3.2 Big data-based national integration Railway safety analysis and prediction technology

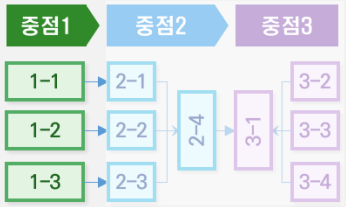
3.3 Big data-based railway safety Supervision and monitoring technology

3.4 Big data-based public Rail Safety Service Information Collection/Generation Technology

The first core developing area

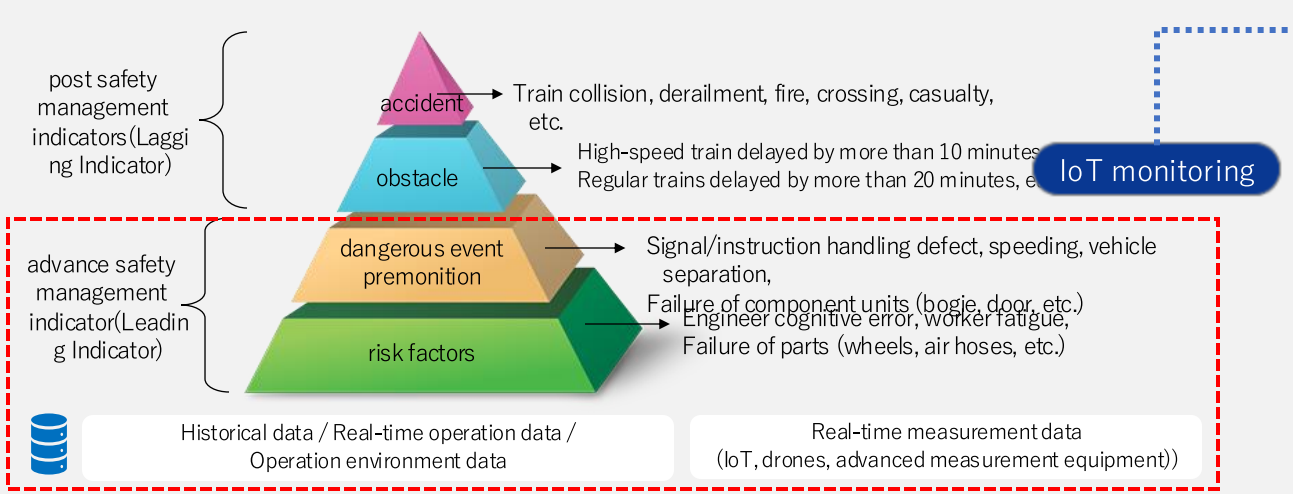
Core 1 IoT-based railway sites safety big data establishment and smart proactive response technology

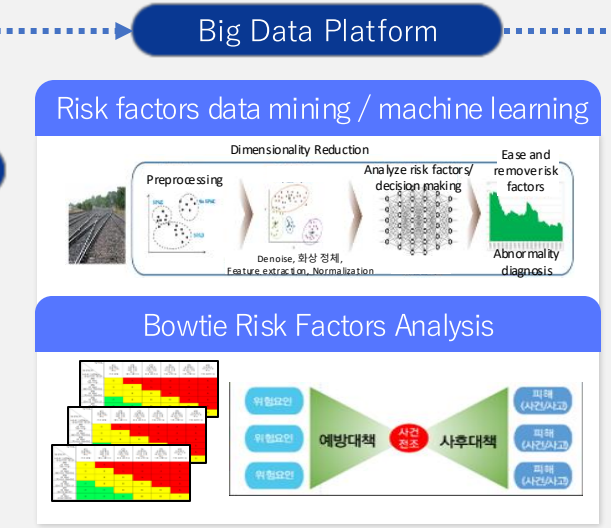
- (IoT monitoring and Big Data Platform Technology) Railway safety data standardization and digitalization technology based on the scenario of risk factor occurrence using IoT and advanced measurement equipment
- (Proactive response technology) Measurement technology to scientifically detect and recognize pre-risk factors of railroad operation sites



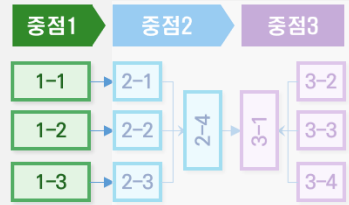
IoT-based railway site safety big data construction and smart preemptive response technology

- **1-1** Railroad workers human error big data Construction and smart preemptive response technology
- **1-2** Railroad facility risk factors big data Construction and smart preemptive response technology
- **1-3** Rail vehicle risk factors big data Construction and smart preemptive response technology





1-1 Establishment of human error big data and smart proactive response technology

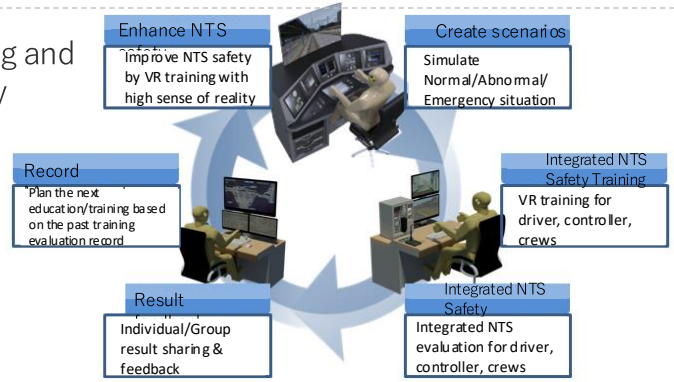


- Collection of human error characteristics data (physical condition, physical environment, external environment, infrastructure, procedures, training/evaluation, etc.)prevention of accidents and disorders due to human error based on diagnostic technology, and development of AR/VR-based education/training system for early response

Establishment of human error big data for railway workers and smart preemptive response technology

Establishment of human error big data for railway workers and data collection technology for real-time risk factors

