

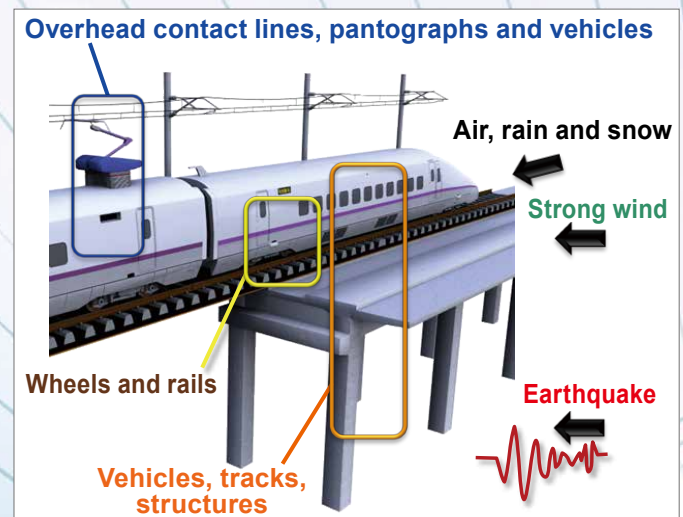
RTRI Simulation Technologies

A railway system is a dynamically complex network of structures, tracks, vehicles, overhead contact lines and other components where “railway dynamics” phenomena, in which interaction between moving vehicles and facilities on the ground plays an essential part, occur. Dynamic interaction between pantographs and overhead contact lines, between rails and wheels, between

structures and tracks and vehicles, between vehicles and the surrounding environmental elements such as air and water (rain and snow), and between other components can affect the safety, maintainability, environmental harmony, and other attributes of the railway (Coupled analysis of phenomena involving various components and elements).



Dr. Fumiaki Uehan
(General Director, Railway Dynamics Division)



Coupled analysis of phenomena involving various components and elements

Ascent No. 10 March 2022

Editor-in-chief Shun-ichi Kubo (Executive Vice President of RTRI)
Managing Editor Tetsuo Uzuka (General Director, International Division of RTRI)
Publisher Railway Technical Research Institute
Address 2-8-38 Hikari-cho, Kokubunji-shi, Tokyo 185-8540, JAPAN
URL www.rtri.or.jp/eng
Contact us International Affairs, Railway Technical Research Institute
Mail Address international_development@rtri.or.jp
Copyright ©2022 Railway Technical Research Institute All rights reserved

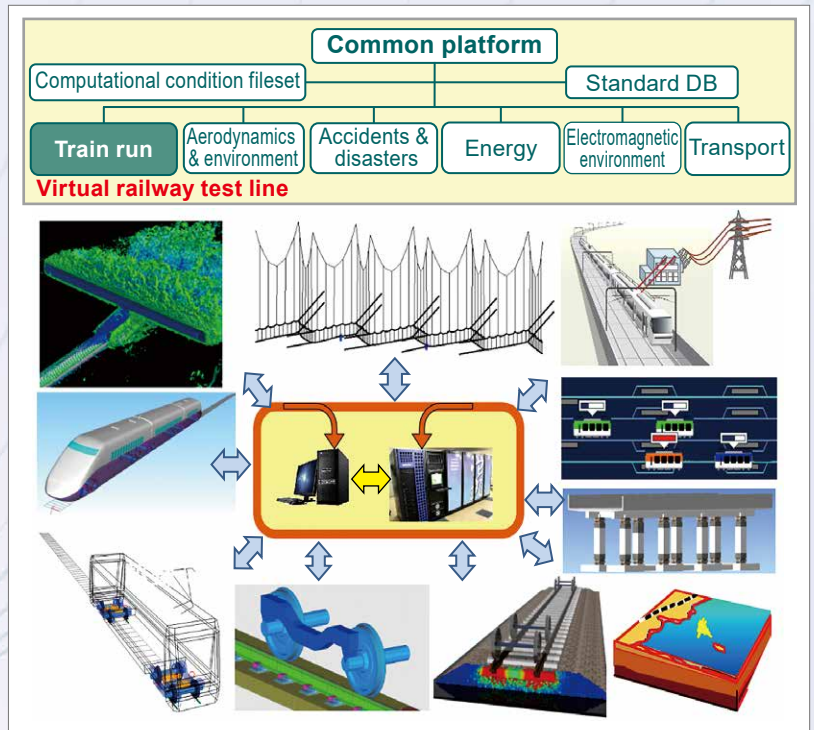
Front cover Photo: Simulation example of a bogie using a wheel with tread flat damage

RTRI has been engaging in the development of railway simulators as a tool to improve the quality and efficiency of research and development efforts and thereby help optimize railway systems and understand complex phenomena.

