Environmental Engineering Division of the Railway Technical Research Institute

The Environmental Engineering Division, which consists of the three laboratories of Vehicle Aerodynamics, Heat and Air Flow Analysis, and Noise Analysis, conducts R&D on the wayside environment and aerodynamic phenomena. The following outlines the issues related to the wayside environment and aerodynamic phenomena and introduces the recent R&D status of RTRI related to the speeding up of the Shinkansen, which is closely related to both.

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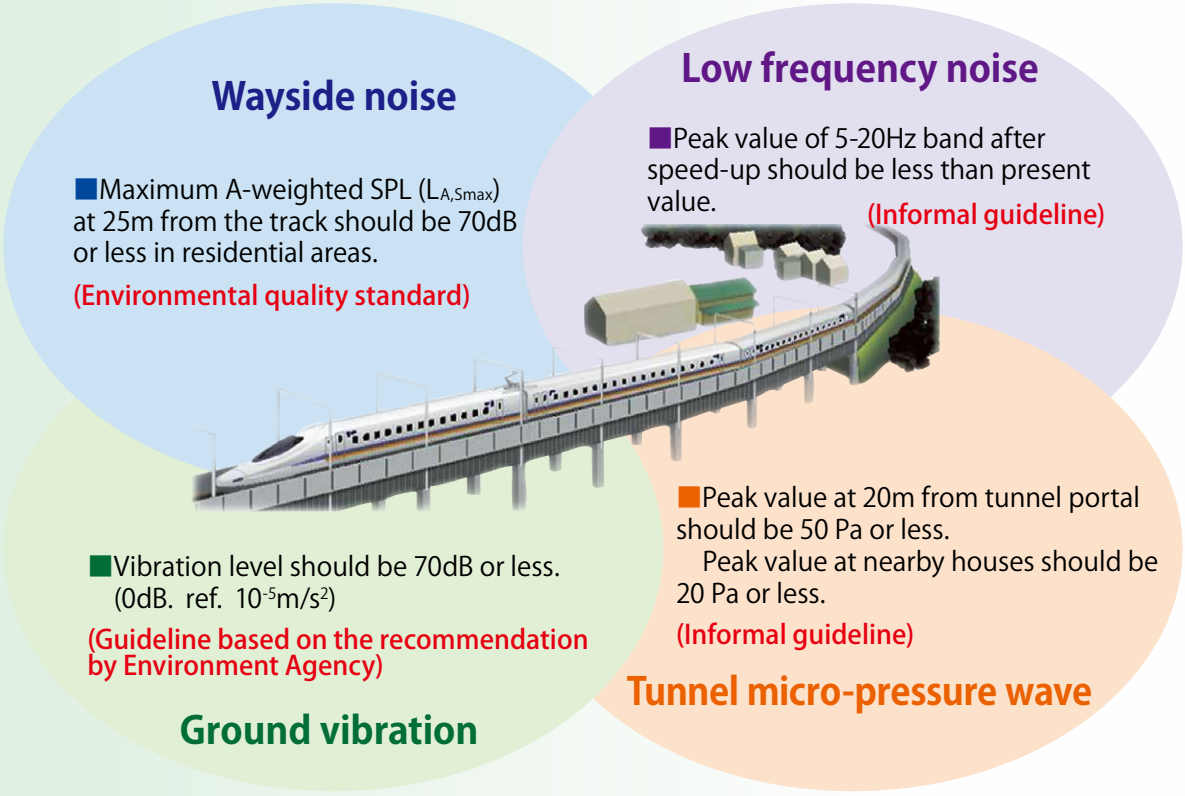
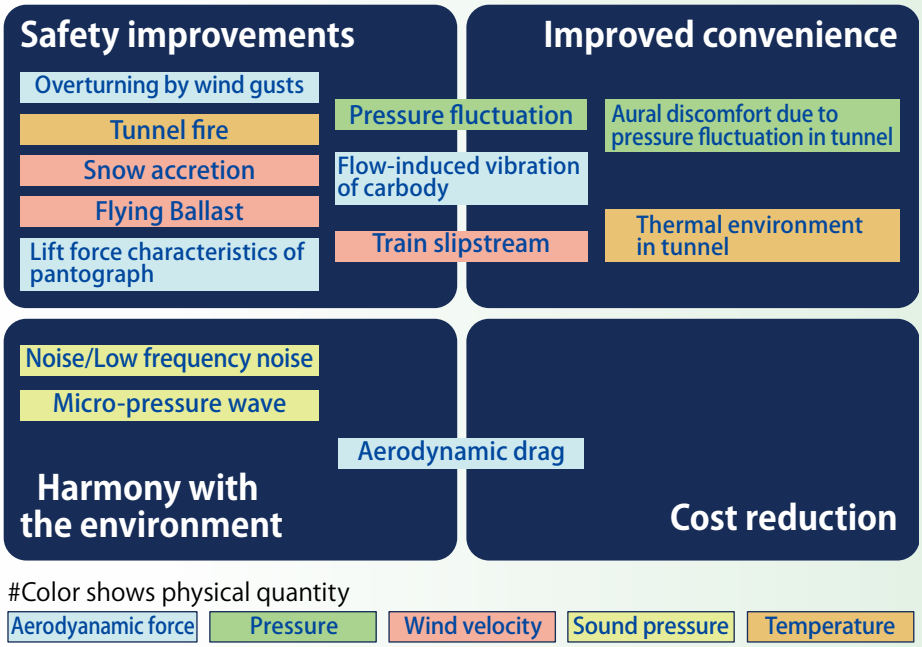