AR/VR based education/training and preemptive response for railway workers



Data-based analysis/prediction/decision technology of human error

Establishment of big data on human error and monitoring system

- Setting technology for characteristic item on human factors
- Big data establishment and diagnosis technology for railway accident/malfunction's human risk factors

Preventive technology for accident/disability

- Multi-user virtual training system that enables joint training Immersion enhancement and interaction technology of virtual training system

Early response technology for human error on vehicle/facility maintenance

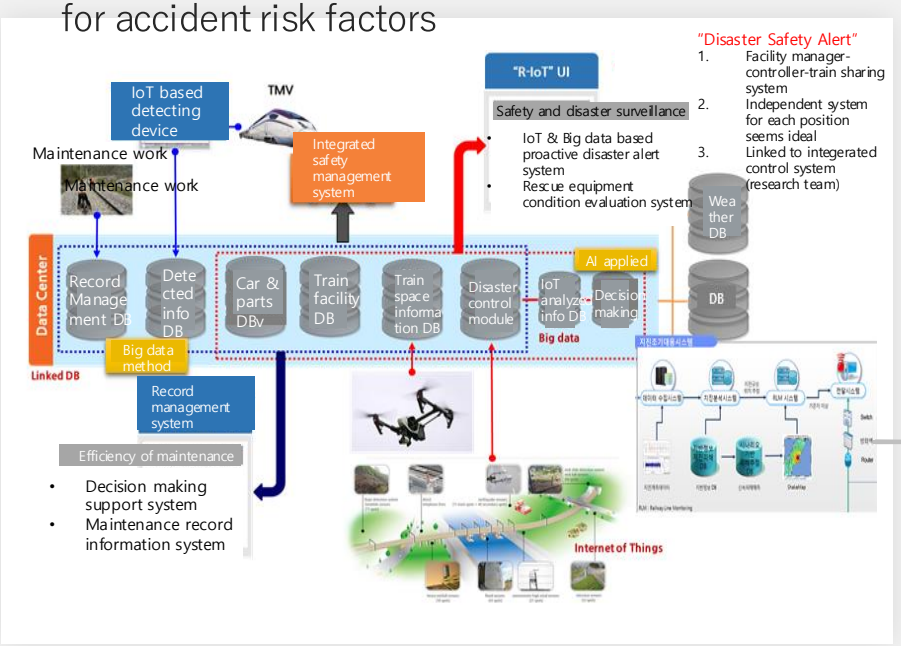
- AR system for maintenance training of railway vehicle/facility
- AR improvement technology for maintenance training and support of railway vehicle/facility
- AR tools for maintenance support of railway vehicle/facility

First step of demonstration on big data system

- Establishing technology on the first step of demonstration on integrated big data system for railway workers' human error

1-2 Developing Big Data and Smart Preemptive Response Technology for risk factors in Railway Facilities

- Improvement of safety and capacity building on safety and condition risk factors for railway facilities (6 fields) by estabilishing safety information big data, real-time anomaly/defect diagnosis technology, and developing preemptive response technology for accident risk factors



IoT-based smart monitoring technology based on risk and condition

- Data collection technology for safety accident/operation disorder of facilities at railroad operation site
- IoT-based smart monitoring technology based on railway facilities' condition and risk

Integrated Big Data Platform of Railway Facilities

- Developing the sign of a safety accident and condition-based scenarios, and data standardization
- Big Data establishment technology based on the condition and risk

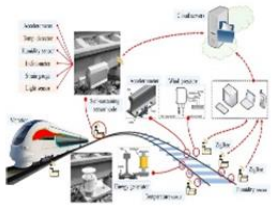
Big data based real-time diagnostic system

- Big data based real-time diagnostic technology for any abnormalities/defects in railway facilities

Big data based real-time diagnostic system

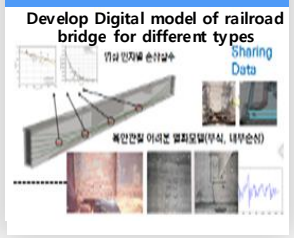
- IoT-based ballast resistance measurement technology and equipment
- Continuous Track Stiffness Measurement System
- Bifurcation linear measurement and analysis technology
- Long-term variation measurement system technology for railway bridges
- Tunnel backside condition evaluation measurement system technology
- Safety accident advance warning system technology for the transportation vulnerable (Smart Block)
- Intelligent search automation system technology at railway station
- Built-in standard failure mode automatic measurement system technology for each type of railroad signal facility
- Mobile platform technology which supports the safety management business based on the diagnosis information at Failure mode
- Emergency response system for pre-empting the spread of social and natural disasters

Human errors monitoring technology



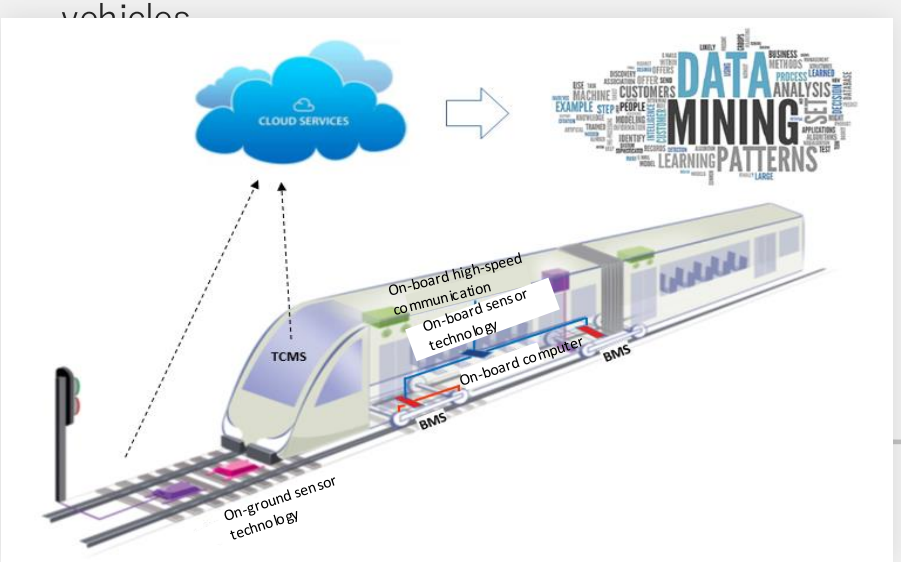
Big data platform

Real-time diagnosis system



1-3 Developing Big Data for risk factors in Railway Vehicles and Smart Preemptive Response Technology

