Experiments using various types of real doors were conducted in order to understand the reasons why "people get stuck in doors" and what needs to be done in order to prevent such accidents. As a result of these experiments, a lot of information has been obtained.

What led to undertaking these experiments was the accident that occurred in March this year (2004) in which a child got stuck and killed in a large revolving door at the Mori Building in Roppongi. Many people believe this accident to have occurred as a result of defects in the design and use of the door and the fact that the risk was left unattended. However, I cannot help but think that the cause is in the fact that despite the "interrelationship of machines and humans" having changed, people interrelate to machines without realizing that such a change has occurred. For this reason, I decided to initiate a "door project" using various types of doors in order to elucidate the phenomenon of "people getting stuck in doors" in terms of the science of dynamics.

In the door project, the cooperation of JR East Group was obtained and a model experiment of a person getting stuck in the door of a train was conducted. The loads that are exerted when a person gets stuck in a double door of normal trains and in the single door of Shinkansen trains, were measured in order to verify what happens when a person or a baby buggy gets stuck in such doors. It is found through the experiment that when the wheels of a baby buggy get stuck in a door an extremely dangerous situation will occur. When the front wheels of a baby buggy get stuck in a double door, depending on the type of baby buggy, the lamp that indicates that the train should not depart will go off despite the fact that the front wheels of the baby buggy were still stuck. Looking more closely, it was found that while the top part of the door was fully closed, there was a gap of slightly more than one centimeter at the lower part of the door. In this state, the lamp indicating that the train should not depart will go off even when the wheel is still stuck (Figure 1).

On the other hand, in the case of doors on Shinkansen trains, there is additional lateral pressure exerted after the door closes in order to maintain air tightness. Learning from past accidents, the additional pressure is exerted after the train leaves the station and picks up speed. However, in order to exert this additional pressure, the width of the groove is made larger than the thickness of the door. With some baby buggies the wheels fit completely in this gap and the door closes.

Fig1: When the width of the axis of the front wheels of the baby buggy is narrow, the lamp indicating that the train should not depart will go off even when the wheel is stuck in the door.
which consider the changing behavior of users with respect to the facilities of the station as a whole will need to be reviewed. Devices realistic. Furthermore, in addition to schemes regarding the train, the concepts and take the necessary steps in order for any solution to be dangerous behavior, the railway personnel will need to change their mothers themselves need to understand the risks and avoid of the door is closed could be adopted on the train. Again, while the lower part of the door in order to prevent the lamp that indicates that the train should not depart from going off even if the upper part of the door is closed, the train will depart with the baby buggy and child still stuck to the door.

From the above, it can be seen that, in order to achieve a truly safe railway system, there are "things that need to be changed" and "things that must not be changed".

One "thing that needs to be changed" is the awareness of railway personnel that the behavior pattern of users has changed. One occasionally sees a mother with a baby buggy rushing to a train that is about to depart in an effort to board the train in time. Railway personnel make announcements and put up posters in the stations to catch the attention of such people in order to prevent such behavior. But such efforts have not been successful in reducing the number of mothers who rush onto trains with a baby buggy. This is believed to be due to the fact that the "scope of human perception of risk" has changed. The mother believes that the door of the train will not close if the wheels of the baby buggy get stuck in the door; therefore, the train will not depart. It is for this reason that they rush onto a train that is about to depart. Since they think that "something that is automatic is naturally safe" and since the "scope of human perception of risk" has changed, railway personnel will be unable to take realistic steps unless they realize that the thinking and behavior pattern of the users have also changed. While catching the attention of users is certainly important, it is more important to introduce a scheme whereby the lamp that indicates that the train should not depart will not go off when a baby buggy is stuck in the door with respect to both the train itself and the baby buggy. With respect to the baby buggy, the width of the wheels may be made wider to prevent the door from closing. Furthermore, a system for detecting the state of the lower part of the door in order to prevent the lamp that indicates that the train should not depart from going off even if the upper part of the door is closed could be adopted on the train. Again, while the mothers themselves need to understand the risks and avoid dangerous behavior, the railway personnel will need to change their concepts and take the necessary steps in order for any solution to be realistic. Furthermore, in addition to schemes regarding the train, the facilities of the station as a whole will need to be reviewed. Devices which consider the changing behavior of users with respect to the gap between the trains and the platform and methods of using escalators and elevators are required. It is necessary to develop awareness of the changing behavior pattern of all users not only of mothers with baby buggies.

There are also "things that must not be changed". This means that "simplistic honest efforts are important". In order to ensure that the train does not depart with a baby buggy stuck in the door, it is necessary that the conductor of the train and station personnel do not neglect careful oversight.

There are cases in which efforts that were simplistically honest led to success. One such case is the derailment of a Shinkansen train as a result of the Chuetsu Earthquake in Niigata Prefecture. The media has reported that about 30 Shinkansen bridge piers were damaged as a result of the Miyagi Earthquake that occurred in the summer of last year. JR East Group reviewed the safety standards of elevated bridges and it was reported by the media that the company reinforced about 3,000 bridge piers in the past year. This is believed to be the most significant reason why despite the derailment of the Shinkansen train, no fatality or serious injury occurred in Niigata. Despite the hop, skip and jump behavior of the train (that is assumed to have occurred) due to the vertical and horizontal seismic movement, the train moved straight ahead and finally succeeded in landing safely. If the elevated bridge had been seriously damaged or destroyed and the rails had been bent, the derailment would not have been as it turned out to be. It can be assumed that the first car would have blocked the route by landing sideways and the cars behind the first car would have collided into this first car as was the case in an intercity train derailment in Germany several years ago. I think such a serious accident did not occur because the elevated bridges were carefully reviewed and the simplistically honest effort was taken to prevent intense damage as a result of a large earthquake.

Things that "must not be changed" are continuous efforts of this sort. Intense effort is required to ensure the safe operation of a railway system. It is to be hoped that awareness of "things that need to be changed" and "things that must not be changed" will remain into the future. The author has looked at things from the perspective of "change" for many years and compiled the need for "change" in a book titled "Changing! The Technique of Thinking." Just as "changing" is important, there are also "things that must not change".