Enhancement and Utilization of Multipurpose Integrated Highly-Advanced Railway Applications (MIHARA) Test Center

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Japan's first comprehensive transportation system test facility, the MIHARA Test Center, has test tracks for three types of transportation systems: a railway test track, an AGT(Note 1) test track, and a HSST(Note 2) test track. The MIHARA Test Center opened on October 2, 2014 when the 3.2 km-long railway test loop track was completed. This facility aims at enhancing Japan's competitiveness in the export of urban transportation systems, which is one of the key pillars of the country's export strategy. Since then, the MIHARA Test Center has been used not only for MHI development projects, but also by other companies and public/private organizations, and has accepted many inspections by domestic and foreign parties.

The facilities of the railway test track have been enhanced for improvement in terms of effectiveness and convenience, reflecting both internal and external opinions. In addition, MHI's development project of a high-speed AGT test track and a center guide AGT test track were completed on May 31, 2016, and June 30, 2016, respectively. In this way, the MIHARA Test Center has evolved further as a transportation infrastructure development base, and is greatly expected in the industry to enhance the export competitiveness of Japanese transportation systems.

Note 1: Automated Guideway Transit

Note 2: High Speed Surface Transport

1. Enhancement of facilities of railway test track

The railway test track consists of the 3.2 km-long loop track, the lead track and the small loop test track, and has a minimum loop track curve radius of 120 m, a maximum gradient of 50‰ and a 1 km-long straight section for a maximum train speed of 100 km/h to 120 km/h(Note 3) (**Figure 1**).

Note 3: The maximum running speed depends on the train performance.

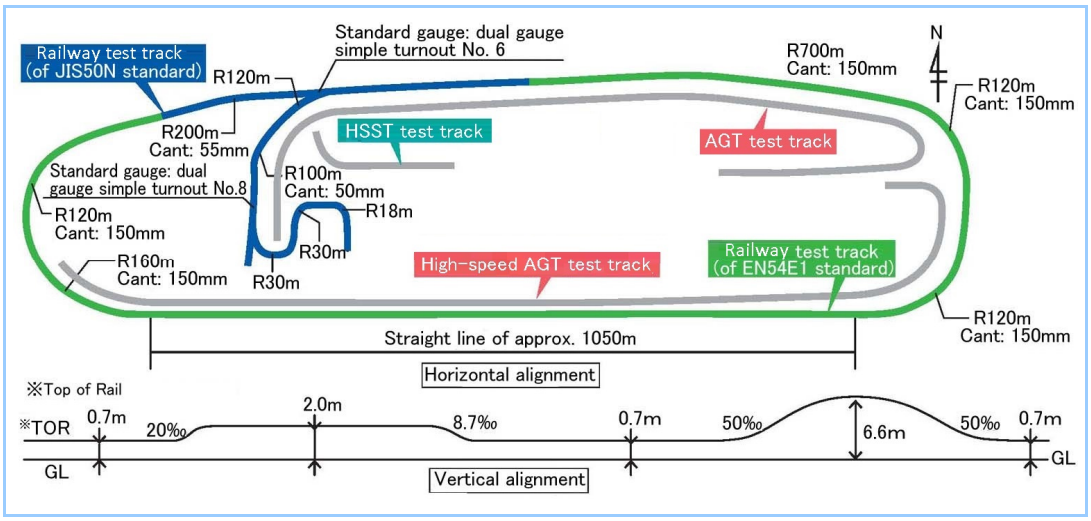

Figure 1 Railway test track and track layout

The track adopts specifications for overseas urban transportation and the rails comply with the European standard (EN). The track is a dual-gauge track that allows the use of the standard gauge (1435 mm) used for Shinkansen and overseas urban transportation and the narrow gauge (1067 mm) used for conventional JR lines. The power supply voltage through the OCS(Note 4) can be either DC1500V, DC750V, or DC600V.

Note 4: OCS stands for Overhead Catenary System.

The following additional facility enhancements of the railway test track have been implemented since the start of operations in October 2014.

1.1 Introduction of MIHARA-Liner

In June 2015, the MIHARA Test Center took over a used train and started utilizing them as a dedicated test train. The train was named MIHARA-Liner (**Figure 2**).