Wayside environmental issues in high-speed railways



Aerodynamic issues in railways

Wayside environmental issues in railways

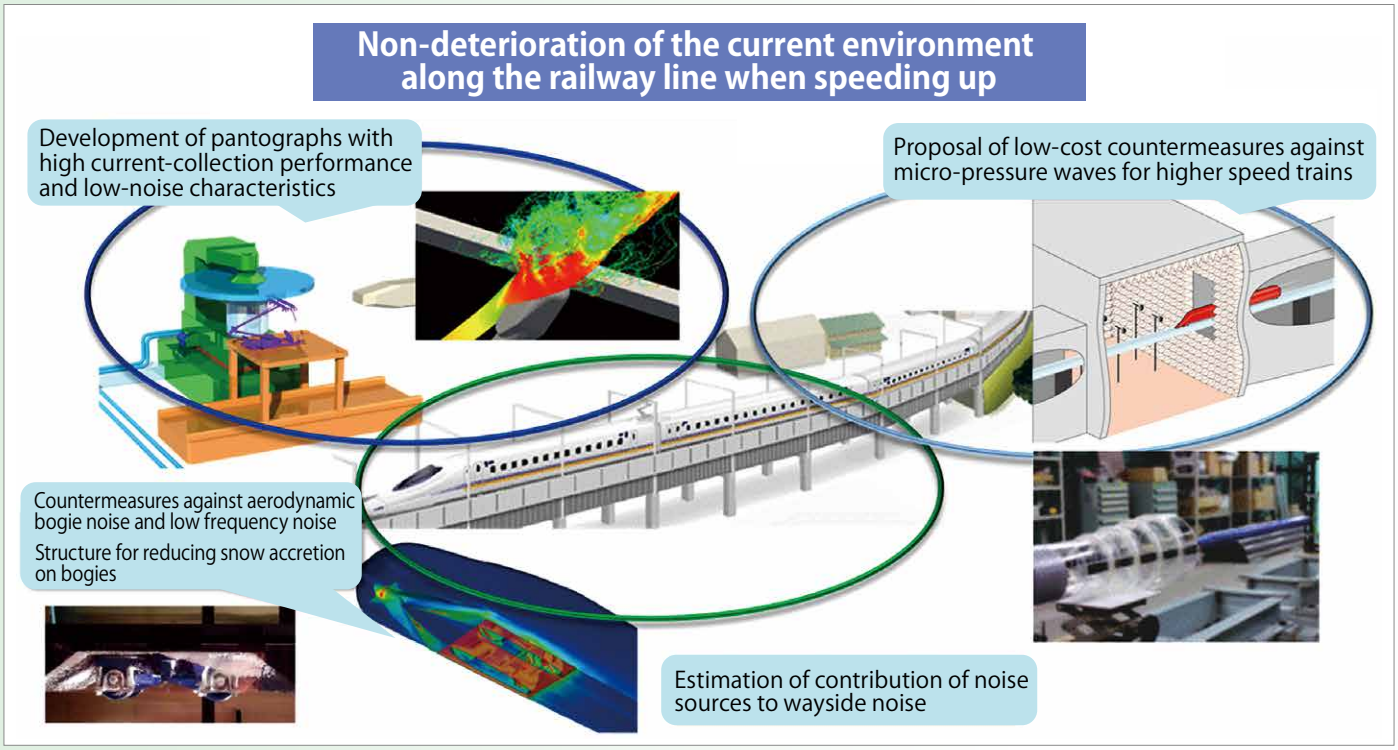
The railway offers high energy efficiency as a means of transportation, which is beneficial to the global environment, in particular for decarbonization. On the other hand, passing trains can be the cause of a range of wayside environmental issues such as acoustic noise, low-frequency sound, micro-pressure waves, and ground vibration (Wayside environmental issues in high-speed railways). Since these phenomena have a large effect on the wayside environment on routes with a large wayside population such as the Shinkansen in Japan, train operation of the Shinkansen requires that the standard values and guideline values related to these phenomena be observed. The effects of these physical phenomena increase rapidly with increasing speed; therefore, it is essential to develop technology to mitigate the environmental load in order to achieve both "the improvement of convenience by improving the vehicle speed and transport capacity" and "the maintenance and improvement of the wayside environment." RTRI is continuously conducting R&D on phenomenon elucidation and the prediction, evaluation, and reduction methods for these problems.

