August 1, 2003

Railway Technology Avalanche

Newsletter on the Latest Technologies Developed by RTRI

No. 3

Railway Technical Research Institute
2-8-38 Hikari-cho, Kokubunji-shi
Tokyo 185-8540, JAPAN

GENERAL INFORMATION

ARTICLES

The Editor Needs a Small Favor from You! Could You Please Advise Him on Whom *"Railway Technology Avalanche"* Be Sent to

"Railway Technology Avalanche," which is at you without regularity but dependently upon the progress in developing railway technologies by Railway Technical Research Institute (RTRI), would in hope be helpful to you in briefly learning what RTRI has just done, is doing, and will do so as to assist railway companies in successfully operating and managing railway service and powerfully lead the railway industry to the much more steady systems in the immediate future. The editor is sure there are some people around you, who would find the publication of *"Railway Technology Avalanche"* interesting. Therefore, could you please suggest information on the people including their names, titles as well as regular-mail and e-mail addresses to the editor at www-admin@rtri.or.jp through e-mail so that *"Railway Technology Avalanche"* can personally be at the people without any difficulty whenever published. Looking forward to being contacted by you on the matter above-mentioned.

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Foreword

Nagasawa, Hiroki
General Manager, Information & International Affairs Division

It is my pleasure to have the third issue of *"Railway Technology Avalanche"* be at you as a newsletter published by Railway Technical Research Institute. As to me, I was appointed as the current title as of May 1, 2003 following Mr. Ogino, who is the last General Manager at this division, and have been encouraging the successful publication of the newsletter. In any event, I wish you would be satisfied with *"Railway Technology Avalanche."*

Well, you may well say, to make railways selected as a transport system by a number of customers, the advantages of railways should be intensified while the disadvantages should be conquered. Technical improvement and development are one of the most important measures for this purpose. As a matter of fact, railway lines naturally stay in conditions dependent upon local circumstances, however, we should make an effort in positively solving the subjects which are shared by a lot of railway organizations at the same time. Therefore, interchange of information between different organizations accelerates technical progress and brings triumph of railways over other transport systems. I hope *"Railway Technology Avalanche,"* which is even a sort of brief note, can promote opportunities for the interchange of information.

Nagasawa, Hiroki, PhD

Visit Us through *Rail. Tech. Avalanche*

Sakai, Hiroyuki
Editor, *Rail. Tech. Avalanche*

As already introduced in the last number of *"Railway Technology Avalanche*," you can see us by turning over to the page in which *"Visit Us through Rail. Tech. Avalanche*" appears whenever receiving the newsletter issued not on a regular basis but opportunely to mention the current state of railway technologies developed by Railway Technical Research Institute. Through this page, you can casually drop by our facilities furnished in the institute. Therefore, please find a few minutes and then join the brief tour planned only for you in the premises of the institute. At this time, let us take you to the Pantograph Testing Machine. Enjoy your time with us!

PANTOGRAPH TESTING MACHINE

Outline. The pantograph testing machine is used for measurement and performance tests as given in Table 1.

Table 1. What Can Be Performed with the Pantograph Testing Machine

Measurement of pantograph compliance characteristics
Measurement of contact loss rate (up to 300 km h^{-1})
Endurance test
Current sending test (up to 400 A)

Features. The pantograph testing machine consists of a pantograph vibrating table and a rotary disk with a 10-m long steel trolley wire installed along its circumference. The rotary disk and the pantograph under test are independently vibrated to simulate changes in the height of the trolley wire and vibration of rolling stock for tests at 300 km h^{-1} with the pantograph passing a current up to 400 A.

