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ARTICLES

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Foreword

Katsuyoshi UEYAMA
General Manager, Research & Development Promotion Division

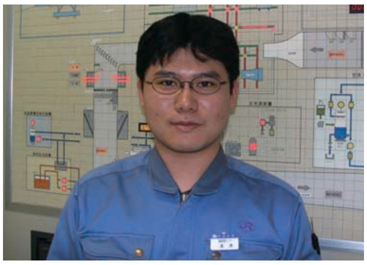
This is the 7th issue of *Railway Technology Avalanche*. We brought out the first publication of this newsletter in January 2003, with the aim of providing speedy, succinct reports on the research and development carried out at Railway Technical Research Institute, Japan Railways (RTRI) to people involved in railways throughout the world. Topics appearing in this newsletter are selected jointly by the Research & Development Promotion Division and International Affairs at Information & International Affairs Division in RTRI. The present articles are on Maglev systems and human sciences. I eagerly hope that readers will find these topics interesting.

RTRI has managed research and development in accordance with the five-year plan "RESEARCH21," which started in April 2000 and will end in March 2005. One of the work frames in the plan is R&D for the future railways. This work year or in 2004, which marks the last year of the five-year plan, we are compiling the results of 14 future-oriented themes we have been tackling. We will introduce these results in *Railway Technology Avalanche* this year.

As you know, in the earthquake that hit the Chuetsu area in Niigata Prefecture on October 23, 2004, a lot of disasters occurred, including the derailment of a Shinkansen train. RTRI expeditiously set up a relief center to assist with the recovery from damage. Currently, we are still on in various supporting activities, such as field investigation and analysis of structural behavior of railway facilities when attacked by the earthquake. I expect that the railway service disrupted by this unexpected incident be in normal operation to serve customers in need in the area suffering from the disaster with convenient transportation by the time when you read this message.

Katsuyoshi UEYAMA
General Manager, Research & Development Promotion Division

RTRI's Large-Scale, Low-Noise Wind Tunnel



Takeshi SUEKI
Assistant Manager, Wind Tunnel Technical Center

RTRI's large–scale, low-noise wind tunnel was constructed for research on various aerodynamic and aeroacoustic issues for the Shinkansen and other high-speed railways. This wind tunnel has an open test section and a closed test section (Figs.1, 2), and has the following features (Table 1).

1. Large test sections and high wind velocity
   - Open test section (Fig. 3)
     The open test section is chiefly used for testing aeroacoustic issues, such as the aerodynamic sound produced by a model. The cross-section of the nozzle is 3.0 m in width and 2.5 m in height, and the length of the test section is 8.0 m. The maximum wind velocity is 400 km/h. The model can be set on a support table (turntable) between the nozzle and the collector. This test section permits testing of an actual pantograph.
   - Closed test section (Fig. 4)
     The closed test section is used for testing aerodynamic issues, such as aerodynamic drag, the aerodynamic characteristics of the model, the flow around the model, and other issues. The closed test section is 5.0 m in width, 3.0 m in height, and 20 m in length. The closed test section is composed of a front part (6.5 m in length) and a rear part (13.5 m in length). The front part is equipped with a boundary suction system and a turntable with a 6-component balance, and the rear part with a boundary suction system, a moving belt ground plane, and a turntable. These two parts are joined together to form the test section. The maximum wind velocity is 300 km/h. This test section permits testing of an actual pantograph and an actual automobile.
2. An extremely low background noise level 75.6 dB at wind velocity of 300 km/h (Fig. 5)
   The aerodynamic sound produced by a model in the open test section can be distinguished accurately in a large anechoic room 20 m wide, 22 m long, and 13 m high. In addition, by using a traversing gear that moves over the whole area of the anechoic room, it is possible to measure the sound field widely (Fig. 6).
3. A high speed moving belt ground plane
   The moving belt ground plane of 2.0 m in width and 6.0 m in length is capable of running at a maximum speed of 220 km/h. By moving the belt of the ground plane at the same speed as the wind velocity, it is possible to simulate the flow under the floor of the vehicle more accurately. The model is supported with a 6-component wire balance installed in the ceiling of the closed test section (Fig. 7).
4 Measuring devices
   The wind tunnel is provided with various measuring instruments, such as omnidirectional microphones, directional microphones, 6-component balance and pressure scanning system, allowing for various types of measurement—sound, aerodynamic force, and pressure.