Aerodynamic issues in railways

As trains run through the air, the resultant interaction between the vehicles and surrounding air produces aerodynamic force acting on the vehicles and aerodynamic phenomena occurring along the wayside. More specifically, possible effects on vehicles include overturning by wind gusts, aerodynamic drag, flow-induced vibration of car body and aerodynamic lift force on pantographs. Possible phenomena along the wayside include aerodynamic noise, micro-pressure waves from tunnel exits, low frequency noise caused by passing trains, flying ballast, accretion of ice and snow, train slipstream, and other phenomena acting on wayside structures and people. In tunnel sections, phenomena such as atmospheric pressure fluctuations in the tunnel, temperature changes, and smoke flow during a fire are also added. Aerodynamic issues in railways summarizes the aerodynamic phenomena that pose issues in railways. As shown in the figure, these phenomena are related to many matters concerning the basic characteristics of railways, such as safety, convenience and comfort, harmony with the environment, and cost reduction; RTRI is continuously conducting R&D to solve issues related to these phenomena.

Efforts to improve the Shinkansen vehicle speed

Needless to say, shortening the time to arrival by increasing speed is one of the most effective measures to improve the value of railways, however, there are many issues in terms of safety, comfort, and environmental compatibility for increasing the Shinkansen vehicle speed. RTRI's mid-term master plan "RESEARCH 2025 –



Increasing Shinkansen train running speeds in harmony with the trackside environment

Research and Development for Creating the Future of Railways –" identified (1) issues with wayside noise and low-frequency sound and tunnel micro-pressure waves as those affecting the wayside environment and (2) issues with snow accretion on railway bogies as those related to safety and stability in harsh environmental conditions such as extremely cold and heavy snowfall areas. We are tackling these issues by setting a future-oriented plan, "Increasing Shinkansen train running speeds in harmony with the trackside environment" (Increasing Shinkansen train running speeds in harmony with the trackside environment).

We will utilize the test methods and numerical simulation methods that we have developed so far to promote this R&D. In particular, large-scale test equipment such as the large-scale low-noise wind tunnel, will be used. The Low-Noise Moving Model Test Facility, completed in FY2020, and the High-Speed Test Facility for Pantograph/OCL Systems (HiPaC) are unique to RTRI, and we believe that these will play a major role in promoting the research. As research products, we plan to obtain:

- the low-cost tunnel micro-pressure wave countermeasures,
- the bogie structure that reduces aerodynamic noise and low frequency noise and suppresses snow accretion,
- a pantograph that has both current collection performance and low noise,
- the sound source contribution analysis and evaluation methods for wayside noise,
- a risk assessment method for accreted and falling snow.

We plan to verify the effects of some of these through field tests in collaboration with railway operators.

Conclusion

Many of the effects of wayside environmental or aerodynamic phenomena intensify significantly as the running speed increases; therefore, this R&D is thought to become increasingly important for future increases in railway speed. To solve the issues, highly accurate current vehicle test data is indispensable in addition to utilizing advanced experimental and numerical analysis methods. Any proposed measure must be evaluated in various respects including ease of construction, cost and the possibility of inducing other physical phenomena before being put in place. We will continue to hold discussions with railway operators to elucidate phenomena and put countermeasure technologies into practical use.