Table 2. Major Dimensions

-Rotary disk	
Speed	Peripheral speed 35 to 300 km h^{-1}
Lateral motion	Amplitude ±200 mm, period about 30 s
Vertical motion	Amplitude, maximum ±35 mm (depending on the frequency); frequency, 0 to 17 Hz
Unevenness of trolley wire	Wavelength, 10 steps from 100 to 500 mm; wave height, 5 steps from p-p 0.5 to 5.0 mm
-Pantograph vibrating table	
Maximum load	300 kg
Maximum lift	1600 mm
Vertical motion	Amplitude, maximum ±35 mm (depending on the frequency); frequency, 0.5 to 10 Hz
Longitudinal motion	Amplitude, maximum ±5 mm; frequency, 3 to 25 Hz
-Current capacity	100, 200, 300, and 400 A at 100 V (AC or DC optional)

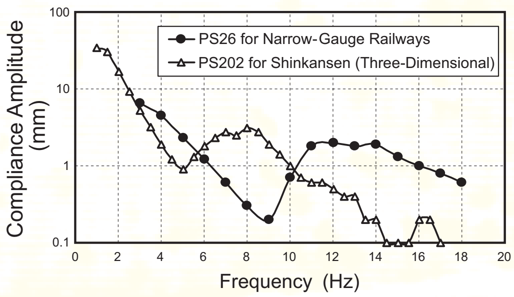

Figure 1. Appearance. Most of the pantographs used by Japan Railway companies are tested on this pantograph testing machine, which is only one of its kind in Japan, to confirm the basic performance at the developmental stage. This testing machine also enables tests against impacts and under accident-simulating conditions which cannot be reproduced in field tests.

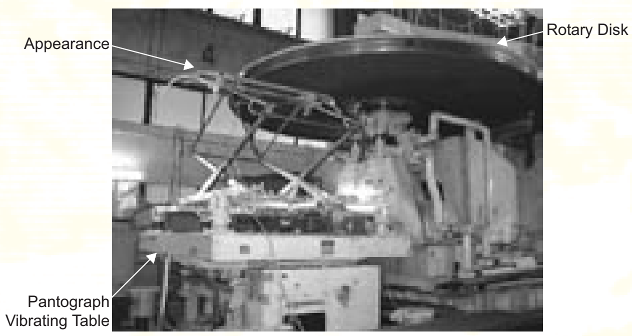

Figure 2. An Example of the Measurement of Pantograph Compliance Amplitude.

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Tanaka, Hiroshi
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CyberRail, Concept and Future

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CyberRail is a business model in dealing railway-service-related information that has been developed to facilitate passenger travel while improving the efficiency and business opportunities for railway operators. The basic concept of CyberRail is not to offer mass public transport, but to offer tailor-made transport choices centered on railways.

The virtual assistant and ubiquitous travelling companion functions of the CyberRail system, which is one of the key features, will require a central and distributed IT system with duplex communications functions for providing and displaying information, which is available everywhere and anytime, when contacted by passengers. This function is realized through an abstract concept called a "Tag." The Tag should be invisible, omnipresent, and unconscious from the view point of ubiquitous computation.

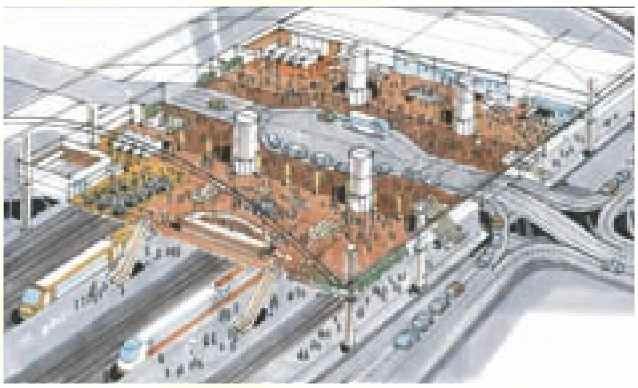

Figure 1. Image of Future Intermodal Transport Station.