RTRI's large-scale, low noise wind tunnel having the above features can be applied to basic research and technical development for not only railways but also other fields such as automobiles and wind engineering. This wind tunnel was put into operation in 1996 and has been used for basic research and technical development on aeroacoustic and aerodynamic issues for high speed railways, and contributed to the development of the environment-friendly railways ever since.

Table 1. Specifications

Item	Specifications	
Tunnel	Göttingen type single return wind tunnel	
Test sections	Open type	Closed type
Width and height	3.0 m(W) × 2.5 m(H)	5.0 m(W) × 3.0 m(H)
Length	8 m	20 m
Maximum wind velocity	400 km/h	300 km/h
Contraction ratio	16:1	8:1
Uniformity of wind velocity	Under ±0.7 % at 324 km/h (90 m/h)	Under ±0.4 % at 288 km/h (80 m/h)
Turbulence intensity	Under 0.2 % at 360 km/h (100 m/h)	Under 0.2 % at 198 km/h (55 m/h)
Background noiseLevel	75 dB(A) at 300 km/h (83.3 km/h)	—
Main instruments	Sound level meter Linear array microphone Parabola microphone apparatus Ellipse microphone apparatue	6-component balance with turntable 6-component wire balance Pressure scanning system
Main accessories	Anechoic room (20 m(W) × 22 m(L) × 13m(H)) XYZ travesing gears in anechoic room Support table with turntable	Moving belt ground plane (2.7 m(W) × 6.0 m(L)) Boundary layer suction system XYZ travesing gears in closed section
Overall dimensions	Length:94 m, Width:42 m, Height:10 m, Total path length:288 m	
Fan	Diameter:5 m, Blades;Moving blades:12, Stator blades:17 Rotation:590 rpm (Maximum), Traction motor:7MW, Three phase induction moter	