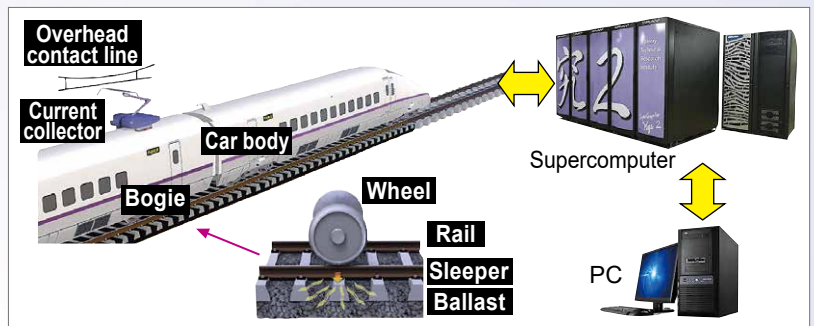
System configuration for railway simulators shows the overall configuration of the railway simulators developed by RTRI up to 2020. The railway simulators are linked to each other for research and development purposes, offering enhanced capability especially in large-scale parallel and coupled computation of multiple simulators.

Virtual railway test line

The virtual railway test line is a railway test line created in a virtual space on a computer by coupling dynamics-related train running simulation techniques (for vehicles, tracks, current collection, etc.) (Railway test line in a virtual space). The virtual test line was developed by the following process: first the train run simulation techniques were improved while techniques for coupling those simulations were studied; then techniques were developed for the simulation of vehicles and tracks capable of handling elastic tracks and car bodies (Simulation of vehicle



System configuration for railway simulators



Railway test line in a virtual space



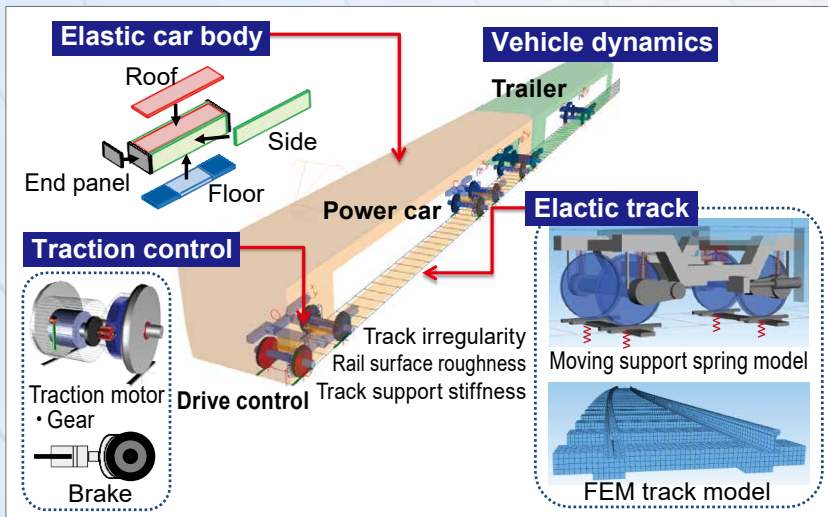
Dr. Tetsuo Uzuka
Managing Editor
(General Director, International Division)

Preface Message from the General Director Dr. Tetsuo UZUKA

Calculation and simulation are among the most fundamental elements of railway research and have been performed at RTRI for a long time.

Traditional simulation methods divide the object into small parts and calculate the (kinetic) interactions. The more recent,

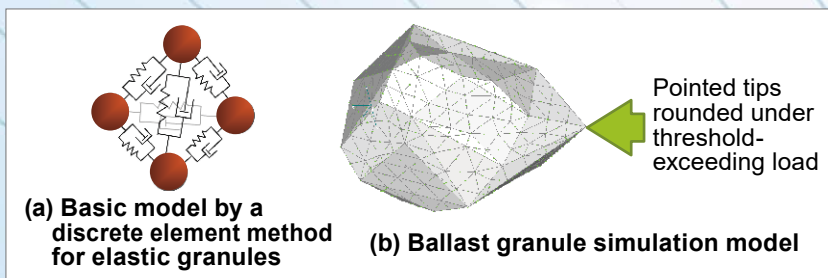
so-called Digital-Twin method reproduces and combines the coherent functions of a complete railway system within a computer. Whichever method we choose, we need to strike a balance between field testing, laboratory experimentation, and simulation.