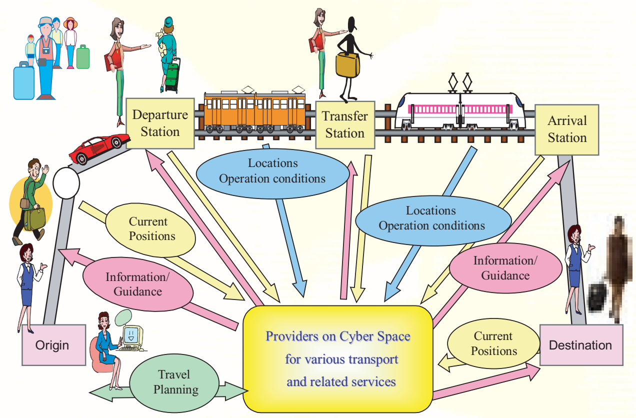

Figure 2. Travel by CyberRail.

Let us explain what happens in a CyberRail world. A passenger asks the system how to travel from a place to another. CyberRail conducts him/her on the way to reach the destination and does necessary arrangements including seat reservations. Once this set-up has been completed, CyberRail could remind the traveler at the proper timing to do the next action in a travel chain and inform him/her of the current status of traffic, etc. As the system recognizes the passenger profile, destination, and current location, the concept of tickets would be changed. In other words, a piece of guidance or advice is the start of the travel contract. The system could provide appropriate and customized information, particularly for "handicapped and elderly travelers." Considering the expeditious development of ubiquitous computing technology, functions of CyberRail will become more and more realistic. These are a sort of the proof how our visions and assessment of IT development are correct and appropriate and how precisely we predict the future transport trend.

We have established a special interest group (SIG) on CyberRail in Japan. In this context, an experiment will begin in 2003 spring. One railway company in the Tokyo Metropolitan Area has commenced an information providing service to passengers, called Goopas, which sends e-mails to customer's mobile phones, at the timing when they pass automatic ticket collection gates. E-mails carry related information dependent upon the interests of the passenger, such as shops, restaurants, events of the town, daily news, and short topics of the day. We are planning to build a part of the CyberRail functions making use of this system. Please visit our Web-page on the CyberRail: http://cyberrail.rtri.or.jp/english/

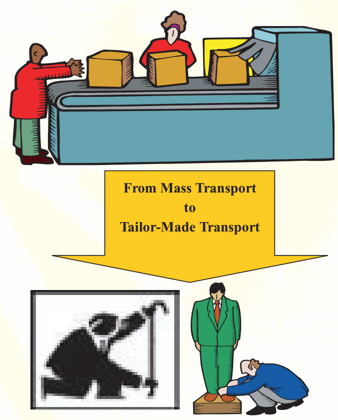

Figure 3. Changing from Mass Transport to Tailor-Made Transport.

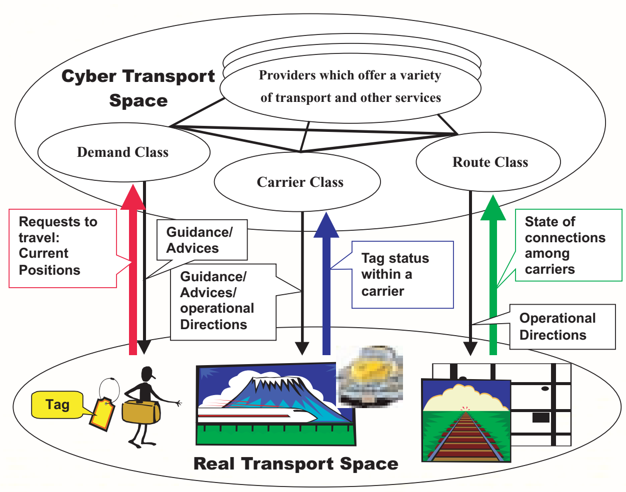

Figure 4. CyberRail Conceptual Model.