This introduction of MIHARA-Liner was determined in order to promote the use of the railway test track with the background where a base train to be used for verification tests of MHI-developed train components was required and a test train dedicated to the railway test track was also increasingly requested as a sole component test or for use as a towing car by external organizations that use the test center. The MIHARA Test Center took over a standard-gauge train that operates with a DC1500V power supply and was manufactured approximately 50 years ago. The original four-car train was modified to a two-car test train. The maximum speed is 80 km/h. MIHARA-Liner allows visitors on inspection tours to actually ride the test train and realize the effectiveness of the test track, and therefore is well-received by domestic and overseas visitors alike.

Figure 2 MIHARA-Liner

1.2 Introduction of dual gauge turnout

The dual gauge turnout (**Figure 3**), introduced in June 2016, is a facility that can switch the courses of the two types of tracks: the standard-gauge track and the narrow gauge track. Much overseas rolling stock uses the standard gauge, while much of the domestic rolling stock uses the narrow gauge. Therefore, the introduction of an easy-to-switch facility was in high demand from domestic railway car manufacturers and railway-related organizations. With such a background, the MIHARA Test Center determined the introduction of a dual gauge turnout in order to promote the utilization of the railway test track. Following the introduction of this facility, applications for use by external organizations have increased and the operation ratio has been enhanced.

Other than this turnout at the MIHARA Test Center, there are no dual gauge turnouts in western Japan, including on railway lines operated by domestic railway companies.

Figure 3 Dual gauge turnout

2. Construction of high-speed AGT test track

2.1 Background of construction

High-speed AGT was developed based on the concept of "market expansion to the field of mass transit urban transportation systems based on the realization of a maximum speed of 120 km/h, equivalent to approximately twice that of a conventional AGT, in addition to freedom in the design of track shape, low cost (construction, operation and electric power consumption) and the low noise of AGT." High-speed AGT is verified using the high-speed AGT test track at the MIHARA Test Center.

2.2 Overview of high-speed AGT test track facilities

The high-speed AGT test track is approximately 1500 m-long and has a minimum curve radius of 30 m. Its maximum cant is 120 mm and the guide width is 3200 mm. The high-speed running section is approximately 1050 m-long and there is an elevated section on the eastern part of the high-speed running section. The western part of the elevated section is a straight line with a gradient of 50‰, and the eastern part is a curved line with a radius of 120 m and a gradient of 100‰. These track shapes verify the ability of high-speed AGT to respond to complex track shapes in addition to its hill climbing ability (**Figures 4**, **5**). The test track has, as peripheral facilities, three platforms on the east, west and in the center, as well as a car maintenance pit at the eastern edge beyond the curve with the 30 m radius. The high-speed AGT test track allows a train to run at a speed of 120 km/h in fully-automatic driverless operation.