- Development of sensing technology for measuring physical quantities on board and on the ground and integrated information analysis technology for real-time data communication and analysis to expand safety management items of core railroad vehicles



Vehicle/ground sensing system technology for core device

- Key device sensor positioning and measurement cycle setting technology for railway vehicles
- Electrical noise removal and feature extraction technology
- Data calibration and big data DB construction technology

Real-time communication technology for large-capacity measurement data

- Vehicle public network standardization and interface technology
- High-capacity two-way communication technology for real-time monitoring of each major train device
- Interface and data path technology with vehicle TCMS

Big data standardization/systematization and information collection technology

- Big data standardization technology for major railway vehicles
- Data structure design technology for database systematization
- Information production technology through data self-mining

Precise diagnosis equipment technology for railway vehicles

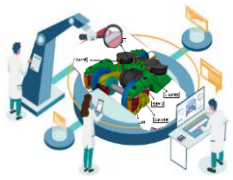
- Damage mechanism analysis technology for major equipment of railway vehicles
- Simulation modeling and verification technology according to the damage mechanism
- Precision diagnostic equipment design and manufacturing technology for each device
- Performance verification and diagnostic evaluation technology for precision diagnostic equipment

Preemptive response technology for risk warning of railway vehicles

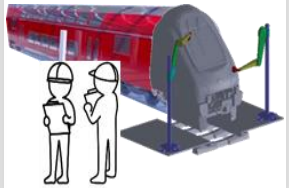
- Risk assessment technology through FTA analysis according to major device failures
- What if scenario simulation technology
- Optimal preemptive response time and method prediction technology

Occupational information collection technology

Precision Diagnosis Equipment



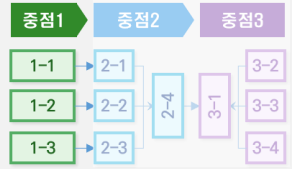
Preemptive response to risk



The second core developing area

Core 2 AI-based railway safety analysis/prediction/decision-making technology

- (Analysis/prediction technology for risk factors of railroad sites) Development of a digital model that considers the characteristics of vehicles, facilities, workers, and users of railroad operation sites, and diagnosis/prediction of risk factor status using it
- (Safe Operation Digital-Twin Decision-Making Platform Technology for Railway) Digital twin platform technology that supports decision-making in real time for optimal response measures for railway operation safety (maintenance, improvement, response to unusual situations, etc.)



AI-based railway safety analysis, prediction, and decision-making technology

1-1 2-1 Data-based analysis/prediction Technology for human error of railway workers

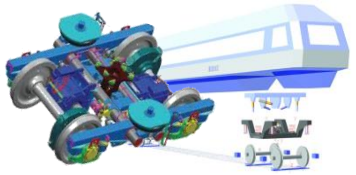
1-2 2-2 AI-based diagnosis/prediction technology for railway facility's risk factor

1-3 2-3 Diagnosis/prediction technology for smart railway vehicle's risk factor

3-1

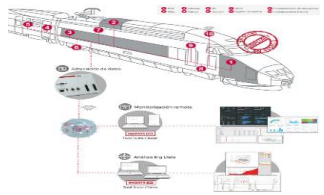
2-4 Digital twin decision-making platform technology for Railroad operation safety

Physical Model



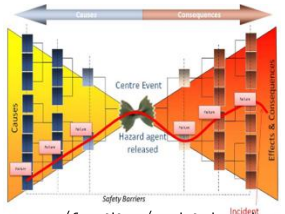
Railway human/facility/vehicle risk factor generation physical model

Data Model



Railway human/facility/vehicle risk factor data analysis model

Status diagnosis/predictive model for risk factor

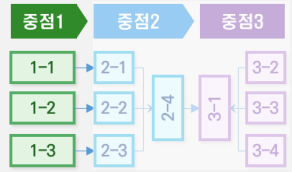


Railway human/facility/vehicle physics-based analytical risk factor ¥diagnosis/prediction technology

Digital Twin Decision-Making Platform

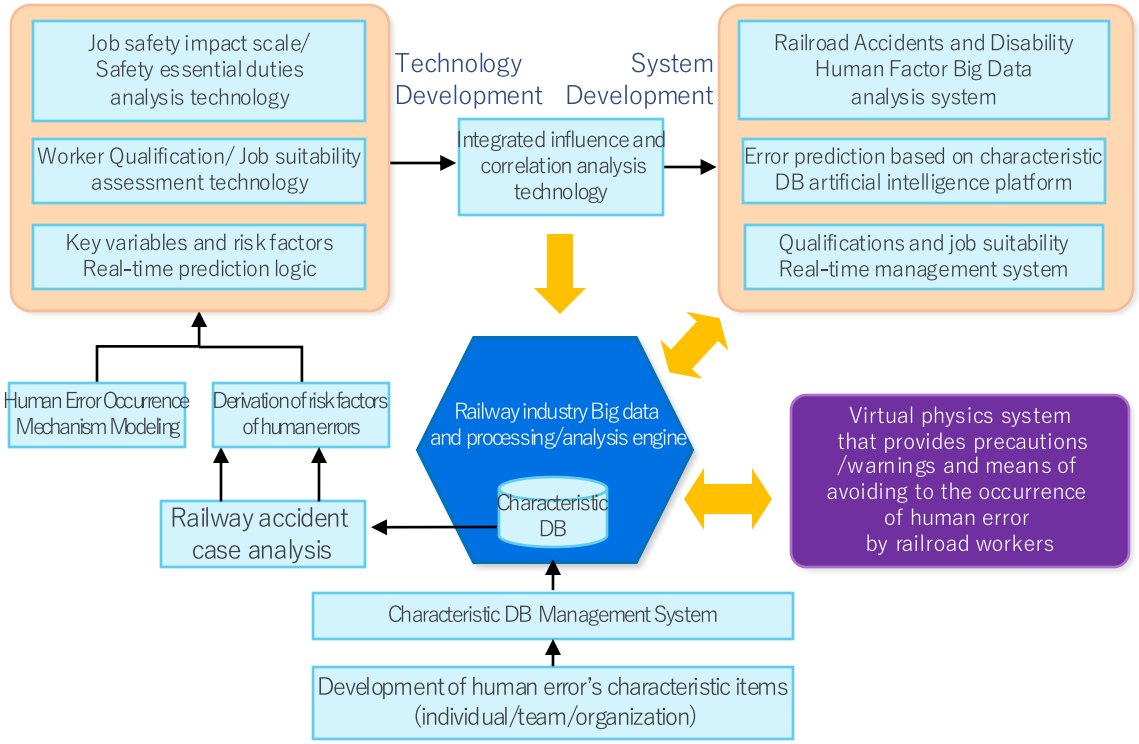
Digital twin platform technology for risk prediction