Development of Algorithm to Calculate Energy Saving Train Performance Curve

Tomii, Norio
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BACKGROUND AND PURPOSE

The power consumption by seven Japan Railway companies amounts to about 13 billion kW or about 125 trillion Japanese yen (Fig. 1). It is desired, therefore, to cut the power consumption and its cost in train operation, which requires a train operation pattern to minimize energy consumption by using the existing rolling stock with the operation time between stations kept unchanged. What is the purpose of this study is to develop an algorithm to design the train operation pattern (energy-saving train performance curve) at the minimum power consumption.

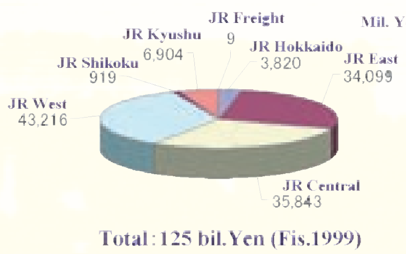

Figure 1. Expenditure on Electricity Consumption of JR Companies.

ESTIMATION AND EVALUATION OF POWER CONSUMPTION

To develop the algorithm to calculate an energy-saving train performance curve, the technique to estimate the power consumption in train operation is required. Although the method to approximately calculate power consumption dependent on the train-performance curve has been known, there have been few studies to evaluate the precision of the curve estimated by cross-checking it with field test results. In this study, the author developed a power-consumption calculating method by applying a loss coefficient, the power consumption by auxiliary machines, and the know-how to the calculating formula introduced based on the rolling stock control theory, and then compared the energy consumption obtained through the method with measurements in field tests. As a result, it was found that the method was capable of estimating power consumption at high precision with small errors of about 2%.

ALGORITHM TO CALCULATE THE ENERGY SAVING TRAIN PERFORMANCE CURVE

The author developed an algorithm to create the train operation pattern (train performance curve) at the minimum energy consumption based on the information given on operation times between stations, rolling stock performance, and track condition.

Conventional studies in this field were mostly to acquire knowledge on the theoretical features of the energy-saving train performance curve under ideal conditions or on the algorithm to determine one that is applicable to actual train operation. There has been no algorithm that is capable of creating an energy-saving train performance curve on a real time basis for sections where complicated and frequently-changing speed limits are set. The newly developed algorithm enables highly speedy data-processing to meet this requirement by using onboard devices.

EVALUATION RESULTS

The author analyzed the operation of a revenue service train running on a line in a coastal area studded with a number of speed limits for curves, calculated the corresponding operation pattern for the train by using the algorithm, and then compared the measured and calculated train operation patterns to find the following.

(1) The train operation pattern significantly differs from driver to driver, which causes remarkable differences in the power consumption (Fig. 2).

(2) Figures 3 shows the train operation patterns 1 and 2 that consume the maximum and minimum amounts of power, respectively, among those observed in actual train operation and the energy-saving train operation patterns obtained by the algorithm. The latter suppresses the maximum speed and tactfully performs coasting, to cut energy consumption about 20% and 7% from that in the patterns 1 and 2, respectively, (Fig. 4).

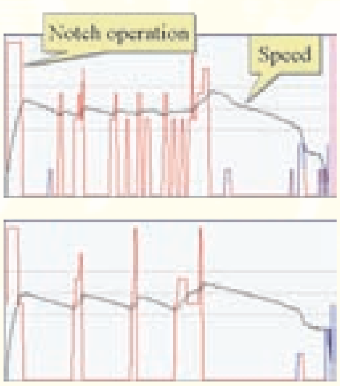

Figure 2. Difference of Driving Patterns among drivers.

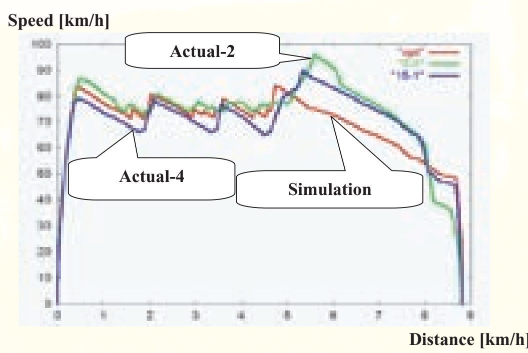

Figure 3. Comparison of Actual Train Driving Patterns and Simulation Results.