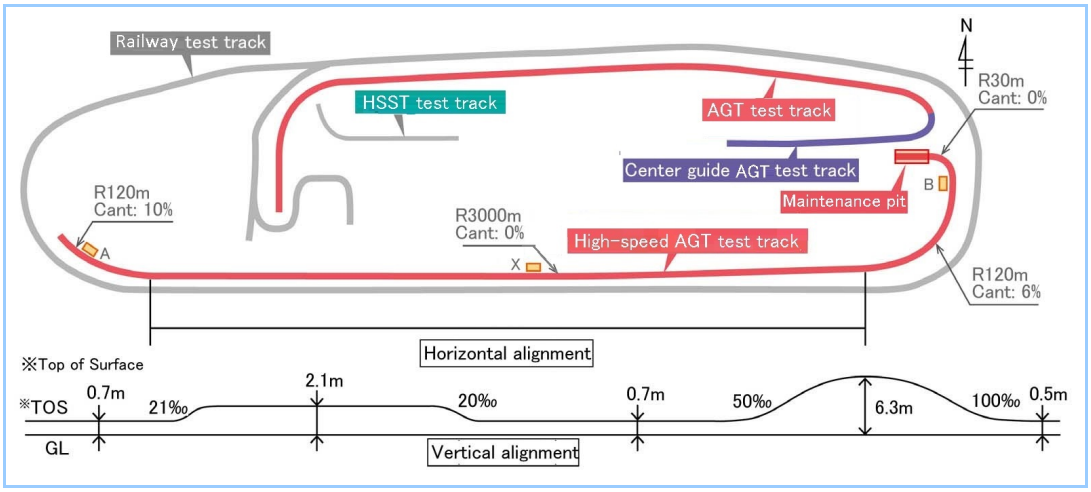

Figure 4 Track shape of high-speed AGT and center guide AGT test tracks

Figure 5 High-speed AGT test track

3. Construction of center guide AGT test track

3.1 Background of construction

There are two types of guide systems for AGT: the side guide system and center guide system. MHI has traditionally adopted the side guide system, but on the other hand, some overseas AGT companies use the center guide system. Approximately 20 years have passed since the start of AGT operations, and therefore demand for the renewal of the existing systems is expected to continue to grow in the future. MHI developed a new center guide bogie to meet this demand and constructed the center guide AGT test track as a running verification facility of the

newly-developed bogie. As a result, this facility can deal with both the side guide system and the center guide system. Using these AGT test tracks in conjunction with the high-speed AGT test track, the MIHARA Test Center aims to provide our country with secure, formidable competitiveness in the AGT market.

3.2 Overview of center guide AGT test track facilities

The center guide AGT test track was constructed by extending the eastern edge of the existing AGT test track by approximately 205 m and connecting the extended section with part of the existing track. The resulting test track is approximately 350 m long and has a minimum curve radius of 30 m and a track shape that allows a train to run at a speed of approximately 45 km/h (**Figures 4**, **6**). There is a maintenance area on the western edge and the area is also used for the introduction of cars into the track.

Figure 6 Center guide AGT test track

4. Usage of MIHARA Test Center by external organizations

As a rule, no MHI employees enter the test track area of the MIHARA Test Center from the perspective of ensuring safety and protecting the technological information of users, and as such, the lending of the test center, which allows users to bring necessary facilities and freely implement testing, to external organizations started. In addition to the enhancements of the test track facilities described above, improvement in the surrounding environment, such as installation of an office, is progressing while conducting interviews with users.

Since the MIHARA Test Center opened on October 2, 2014, MHI has urged external organizations to use the test center for (1) training, (2) product development and safety analysis, as well as (3) accommodating international standards. The past use results of external organizations as of the writing of this report (June 2016) are shown in **Table 1**.

Table 1 Usage record of MIHARA Test Center by external organizations

Classification		Number
External utilization	Research and development	6
	Standards certification	1
	(Total)	7
Observing party	Overseas	18
	Government authorities, research institutes, consultants	25
	Railway operators, manufactures, etc.	37
	(Total)	80

An outline is summarized below.

4.1 Training

The majority of past use cases of the MIHARA Test Center were observation tours. However, multiple cases were from foreign countries, and the center is highlighting its use as a facility of a nation of advanced railways. The center has also accepted observation tours from government authorities, manufacturers, research institutes, universities, consultants, etc. The response to the railway test tracks was significant, and it is expected to evolve into its utilization for training in the future.

4.2 Product development and safety analysis

There have been six past use cases, with three being significant; two new railway car running tests implemented by a railway car manufacturer and one new bogie test implemented by a research institute. The user highly evaluated the MIHARA Test Center as being a test track with the only loop track in Japan to allow cars to run continuously and freely. One case that is unique to a comprehensive railway transportation system verification facility was the development of a prototype safety running support system for tramcars and automobiles implemented by the University of Tokyo, the National Traffic Safety and Environment Laboratory, Hiroshima Electric Railway Co., Ltd., and Mazda Motor Corporation(Note 5). This was a test of a tramcar-automobile intercommunication system for avoidance of accidents from contact/collision between tramcars and automobiles (**Figure 7**). This test was conducted to verify intercommunication between a tramcar and an automobile by placing an automobile very close to a tramcar at the crossing on the loop test track. Because the MIHARA Test Center is located on the premises of an MHI worksite where the Road Traffic Act is not applicable and people not involved in the test can be shut out completely, the test center allows a running test under conditions that cannot be realized on public roads.