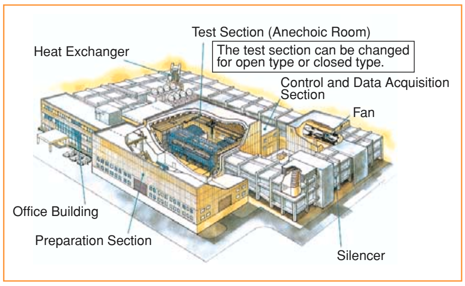


Figure 1. RTRI's large-scale low noise wind tunnel

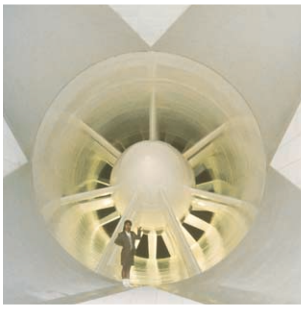


Figure 2. Fan

Figure 3. View of open test section

Figure 4. View of closed test section

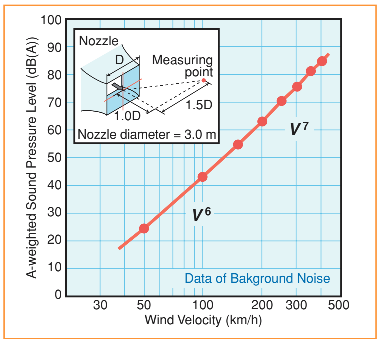


Figure 5. Background noise level

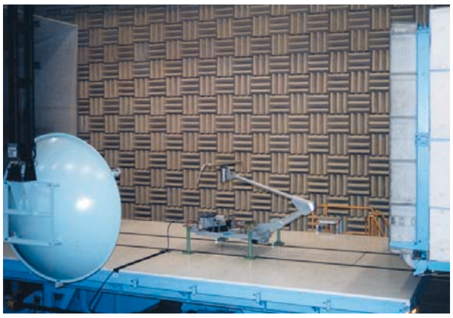


Figure 6. Aeroacoustic test of pantograph using ellipse microphone apparatus

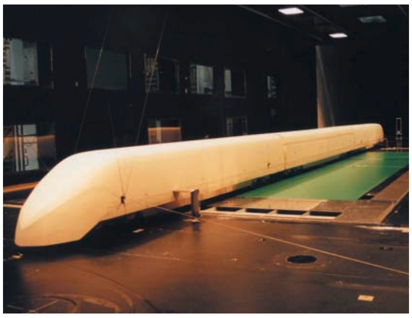


Figure 7. Vehicle model supported with 6-component wire balance

Our Manned Maglev System Attains Maximum Speed Record of 581 km/h

Takashi MIZUTANI
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The maglev system running test, which was started on the Yamanashi Maglev Test Line in April 1997, has been carried out smoothly and steadily (Table 1). Many of the tests have been completed. On the basis of the test results obtained in the first three years, the Maglev Technological Practicality Evaluation Committee organized by the Ministry of Transport, favorably evaluated our technology saying that: "It is considered that the technology has paved the way for practical use of maglev railways as a super high-speed mass transit system, although there is still room for further improvements from the standpoint of long-term durability and economic efficiency."

Since 2000, we have been making further improvements through our five-year plan. To improve long-term durability, we have carried out continuous running tests. To improve economic efficiency, we have developed new technologies for cutting costs and subjected them to verification tests. In 2002, we introduced newly developed facilities and vehicles to the Maglev Test Line and confirmed that they could achieve planned performance. They are still being tested on the line.

Under these conditions, in order to attain a higher objective while continuing stable running tests, we planned to break the speed record of maglev systems and started to meet the challenge in 2003. The minimum requirement of the Maglev Test Line (total length: 18.4 km) was that it should allow for a maximum speed of 550 km/h, although there were many unknown factors in the design stage. Therefore, while the installed capacity was given a little allowance, we made necessary preparations, including improvement on control of the power converter and bench tests on vehicle parts. From the running test data accumulated in the past, the running resistance and brake performance required were clearly known. On the basis of this knowledge, we set 580 km/h as the maximum speed at which the train could be stopped safely. Since the reliability of our system had been proved by a long period of stable running tests, we started the test with more confidence than we had five years ago when the maximum speed of 552 km/h was attained. On December 2, 2003, we twice recorded a top speed of 581 km/h (Figure 1). This speed is considered near the limit on the 18.4 km experimental line. However, since our maglev system boasts exceptional acceleration, we felt that it could easily break the new speed record of 581 km/h if the line were extended.

There are only a few months left for the five-year plan that was started in FY 2000. We have actively tested and evaluated our maglev system. Incidentally, the cumulative running distance exceeded 400,000 km in October 2004.

Table 1. Major Developments on Yamanashi Maglev Test Line

Apr. 3, 1997	Running test started.
Dec. 24, 1997	Maximum speed of 550 km/h attained (unmanned).
May 17, 1998	Test riding started.
Apr. 14, 1999	Maximum speed of 552 km/h attained (manned).
Nov. 16, 1999	Relative speed of 1,003 km/h attained by two trains having passed each other.
Aug. 26, 2000	Cumulative running distance exceeds 100,000 km.
Jul. 26, 2003	Cumulative running distance exceeds 300,000 km and cumulative number of persons aboard test cars exceeds 50,000.
Nov. 7, 2003	Traveling distance per day reaches 2,876 km.
Dec. 2, 2003	Maximum speed of 581 km/h attained (manned).

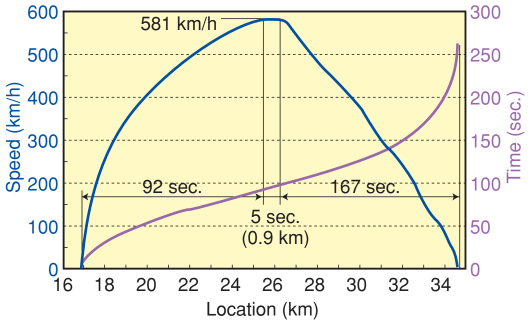

Figure 1. Running pattern during 581km/h test

Figure 2. Photograph of the running test

Super High-Speed Model Launching Test Apparatus

Masao URABE
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1. Necessity of model launching test apparatus

The model launching test apparatus is used to launch a model train at a very high speed for analysis of aerodynamic phenomena which occur when an actual train passes along an open space or rushes into a tunnel. It consists mainly of a launching device, a brake device and take-up devices (Figure 1). Although RTRI already had a test apparatus capable of launching a model at a maximum speed of 450 km/h, a new launching test apparatus capable of a higher speed became necessary for the development of high-speed railways of the 500 km/h class.

