Comfort and Digitalization

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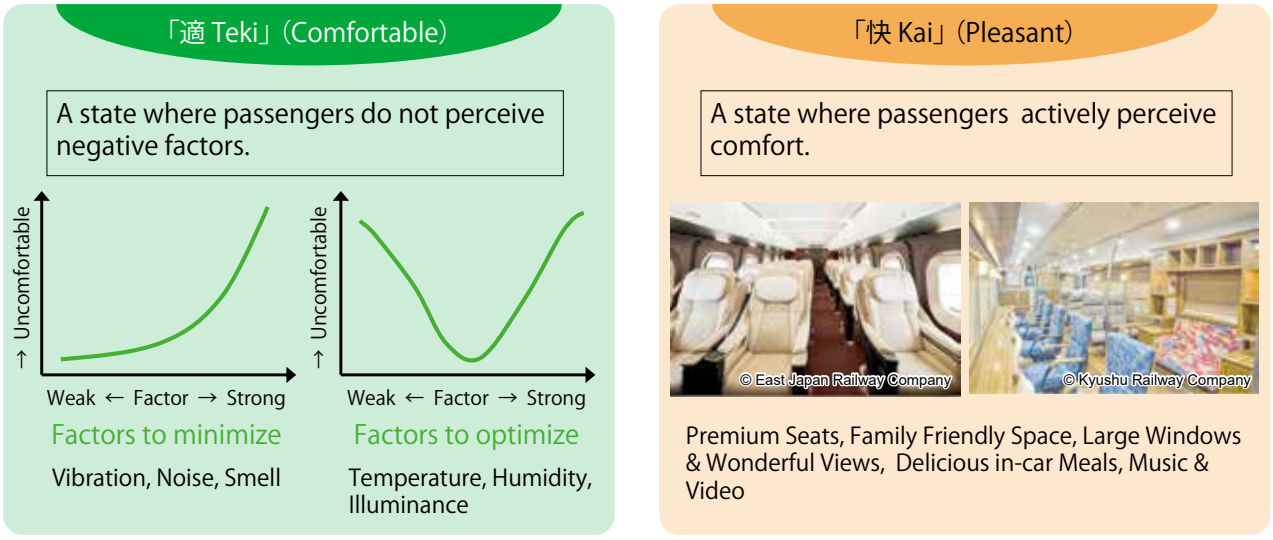
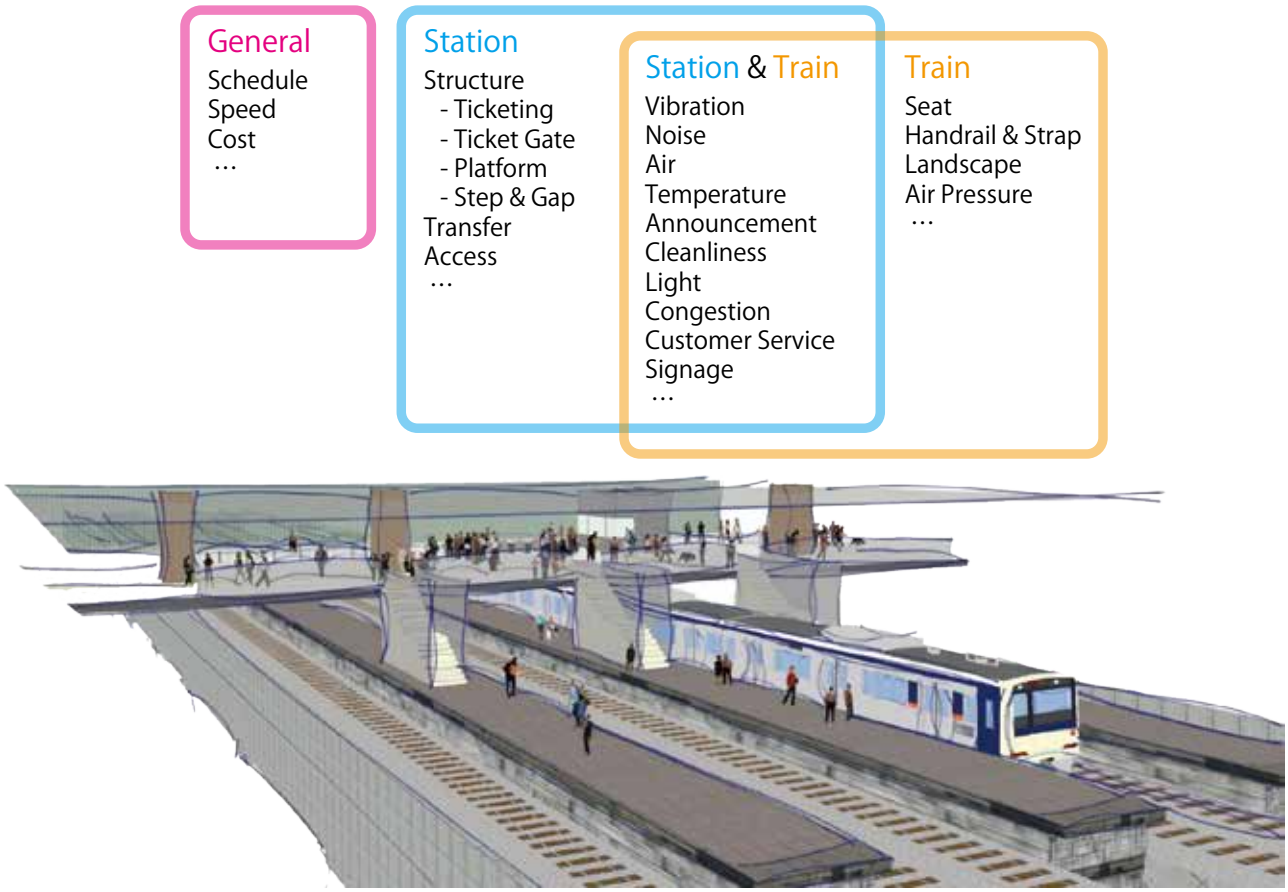
Technologies to minimize vibration and noise on trains must be developed to provide good ride comfort. It is also important to develop ways to measure the sense of comfort and discomfort of passengers because the concept of "comfort" is ambiguous. If an index of discomfort resulting from vibrations can be developed, it can be utilized to evaluate technological development aimed at minimizing that particular discomfort. To enhance the competitive edge over aircraft and expressway buses, railways have endeavored to increase speeds, improve stations, and optimize train schedules. These efforts are made through research to improve the overall comfort of passengers and to enhance customer experience at all the contact points with the railway transport service. Recently, the development of digital technologies is making it possible to further improve comfort. This article describes the basic concept of research on comfort and the direction of future efforts.