Simulation of vehicle dynamics

dynamics), the simulation of overhead contact lines and pantographs capable of handling detailed 3D structures, the simulation of wheel/rail rolling contact capable of handling a single bogie model and the simulation of ballasted tracks capable of large-scale and long-term deterioration analyses (Modeling of ballast granules by a distinct element method for elastic granules); and finally the technique for coupling those simulations was developed.

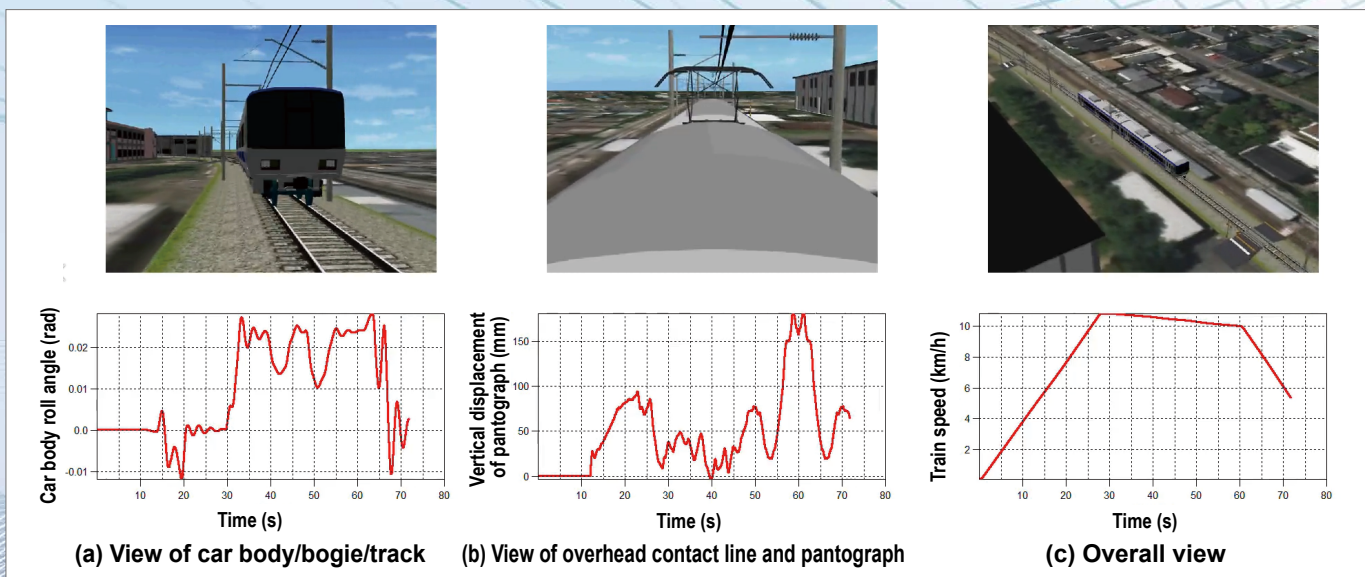
The simulation technique makes it possible to observe all necessary details from whatever angle desirable and view videos that show how vehicles, overhead contact lines, tracks and other components behave and change their behavior over a period, as if they are all real (Representation examples of results of virtual railway test line simulations).