The new apparatus has the same basic launching mechanism as the existing one, but it has been fabricated so that it secures a 20 m section in which a model tunnel or the like can be installed for testing, and is capable of maintaining a moving speed of 500 km/h or more while it is passing through the section.

2. Launching device and brake device

The launching device consists of four pairs of upper and lower wheels (launching wheels), which are rotated at high speeds to send out the model train set in between. The cross-section shape of the rubber bonded to the rim of each launching wheel to obtain the force of friction with the model train surface was designed so that the rubber would not peel off due to the centrifugal force resulting from high speed rotations of the wheel. As the model train is sequentially pushed out by the four pairs of launching wheels, it is accelerated in stages. When the target speed is attained by the front-end pair of wheels, the model train is launched (Figure 2).

The brake device consists of a cylinder lined with a laminated plate of rubber sheets. As the model train passes through the cylinder, it is decelerated by the friction between its surface and the rubber lining till it stops. The main braking apparatus is about 3 m in length and capable of completely stopping the rapidly running model train within the section. This braking apparatus is provided with another braking apparatus with cushion toward its front (Figure 3).

In order to make the model train run along a prescribed course, steel wire is stretched from the launching device to the brake device by the take-up device so that the model is guided by the steel wire.

3. Attaining maximum speed of 500 km/h

One of the most difficult challenges was how to allow the model train sent out by the launching device to reach the brake device 20 m ahead without causing it to slow down. The pushing force was determined by adjusting the axle-to-axle distance of launching wheels sandwiching the model train. In addition, the rotational speed of each individual launching wheel was adjusted. As a result, we were able to launch a model train at a speed exceeding 500 km/h. It was confirmed that the speed of the model train at the time when it reached the brake device 20 m ahead was 500 km/h. The brake device could stop the model whose mass was some 600 grams without being damaged.

Thus, the purpose of the present development was to devise means of increasing the speed of model train and decelerating it effectively. We expect that the new apparatus will be extensively used for various test purposes.

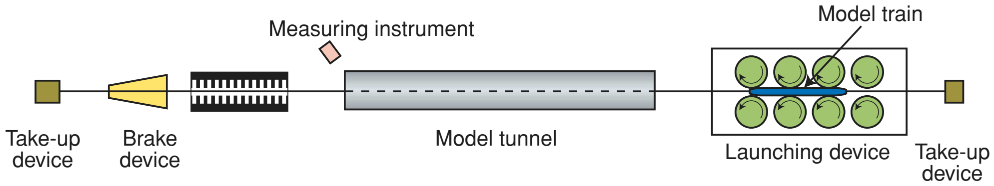

Figure 1. Scheme of model launching test apparatus

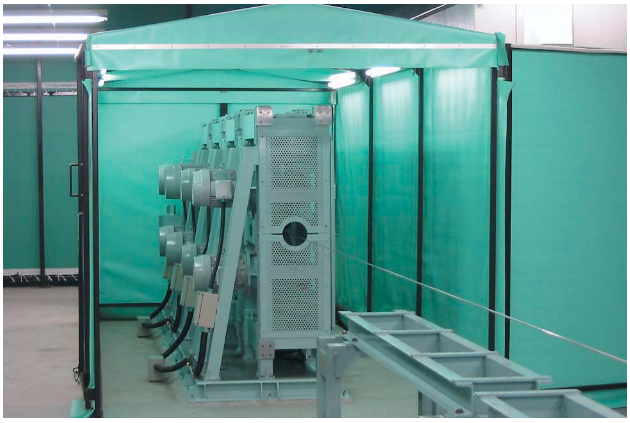

Figure 2. Launching device

Figure 3. Brake device

Installation of Tactile Ground Surface Indicators for Blind Persons on Railway Platforms

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As part of research aimed to facilitate the use of railways by blind persons, we carried out a study for standardizing methods of laying tactile ground surface indicators (TGSIs) on station platforms to warn of the platform edges. In Japan, more and more railway stations are adopting TGSIs in accordance with guidelines of the Foundation for Promoting Personal Mobility and Ecological Transportation. However, since the method for installing TGSIs is not described in detail in the guidelines, it was not uncommon for different stations to use different methods. The unification of installation methods was thus called for.