Table 1. Improvement Ratios of the Algorithm[a]

	Actual-1	Actual-2	Actual-3	Actual-4	Simulation
Running time (actual) / s	480	477	482	479	480
Energy consumption / kWh	28.2	30.5	28.0	26.1	24.2
Improvement ratio, %	14	21	14	7	---

[a] Distance, 8.8 km; car type, 731 Series; running time (specified), 480 s.

A Technique to Analyze and Predict the Shinkansen Noise Sources with Measurements

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To take effective measures to reduce the wayside noise of Shinkansen, it is important to develop a technique to analyze and predict noise sources at high precision.

As a means to analyze the noise sources of Shinkansen, allay-typed directional microphones are widely used to determine the distribution of noise sources in the longitudinal direction of Shinkansen cars, and provide profound knowledge on the noise sources. Based on this information, the author has classified the noise elements of the Shinkansen cars into those of the current collection system, car substructure, car superstructure, and structure of viaducts. Furthermore, the author established a measure to calculate the contribution of each noise source to the noise level at the measuring point. See Fig. 1. This measure determined the structure noise originated from the noise directly under a viaduct where the object train runs in consideration of the distance attenuation characteristics at the evaluation point first, and then separated the noise generated from the current collecting system by using the noise measured with an allay-typed directional microphone and an appropriate noise source model from the noise after structure noise removed therefrom. In this manner, noise sources are separated one by one. Figure 2 compares measured and calculated values of time history of the total noise level at the time-weighted characteristic S measured with a non-directional microphone at a 25 m-distant point, to prove that there is good agreement in between. Figure 2 also shows the component noise level of different noise sources. This fact verifies that the array of noise sources thus obtained appropriately expresses the distribution of noise sources of Shinkansen cars.

The author applied this technique to noise measurements, determined the contribution and characteristics of each noise source, and subsequently established a method to predict the noise level of Shinkansen cars based on an energy-base calculation model (Fig. 3). By this method, it becomes available to expect the noise levels of Shinkansen cars in service by inputting the conditions of track, structures, and train speed (Table 1). Application of an energy-base calculation model enables estimating not only the maximum noise level of the time-weighted characteristic S ($L_{pA,Smax}$), but also single noise exposure level (L_{AE}) and equivalent noise level ($L_{Aeq,T}$). In calculating such evaluated values, it is a rule to determine changes in the time series in the noise at the receiving point when the noise source moves (unit patterns) and its integrated value with respect to time. When the noise sources of Shinkansen cars are regarded as an array of a finite number of discrete noise sources, L_{AE} is the sum of the integrated values with respect to time of all unit patterns.

Statistical analysis of predicted and measured values indicates that the average value of the difference in between is 0.7 dB and the standard deviation is 1.5 dB, to prove that the technique can predict noise levels at sufficiently high precision (Fig. 4).

There are several subjects to be addressed in the future, including the review of power levels under different conditions, a technique to estimate the noise level near the tunnel entrance and when the structure profile changes into the longitudinal direction along the track, and introduction of a more detailed sound propagation model.

Table 1. Extent of Application of the Prediction Model

Type of car	All Shinkansen cars in operation
Velocity	150-km h^{-1} maximum velocity in operation
Track	Ballast track, slab track, and vibration-reducing track
Construction	Concrete bridge structure and embankment
Sound barrier	Straight type with or without absorbing materials
Measuring point	At the point at a horizontal distance of 12.5 to 50 m from the track and at a height lower than the upper end of the sound barrier

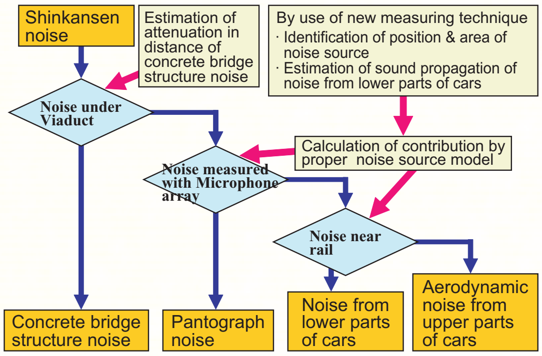

Figure 1. Method of Noise Analysis.