Modeling of ballast granules by a distinct element method for elastic granules

Non-train Run Simulations

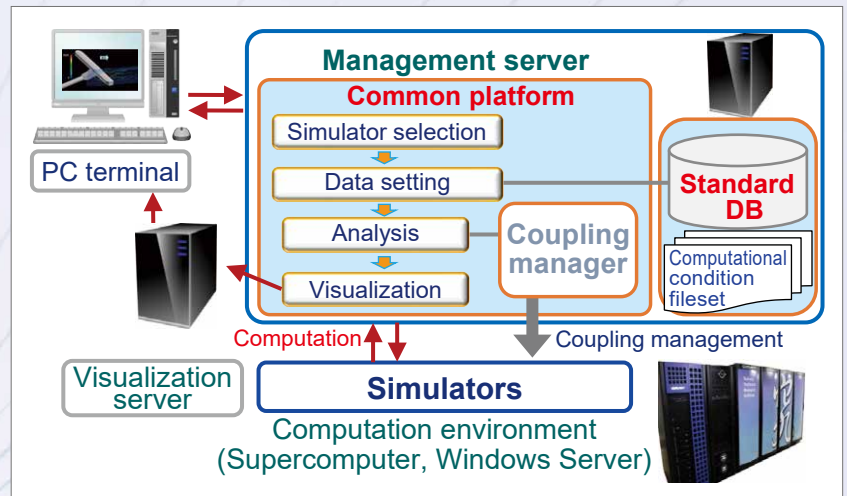
RTRI also has developed various simulation methods, including the following: The Airflow Simulation, based



Representation examples of results of virtual railway test line simulations

on the Cartesian grid method, is used to elucidate aerodynamic phenomena around the vehicles. Train Operations/ Passenger Flow Simulation is used to comprehensively evaluate advanced train control methods, including passenger flows. The Railway Communication Environment Simulation analyzes the transmission quality of communications within the railway system in an integrated manner, as well as radio noise and electromagnetic induction. The Earthquake Damage Simulation can automatically conduct modeling from faults that generate earthquakes up to structures and perform seismic response analysis.

Regarding the railway simulators, we have been configuring the system so that the various simulation methods shown so far can be executed in a unified environment (System configuration for railway simulators). The common platform built in the management server is the simulation execution environment. Simulations are executed by super computers and Windows Servers that are automatically selected for the execution. These servers are connected to each other on the network for transmission of input



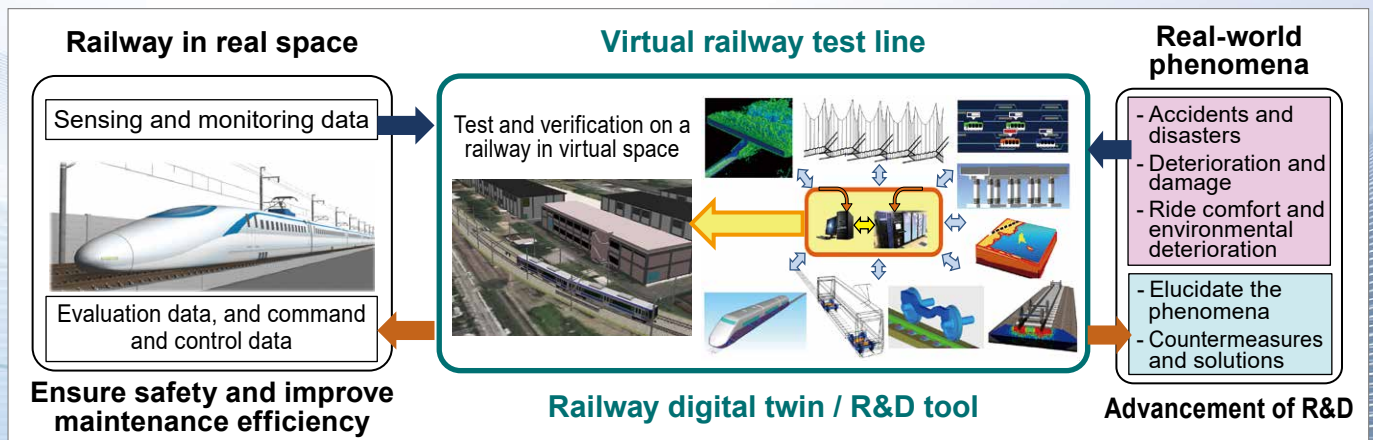
System configuration for railway simulators

and output data, program execution control and other actions. In addition, a visualization server is provided to display simulation results.

Future Railway Simulators

In the near future, we will develop railway simulators and virtual railway test lines into tools, for example, to elucidate the dynamic phenomena of railways, reproduce accidents and disasters that

cannot be tested, and grasp long-term deterioration and damage. Furthermore, we would like to operate them as railway digital twins in virtual space and develop them into tools that provide useful data for the safe operation of railways and the efficiency of maintenance by modeling main line sections and incorporating sensing and monitoring data from actual line sections in near real-time (Role of the virtual railway test line in the future).



Role of the virtual railway test line in the future