Under that condition, we, the members of the Study Committee for Improvement of TGSIs (Chairman: Osamu Sueda, professor at The University of Tokushima, Secretariat: the Foundation for Promoting Personal Mobility and Ecological Transportation), carried out various experimental studies (Figure 1). The main items studied are outlined below.

(1) Effect of widening TGSIs which warn of the platform edge

There are cases in which a blind person falls from the platform as he or she steps over a TGSI installed near the platform edge without recognizing it. Needless to say, to prevent such an accident, it is effective to increase the TGSI width. However, this is not always possible because many of the platforms of Japanese railway stations are not very wide. In view of this, we first studied the relationship between the width of TGSI and the rate at which a blind person can recognize the TGSI and stop there safely. As a result, it was found that the rate was 90% for a TGSI width of 30 cm, 95% for 40 cm and 100% for 60 cm. Another important finding was that there must be a distance of at least 80 cm from the front end of the TGSI to the platform edge for a blind person to be able to stop after recognizing the TGSI.

Figure 1. View of experiment using blind persons as subjects

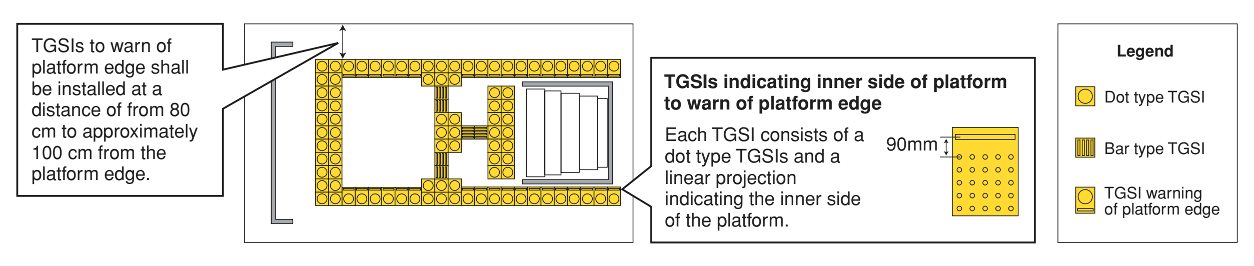
(2) Development of a new TGSI which warns of the platform edge

To warn of the edges of platforms, dot type TGSIs have been commonly used. With these TGSIs, however, although blind people notice that they are near the platform edge by means of dot type TGSIs, they often fail to discriminate the inner side of the platform from the outer side. This is because conventional TGSIs have only symmetrical raised dot patterns, which do not give information about direction. We therefore developed a new TGSI indicating the inner side of the railway platform by means of a linear projection added inside each dot type TGSI, and whose width has been increased in view of the study result mentioned in (1) (Figure 2). The linear and dot projection conforms to JIS standards and the new TGSI has been included in the above guidelines as a TGSI to warn of the platform edge.

(3) Position of installation of TGSIs to warn of the platform edge

There was the only rule concerning the position of installation of TGSIs to warn of the platform edge: "They shall be installed at a distance of at least 80 cm from the platform edge." Because of this, the actual installation position was different from one station to another. Therefore, the unification of installation positions has been called for. On the basis of the results of our experiments, we concluded that TGSIs to warm of the platform edge should be installed at a distance of from 80 cm to approximately 100 cm from the platform edge (Figure 2).

There are various causes for the fall of a blind person from a platform. Therefore, improving TGSIs alone is insufficient. However, we consider that providing platforms with better TGSIs is a minimum requirement to blind persons and that it is effective to improve the safety of blind persons who utilize railways. The present research was carried out at the request of the Foundation for Promoting Personal Mobility and Ecological Transportation and with a subsidy granted by the Ministry of Land, Infrastructure and Transport.



TGSIs to warn of platform edge shall be installed at a distance of from 80 cm to approximately 100 cm from the platform edge.

TGSIs indicating inner side of platform to warn of platform edge

Each TGSI consists of a dot type TGSIs and a linear projection indicating the inner side of the platform.