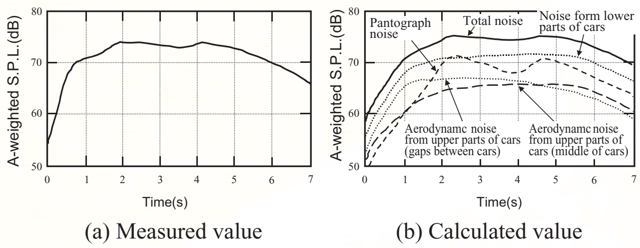

Figure 2. Comparison of measured and calculated data of time history of noise by sound level meters (25-m away from track).

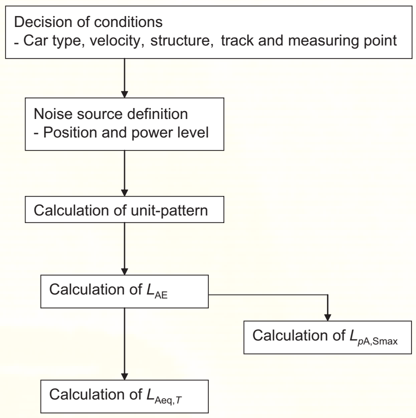

Figure 3. Flow chart of prediction model.

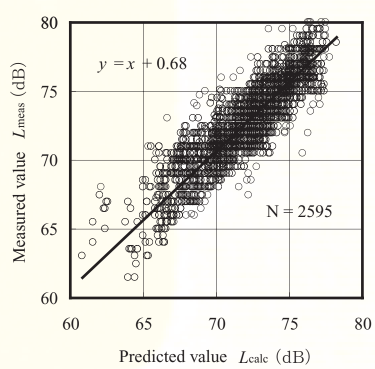

Figure 4. Result of case study.

Analysis of Aerodynamic Noise Source Distribution by Wind Tunnel Tests

Nagakura, Kiyoshi
Senior Researcher, Noise Analysis, Environmental Engineering Division

To analyze the mechanism of aerodynamic noise generated when rolling stock runs at high speed and develop noise reducing measures, it is effective to search noise sources by wind tunnel tests. A paraboloidal apparatus collecting sound that combines a microphone and a paraboloid of an ellipsoidal reflector, 1 m in diameter, has been used to search noise sources with a large-scale low-noise wind tunnel installed in Wind Tunnel Technical Center (WTTC) at Maibara as an instrument for searching noise sources since it started operation. So as to improve the precision of acoustic measurement, WTTC has developed an ellipsoidal apparatus to collect sound as a new noise-source searching instrument to replace the conventional one. This instrument has a microphone equipped at the closer focal point of the reflector, 1.7 m in diameter, that has a profile generated by rotating the part of an ellipse around its major axis to have a strong directivity for the other focal point (Fig. 1). It has substantially improved resolution, especially in high-frequency bands, to separate two 100 mm-apart sound sources in the 5 to 20 kHz band, in contrast to the conventional sound-collecting paraboloidal apparatus that was not able to separate two sound sources unless they were about 400-mm apart from each other (Fig. 2). As the frequency of aerodynamic noise in reduced scale model tests tends to shift to a higher side, the new apparatus exercises its power in the measurement in model tests in particular.