2-1 Data-based human error analysis, prediction, and decision-making technology



- Modeling human error mechanisms of railway workers and developing error analysis, prediction, decision-making artificial intelligence platform, and decision-making Cyber Physical System (CPS) technology for avoiding human error

Data-based human error analysis, prediction, and decision-making technology for railway workers



Establishment of human error big data for railway workers and smart preemptive response technology

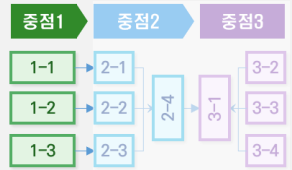
• Modeling human error mechanisms and data analysis technology

- Human error occurrence mechanism modeling for driver, human error characteristic data and safety essential job analysis technology
- Human error occurrence mechanism modeling for control worker, human error characteristic data and safety essential job analysis technology
- Human error occurrence mechanism modeling for crew and station staff, human error characteristic data and safety essential job analysis technology
- Human error occurrence mechanism modeling for vehicle and facility maintenance work, human error characteristic data and safety essential

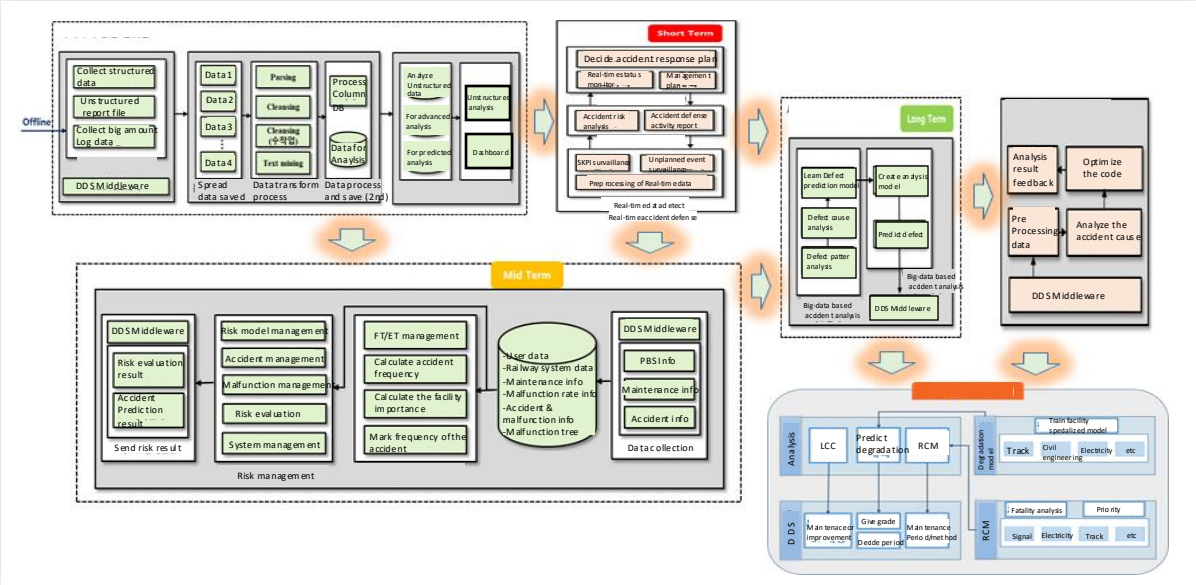
• Big Data based Advanced ICT technology that predict the human error

- Big Data Analysis System for Human Factor of Railroad Accident/Disability
- Human error probability evaluation model for railroad workers
- Error prediction AI integrated platform technology based on characteristics DB of human error
- Construction of a virtual physics system (CPS) that provides cautions/warnings and avoidance methods from the occurrence of human errors in railway workers
- Real-time qualification/job suitability assessment for railroad workers, AI model diagnosis, and safety driving support technology for engineers
- Demonstration of safety management data system for integrated human

2-2 AI-based risk factor analysis, prediction, and decision-making technology



- Implementation of prevention through risk-based prior risk factor analysis considering various rail facility characteristics and behaviors, results based on risk-based predictive models, and economic and efficient decision-making technology using them



AI-based analysis system for railway facility risk and condition defect

- AI-based risk analysis technology for each railroad facility
- Condition-based analysis model for each railroad facility
- Deterioration model for each railroad facility
- RCM model for each railroad facility

AI-based safety risk prediction system for railway facility

Risk probability-based prediction model for each railroad facility using AI technology

AI-based decision-making platform technology for railway facility

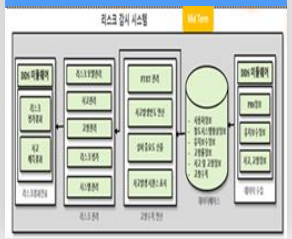
- AI-based safety measures decision-making model for each risk factor of railroad facility
- AI-based safety measures decision-making platform for railroad facility