What is the Japanese word for "Comfort"?

The Japanese word for "comfort" is "Kai-Teki" (快 − 適). This word, which originally derived from a classic Chinese poem, is an important keyword in explaining the modern railway service in Japan. Let me attempt my own interpretation of this word. In English, "Pleasant" and "Comfortable" are two words with close meanings but different nuances. In Japanese, however, there are no words that can express the differences of nuances of these two English words. The word "Kai-Teki" consists of two Chinese characters with meanings close to "Comfortable." The second character "Teki" (適) also has the



Concept of "Comfort" is divided into two aspects



Factors affecting passengers' comfort/discomfort

meaning of "Proper." Here, I am venturing to define the second character "Teki" as "Comfortable" and the first character "Kai" (快) as "Pleasant." In other words, "Teki" represents a state without any uncomfortable stimulus. For example, it represents an environment on trains and at stations with reduced noise, vibration, and congestion and optimized temperature and lighting intensity; where passengers do not feel uncomfortable. These are the basic requirements to be satisfied so that efforts to increase "Teki" should form the basis of commuter transport. On the other hand, "Kai" represents a state in which pleasures are provided positively on trains and at stations, such as premium seats, family friendly space, large windows and wonderful views, delicious in-car meals, and music and video services. This state is realized by enhanced services intended to acquire new customers or enhance customer experience. As passengers' demand for services tends to get higher as time goes by, services that were "Pleasant" in the past may be recognized to be "Comfortable" at present. Some examples of such services are Wi-Fi access and power outlets for laptops and smartphones at stations and on trains.

What has been researched

Research and development to improve comfort has been conducted in the following three sectors:

(1) On trains (vibration, noise, temperature, congestion, seats, etc.)
(2) At stations (train boarding and alighting, ease of movement, signage, announcements, etc.)
(3) In the railway usage environment (number of train services, train schedules, fare settings, access to stations, etc.)