WTTC employed the ellipsoidal apparatus newly developed for collecting sound to measure the aerodynamic noise generated from a 1/5 scale Shinkansen car model and determined the detailed noise source distribution of a Shinkansen car running at high speed (Fig. 3). As a result, it was proved that the aerodynamic noise caused by railway vehicles comes mainly from the parts where local profile changes along the carbody, such as the wipers at the upper part of the head car and door handles outside the driving cab. Based on the data obtained from this test, WTTC proposed a technique to model the sources of the aerodynamic noise observed at various parts of the test model and determine their contributions to the noise level in the far field. By applying this technique to the experimental data given through the 1/5 scale Shinkansen model car test, WTTC estimated the noise level developed at various parts of Shinkansen cars except pantographs at a 25 m-distant point when it runs at 300 km h^{-1} (Fig. 4). Table 1 shows the noise levels that reflect the length of train composition and the effect of noise barriers. The Table also shows that the contribution of the aerodynamic noise at the truck is the highest, followed by that generated from the part above the gap between cars in the case of a train running on a viaduct section installed with sound barriers. The detailed distribution and contributions of noise sources thus obtained will be useful in determining the measures to reduce Shinkansen car noise.

In the past several years, a number of tests have been performed by using the large-scale low-noise wind tunnel at Maibara and similar facilities in Japan to acquire knowledge of the aerodynamic noise caused by rolling stock in wide ranges, mainly due to the information available through the high-performance wind tunnel at Maibara and refined techniques for tests and measurement. WTTC will continue wind tunnel tests, improve the technique for tests further, and promote research and development to establish wind tunnel tests as a tool to investigate and reduce the aerodynamic noise emitted by running rolling stock.

Table 1. Estimated Sound Pressure Levels of Aerodynamic Noise Generated from Individual Parts of the Shinkansen Car[a]

Noise source position	Sound pressure level / dB
Gaps between cars (upper parts)	65
Bogies	62
Driving cab doors	58
Gaps between cars (lower parts)	58
Lower parts of leading car	57

[a] Train speed, 300 km h^{-1}; train length, 200 m; measuring point, 25-m away from the track; construction, elevated viaduct with sound barriers of 2-m height.

ACKNOWLEDGEMENT

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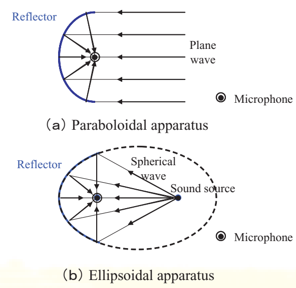

Figure 1. Principle of paraboloidal apparatus and ellipsoidal apparatus.

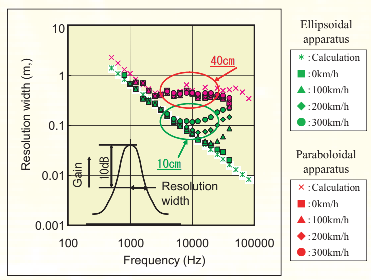

Figure 2. Resolution width of ellipsoidal apparatus and paraboloidal apparatus at different wind velocities.

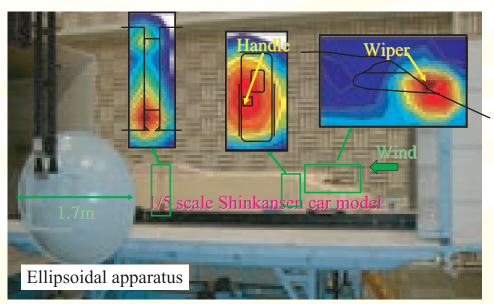

Figure 3. Noise source distribution measured by ellipsoidal apparatus.

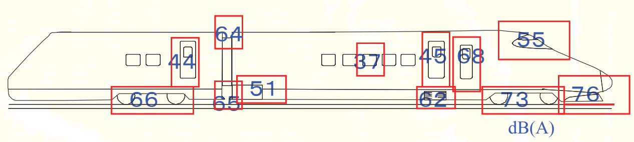

Figure 4. Estimated sound pressure levels of aerodynamic noise generated from individual parts of the Shinkansen car. Train speed, 300 km h^{-1}; measuring point, 25-m away from the track; sound barrier, not available.