AI-based S-RAM system for railway facility

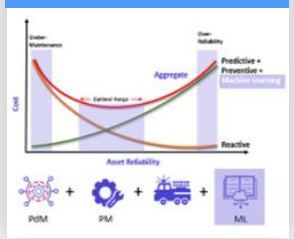
- RAM data management systemization technology for each railroad facility
- LCC Statistical/Analysis Technology
- RAM platform development for railway facility

Danger & defect analysis system

Risk rate prediction system

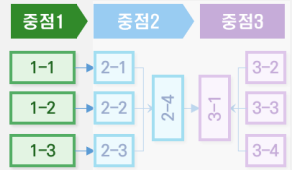


Decision making platform technology

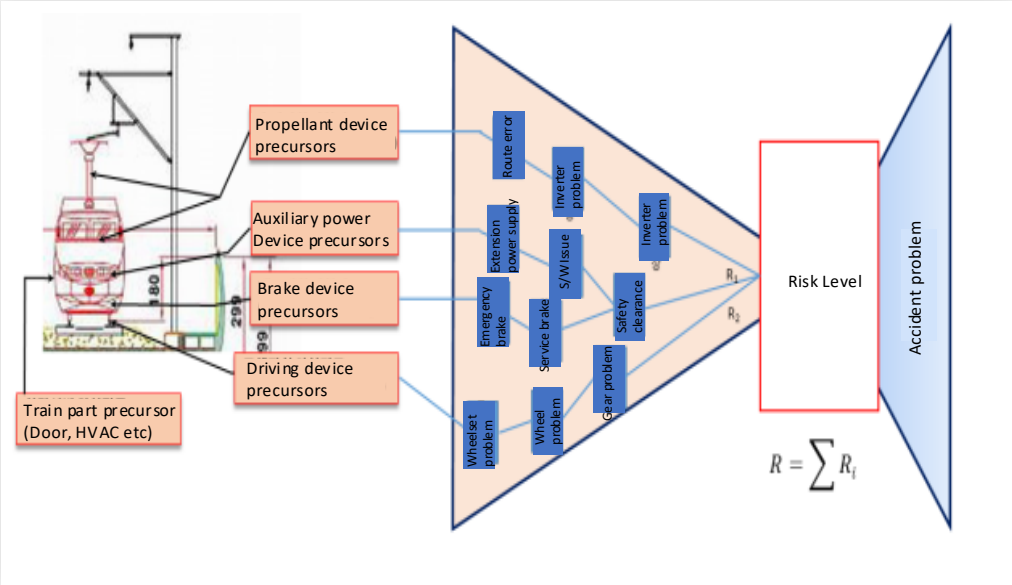


S-RAM system

2-3 Smart Rail Risk Factor Diagnosis/Prediction Technology



- Condition diagnosis technology based on dynamic behavior traits of the railway vehicle's core device, risk precursor evaluation using the Bowtie model, and developing a tool for decision-making



Diagnosis/prediction technology of risk factor based on major vehicle devices

- Physical analysis model of core parts for each major device of railway vehicle
- Simulation and result DB by failure mode for each major device
- Test bed construction and condition evaluation and modeling technology in finished vehicles

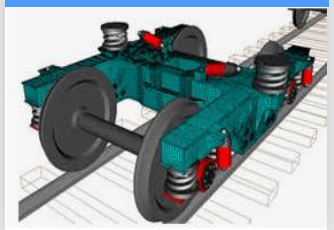
Diagnosis/prediction technology of risk factor based on data learning

- Data-based condition evaluation modeling technology for each major device of railway vehicle
- Test device configuration for key performance evaluation by core devices / various parameter test results DB
- Building a learning DB for each failure mode and AI analysis modeling technology
- Test bed construction and condition evaluation technology for each key device in automobiles

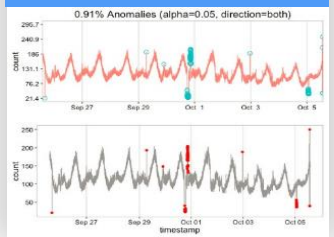
Risk prognostic assessment and decision-making technology using Bowtie model

- Preliminary Hazard Analysis (PHA) Model for Major Vehicle Equipment
- Hazard Prediction Assessment Algorithm for Major Vehicle Equipment Using Bowtie Model
- Optimal decision-making model based on Whif if scenario