Figure 2. TGSI to warn of platform edge

RTRI Method of Accident Analysis

Masayoshi SHIGEMORI
Assistant Senior Researcher, Psychology & Physiology, Human Science Division

Japanese railways strive to prevent accidents by analyzing causes of various accidents, including even such minor ones as the failure of a train to stop exactly at a prescribed position or the delay of a train by only a few minutes. At present, however, there are several cases in which the causes of accidents, especially those involving human factors, are not analyzed satisfactorily. This is due to the fact that in analyzing the causes of those accidents, field managers at the operating sections and facility/electricity sections who are not experts in analysis resort in a large measure to their experiences, rather than analytical techniques. As a matter of fact, the existing analytical techniques, such as fault tree analysis (FTA) and variation tree analysis (VTA), are so sophisticated that they can hardly be used by non-experts in accident analysis. In the present study, therefore, we developed a new method that permits even non-experts in accident analysis to easily and accurately analyze the causes of accidents which involve human factors.

The newly developed method, which is based on the concept of root cause analysis, is an integrated analysis system combining simple techniques to analyze an accident in three steps: (1) analysis of deviations, (2) investigation of causes of deviations and (3) identification of problems.

The first step—analysis of deviations—is to clarify events which deviated from the normal course of events during the accident. For this type of analysis, VTA has often been used. For the new method, however, we worked out a time-serial collation analysis technique to facilitate the analysis of deviations. In this technique, the "normal flow of events" (i.e., the way the work should have been done) and the "flow of events during the accident" are tabulated on a time-serial basis (Table 1), and any differences between them are regarded as deviations. This technique, though simple, has a marked advantage in that it clearly reveals any deviation as a difference from the normal course of events.

The second step—investigation of causes of deviations—is to reason the causes of the individual deviations clarified in the first step and the origins of those causes. In this step of analysis, we apply a cause-down analysis approach whereby the causes of the deviations are determined by a successive series of questions (Figure 1). For the purpose of this analysis, we also prepared a "human factor guide" which tabulates a chain of interrelated human factors to help reason out the causes of deviations involving those human factors.

The third and last step—identification of problems—is to clearly identify problems revealed in the above two steps. In this step of analysis, a table of multiple viewpoints based on an m-SHEL model is used (Table 2).

These new techniques have made it possible for non-experts in analysis to easily and properly analyze the causes of various accidents in the field.

Table 1. Example of time-serial collation analysis

(a) Course of events during accident	(b) Normal course of events	(c) Deviation
The driver started inspection before departure from depot.	The driver started inspection before departure from depot.	④
The driver completed the inspection.		
The driver checked the time.	(The driver checked the time.)	
The driver waited at the driver's desk till the departure time came.	The driver completed the inspection.	③
	The driver waited at the driver's desk till the departure time comes.	
:	:	:
	(The driver called out the aspect of the go signal for Track No. 1.)	⑦*
The train ran beyond the go signal for Track No. 1 despite the stop aspect.		**Accident**

Table 2. Examples of problems identified by multipoint analysis and corrective measures

Viewpoint	Problem	Corrective Measure
Management	Company policy overly focused on efficiency	Give the driver a clear-cut instruction as to things to be done without delay and those to be done safely.
Procedures	Driver thought that in most cases things would go alright without accurately performing the inspection before departure from depot.	Clarify relevant points at the depot and let problems occur if the inspection is not performed accurately.
Equipment	There were insufficient arrangements which reminded the driver that he should check the departure time when starting the train.	Install a clock which displays the current time at the touch of a button and make the system remain inactive unless the button is pushed.
Environment	Driver thought that no one knew if he did not do finger pointing and call accurately.	Make the driver visible and audible from the passenger room and let the correct manners of finger pointing and call known to passengers.
Personality	Driver had an inclination toward excessive efficiency.	Give the driver suitable instructions periodically.
Human relations	Driver thought that no collea gues knew if he did not do finger pointing and call accurately.	Let colleagues warn the driver of negligence.

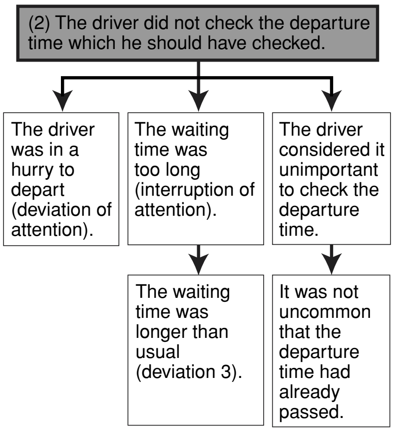


Figure 1. Example of cause-down analysis using "human factor guide" (only part of map is shown)