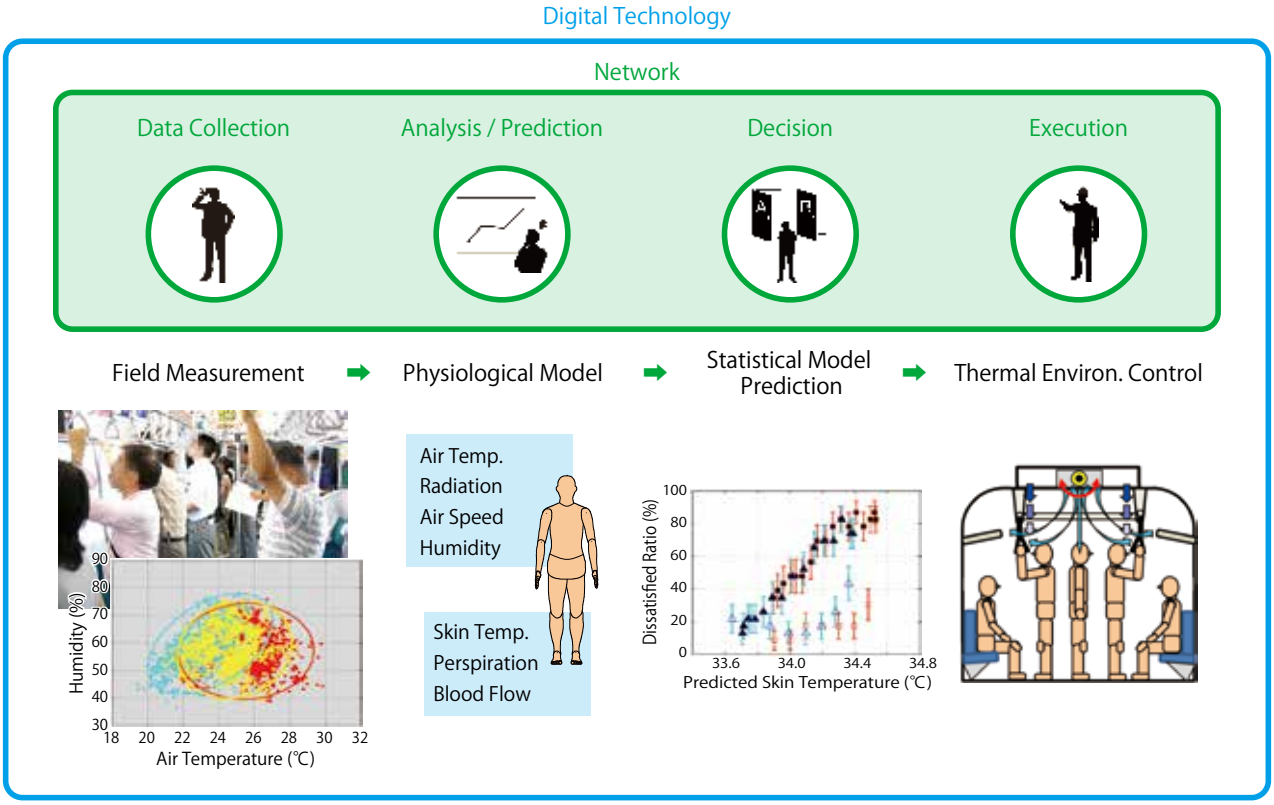
First, research and development on vibrational discomfort on trains is described as an example. Vibrations with the same physical intensity but different frequencies have different perceived intensities. Therefore, a filter that corrects the physical vibration intensities according to how they are felt by people was devised in an effort to develop an evaluation index

of ride comfort. For example, a vibration with a frequency less than one hertz is the main cause of motion sickness. A passenger survey on trains that run in mountainous sections discovered that the number of people who get motion sickness increased in sections with frequent lateral motions of approximately 0.3 Hertz. As a result, a car that prevents motion sickness can be developed if the motion of a tilting train can be controlled to avoid this frequency band. Efforts were also made in research and development to develop a vibrational discomfort index that matches how passengers feel and helps with track management and to discover ratios of factors such as vibration, noise, seat design, and views that have impact on the overall comfort on trains.