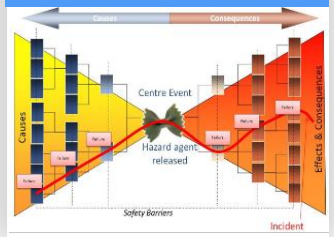
Physical modeling technology



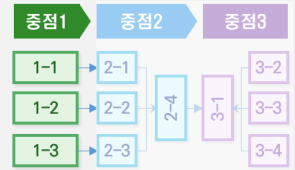
Data modeling technology



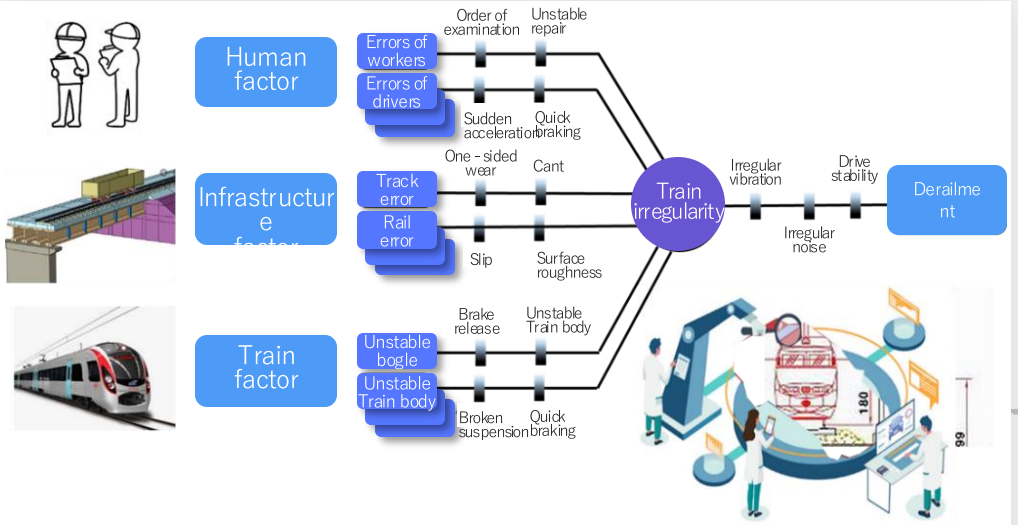
Risk modeling technology



2-4 Safe Operation Digital-Twin Decision-Making Platform Technology for Railway



- Bow-Tie modeling technology for the potential risk factors of the integrated railway system interface and developing an automated optimal decision support platform-based crisis management system



Integrated Decision Making Platform of Railway system

Risk modeling technology for integrated analysis on rail system

- Hazard discovery technology for human, infrastructure, and vehicle interface elements
- FTA analysis technology for human, infrastructure, and vehicle interface elements
- Bow-Tie model and simulation platform technology for each risk source

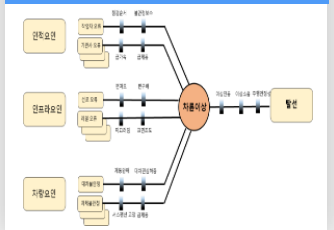
Integrated simulation technology for risk prediction

- Human, infrastructure and vehicle interface risk factor modeling technology
- Integrated simulation platform technology

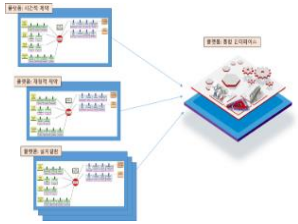
Digital twin decision-making platform technology for integrated operation safety

- Open data hub and high-reliability/real-time IoT network technology for railway safety information management at railway sites
- Development of AI-based train operation safety evaluation and optimal decision support system
- Development of on-site response technology for each type of risk warning and cyber security operation technology of railway system for safety control

Integrated risk rate modeling

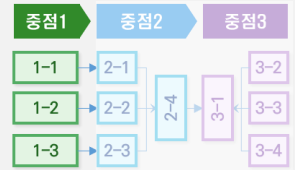


Integrated simulation technology



Digital twin decision making technology

Core 3 Big Data-based National Integrated Railway Safety Management System



- (Nationally integrated railway safety diagnosis/prediction technology) Integrated safety management technology for the diagnosis, prediction, and decision-making of railway safety for all operating institutions at the national level, and test bed operating technology for verification
- (Data-based railway safety monitoring/supervising technology) Data-based railway safety system evaluation, supervision and monitoring technology

Big data-based national integrated railway safety management system technology

2-4

3-1 Smart railway safety management national integrated data system construction and test bed operation technology

Risk Information

3-2 Big data based on premonitions of accidents Development of national integrated railway safety prediction, evaluation, and decision-making support technology

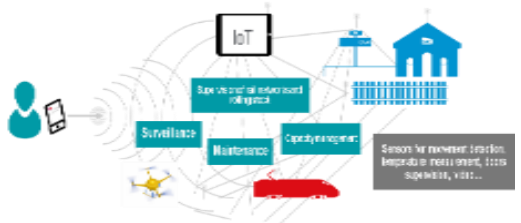
Safety supervision and monitoring

Public input data and information service

3-3 To improve the effectiveness of the railroad safety management system Data-based railway safety supervision and monitoring technology

3-4 data-based public railway safety service Information collection and generation technology

data foundation Railroad Safety Supervision and Monitoring



- SMS maturity diagnosis and evaluation model
- Railroad Safety Supervision Data Mining Technology
- Variable SMS inspection and management

National Railroad Safety Service Create information collection

- National railway safety accident analysis and prediction technology using social networks
- Railway safety culture analysis model

National integrated railroad safety Decision support technology

- National Integrated Railroad Safety Chain Model
- Big data-based national railway safety prediction, evaluation, management, and decision-making technology

Smart Rail Safety Test Bed

System

- Railway integrated safety management system test bed establishment and demonstration project

3-2 Big data based national integrated railway safety analysis, prediction, decision support technology

- Railway safety decision-making for stakeholders based on safety information of all railways and the development of national integrated railway safety predicting, evaluation, and decision support technology to support PDCA

National railway safety prediction, evaluation, and decision-making support system

Risk model based on precursors of integrated safety management (Utilize railroad safety chain model)

Standardization of railway safety prediction/evaluation technology – Support operation organization

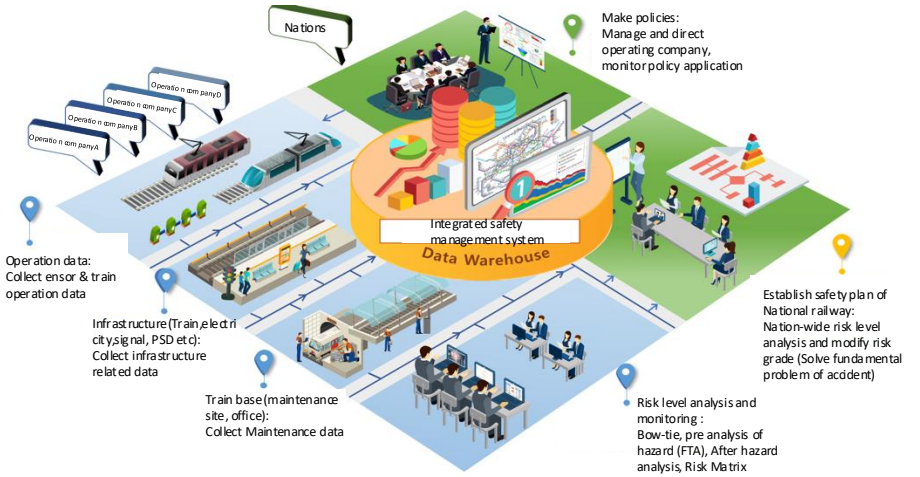
Risk evaluation model based on Big data -> National integrated safety Prediction / evaluation (Utilize FTA.ETA, DB Mining etc)

Create multi-dimension (Risk factor, subject etc) risk info, Judge the risk condition (Diagnose -> Utilize machine learning like deep learning and so on)

National railroad network connect/risk info -> Integrated railway safety plan decision making

Establish national railroad policy
- Manage railroad safety In dex
- Establish railroad safety plan
- Decide railroad network safety investment

National integrated smart railway safety management data system



Standard model of safety chain for national integrated railroads

- Standard model of safety chain for risk occurrence, damage spread, and prevention measures for national integrated railroads centered on accident precursors for accident prevention
- Big data-based national integrated railway safety data standardization technology
- Big data-based national integrated railway safety data verification technology

Risk assessment technology based on big data-based accident warning

- Big data-based integration and analysis technology for national integrated railway safety data
- Big data-based prediction and evaluation technology for national integrated safety state

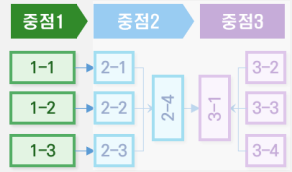
Safety policy decision-making support technology at national level

- Multi-dimensional risk information generation and risk status judgment technology at the national level
- Big data-based decision-making support technology for national safety measures considering the interconnectivity and risk information of the national integrated railway network

Big data-based SW development technology for railway safety

- Big data-based prediction, evaluation, management SW development technology for national railway safety

3-3 Data-based railway safety supervising/monitoring technology



- Developing a national safety management system for information evaluating/supervising/managing technology that enables self-inspection by operators and facility managers to improve the effectiveness of the railway safety management system and support autonomous safety improvement

Railroad safety system management/supervision/information system in accordance with railway safety management system maturity evaluation model

- Collect data of Railroad safety supervisor
- Analyze/complement data availability of railroad safety supervisor
- Deduce examination/ management category of railway safety management system
- analyze economic feasibility for each scenario

National maturity analysis technology of railroad safety management system which allows operators & Facility managers to self-examine

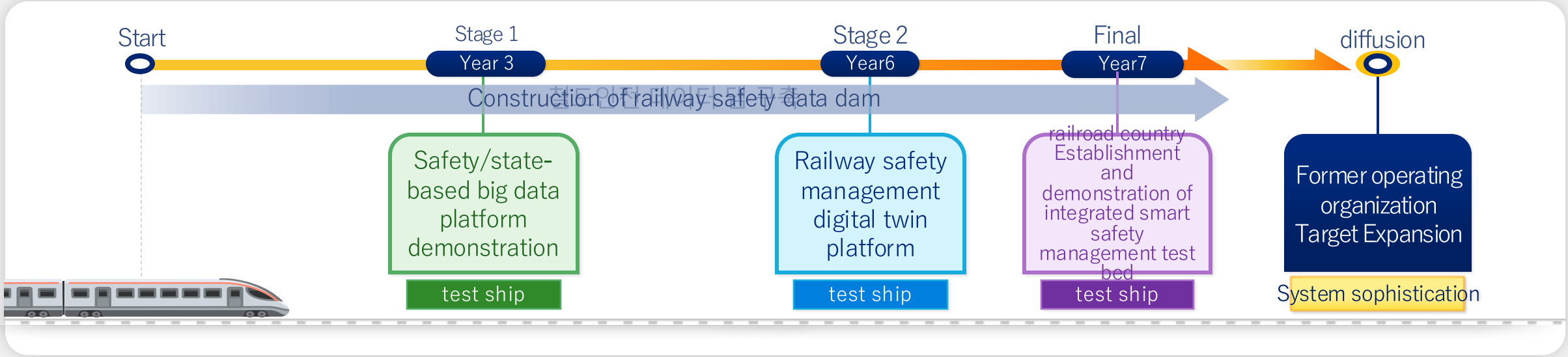
Diagnosis/evaluation technology of the maturity of system

- Railway safety management system and supervisory maturity analysis technology
- Development of a maturity diagnosis and evaluation model for national railroad safety management system

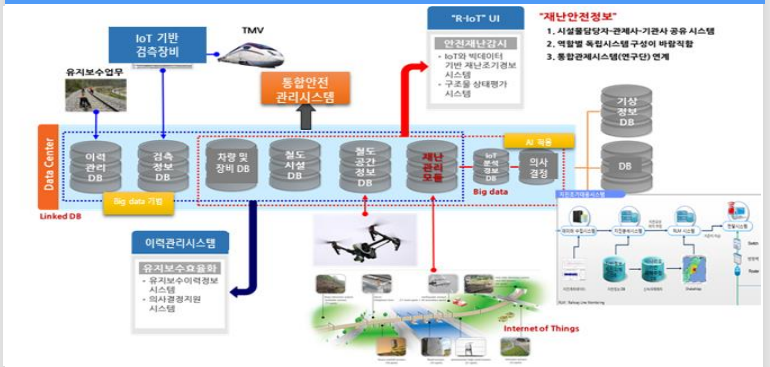
Establishment of information system that manage/supervise the railway safety system

- Establishment of unstructured big data for supervision/management of railroad safety management system, Development of risk/safety information linkage technology
- Development of text mining technology for safety-related data collected during the supervision and management of railway safety inspectors
- Development of big data-based knowledge technology from various unstructured data and risk/safety information collected during safety supervision and management
- Development of technology for deriving items for inspection and management of variable safety management systems
- Development of evidence-based railroad safety management system and tracking system technology for corrective actions after accidents
- Development of field support system for smart railroad safety management system supervision/management using mobile devices
- Development of situation mock management/supervision technology to strengthen the management/supervision capabilities of the railroad safety management system