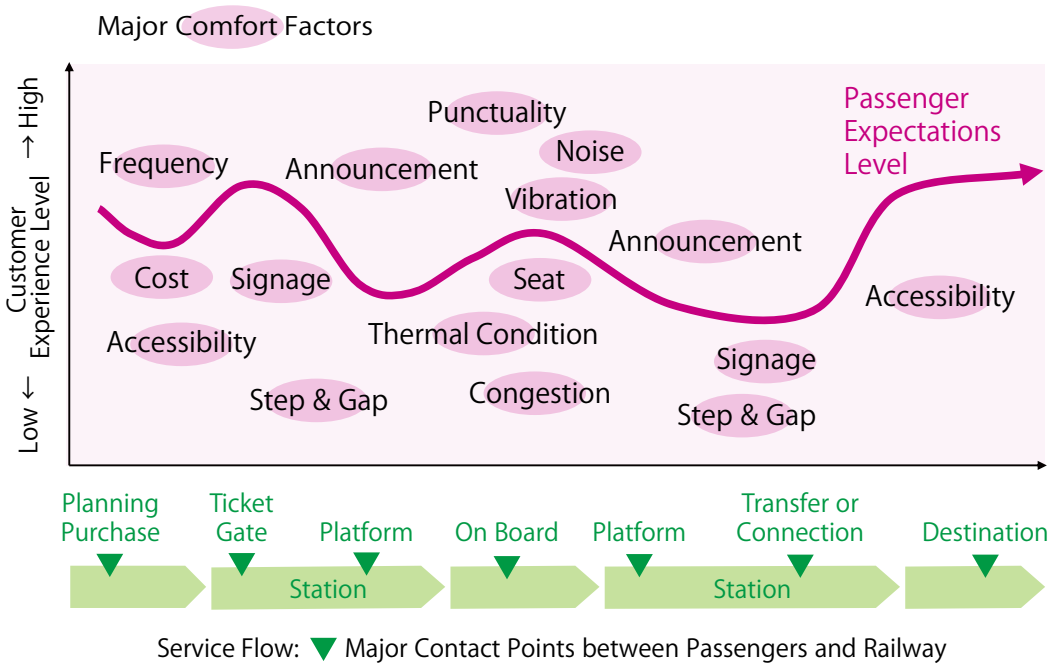
For stations, an evaluation index for difficulty of walking on the premises was developed. A simulation was also developed to visualize the flow of passengers. Efforts were also made to develop evaluation indexes of ease of listening to announcements and overall comfort of station space. Although trains operation are very frequently in Japan, congestions and delays still occur in the morning and evening. Research and development have also been conducted to quantify the degree of discomfort due to congestions and delays and optimize train schedules to adjust train intervals and level out congestion. Whereas the main approach to the study of comfort was to develop evaluation indexes and utilize them in improvement measures, the recent development of digital technologies is enabling further development.

Enhancement of customer experience by use of digital technologies

Digitalization refers to conversion of continuous analog quantities to discrete digital quantities. However, recent advancement and cost-reduction of sensors, computers, and networks have expanded the concept of digitalization. Digital data stored on computers and shared over a network is used for the sake of prompt and precise identification,



An example of utilizing digital technology for the control of thermal comfort



Examples of major comfort factors for enhancing customer experience

analysis, prediction, and judgment of system states. This process is called digitalization of operations. Whereas RTRI has already promoted digitalization efforts in the safety and maintenance sectors, digitalization can also be applied to the study of comfort.

The operational reform based on digitalization is conducted as follows: (1) Various factors that have impact on comfort at stations and on trains are converted into digital data and collected over a network (Data Collection); (2) Collected data are analyzed to reproduce the degrees of comfort in a digital model and identify and predict states (Analysis and Prediction); and (3) Methods for further enhancing degrees of comfort are formulated (Decision) to control the environments precisely (Execution).

For example, the thermal environments at stations and on trains change according to the temperature, humidity, radiation, air speed, and congestion. These are analyzed precisely to realize an optimal thermal environment. This is the digitalization of thermal comfort. Conventionally, the thermal environment on trains is controlled by conductors. However, thermal environment control by introduction of digital technologies is indispensable in the light of the future introduction of unattended- train operations. For vibration factors, the introduction of active vibration control technology by detection of vibration states of trains is under way. Moreover, the control based on digital technologies can also be applied to other factors such as ease of listening to announcements, glare of sunlight, air quality and odors.

The sense of satisfaction of passengers is influenced by the physical factors and customer services at all contact points, such as reservation and purchase of tickets, passage through ticket gates and movement on station premises, waiting time on platforms, train boarding and alighting, and environments on trains. In the future, RTRI will promote the efforts not only to improve the individual contact points but also to integrate the contact points to enhance the customer experience and thus improve the superiority of railways.