Promotion Plan for Demonstration

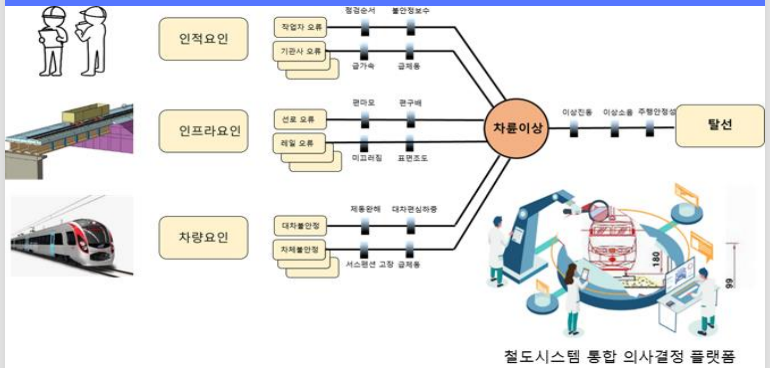


1 Step Proof



(EX) The establishment of railway facility risk factor big data & smart early response

2 Step Proof



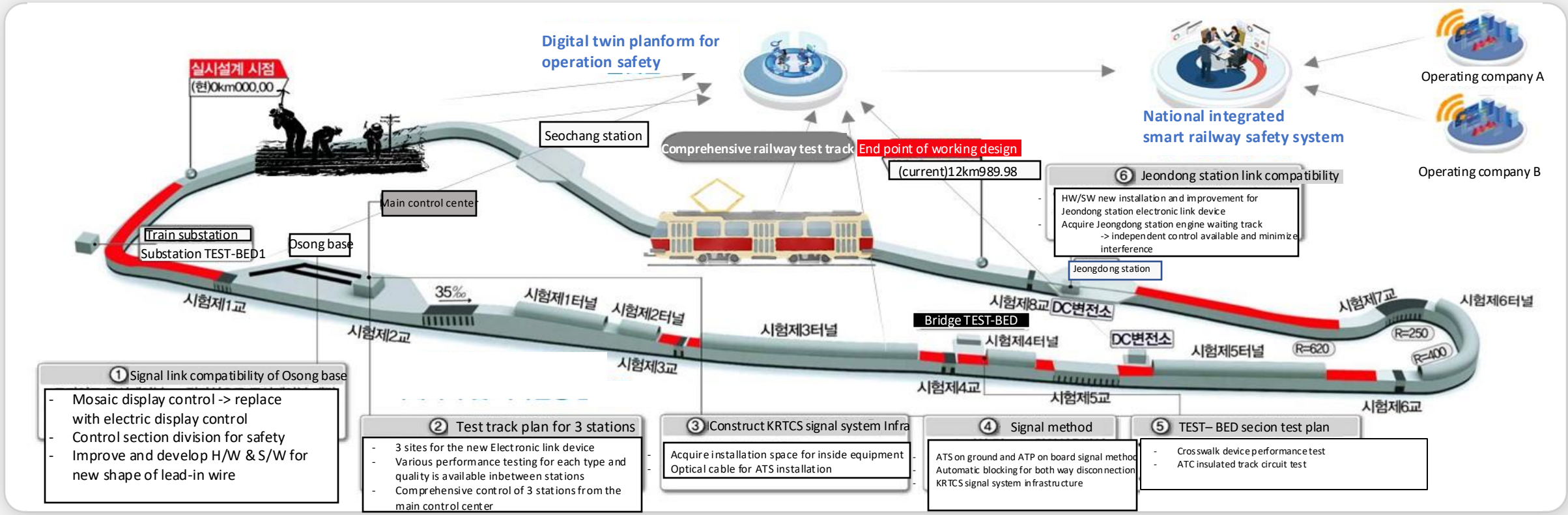
(EX) Railroad operation safety digital twin decision making platform technology

3 Step Proof

(EX) Established national integrated data system of smart railroad safety management & Testbed operation technology

Verifying the technology within the business period

Verification of the development technology by the comprehensive test about railway vehi
facilities, and workers' result of safety management using Osong Railway Comprehensive Test Track



Plan for spreading after the project

After the project is over, we'd like to promote a plan to spread it to actual operating institutions
nationwide after applying it to domestic business lines through a separate pilot project in the three-year gestation period.

- The national integrated railway safety management system technology will be managed by the government in line with the insititution

Expected results and ripple effect

Scientifical results

IoT - based railway risk factor detection technology and big data construction technology

- Constant remote data collection by introducing IoT-based data acquisition technology
- Can collect and analyze big data based on safety data in all fields such as railway vehicles, facilities, and signals

Preemptive response technology based on risk prediction analysis

- Paradigm shift from follow-up maintenance to preventive maintenance and timely/proper preventive measures technical stage
- Large contribution to developing the insufficient precise safety diagnosis technology, decision-making technology, and safety culture in Korea

Development of railway risk factor analysis technology based on AI and digital twin

- Development to the risk factor analysis technology based on event precursor bow-tie using failure tree and event tree
- Promoting the development of AI and digital twin technologies in the domestic railway sector

Development of performance prediction technology of railway system

- Can develop systematic and accurate performance prediction technology through continuous and long-term performance data collection of railway systems
- Can develop response technology based on accurate performance prediction

Expected results and ripple effect

Social/ Economical results

Reduce the costs from railway accident / disorder damage

- Reducing social cost due to accident/disorder
- Building a low-cost safe society

Reduce railway safety management costs

- Efficient distribution of national budgets for railway projects
- Reduced budget can be invested in fields such as the development of advanced railway technology

Create high value-added jobs and train manpower

- Creation of new business by creating a new railroad smart safety industry ecosystem
- Promotion of development of high skilled manpower in response to the 4th industry in the railroad sector in Korea

Reduce the damage of people by the integrated safety management

- Can reduce social costs such as human damage to the people
- Securing safety technology to respond to disasters such as earthquakes, and extreme weather such as heavy rain/snow

Thank You