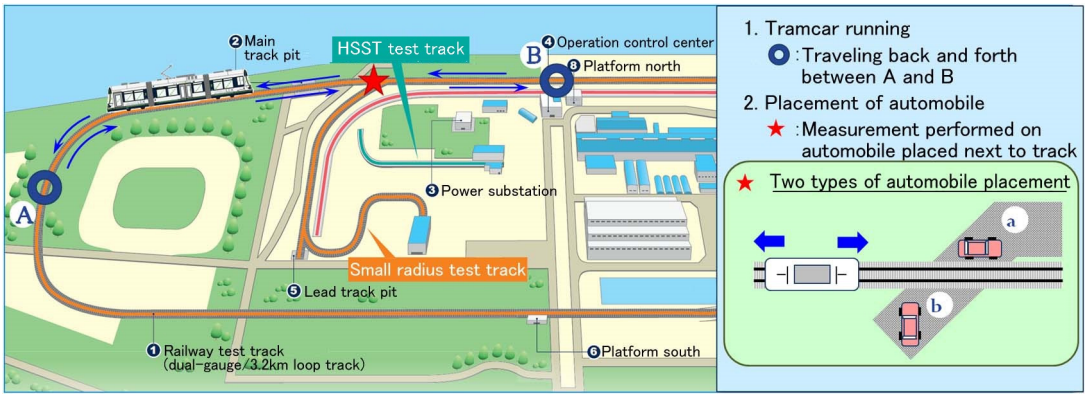

Figure 7 Tramcar-automobile intercommunication test

Note 5: Safety Engineering Symposium 2015 Collection of Papers (pp. 320-323)
Title: Development of prototype cooperative ADAS between tramcars and cars using 760MHz-band V2V communication (In Japanese)
Authors: HIRASAWA Takayuki, SUDA Yoshihiro, NAKANO Kimihiko, WATANABE Sho*
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FUJIMOTO Hideki, HIGASHI Koichi (Hiroshima Electric Railway Co., Ltd.)
YAMASAKI Toshikazu, MORII Norihiro (Chuden Engineering Consultants Co., Ltd.)

4.3 International standards

Past use cases include accuracy verification of integral power measurement with onboard sensors for data preparation in order to include Japanese railway technologies into international standards implemented by Toyo Denki Seizo K.K., the University of Tokyo, the National Traffic Safety and Environment Laboratory, and Hiroshima Electric Railway Co., Ltd. (**Figure 8**).

It is difficult to perform reproducible data acquisition on an in-operation railway line because the available time is limited and other trains are running. On the other hand, at the MIHARA Test Center, which has a stable electric power supply based on a dedicated power transmission facility and allows isolated and repeated test runs, data acquisition can be performed under circumstances where there are no disturbances. MHI uses the MIHARA Test Center to contribute to the acquisition of data for international standards that are required to export railway systems.

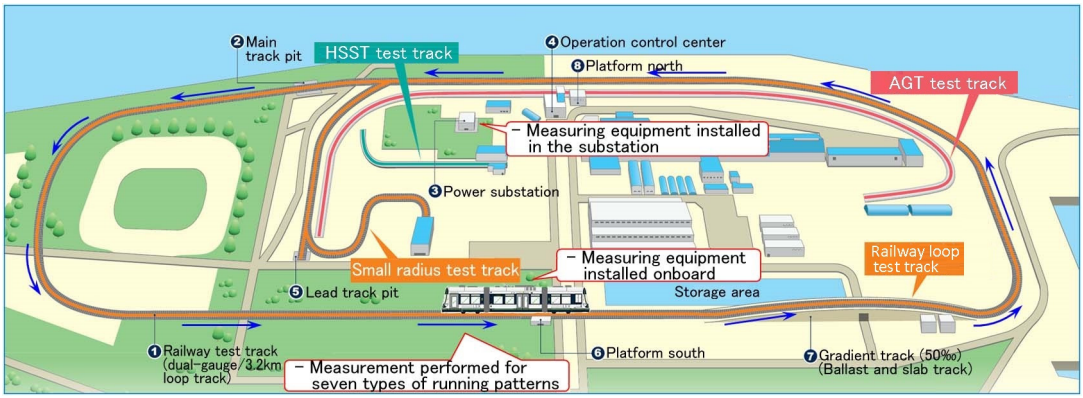

Figure 8 Onboard power measurement test

5. Future development

The enhancement and expansion of the MIHARA Test Center, its utilization since the opening of the test center, and the past use cases and advantages were described above. MHI will use the test center to offer secure and safe transportation systems to customers by accumulating research and development efforts and the verification of completed railway cars. At the same time, MHI expects external parties such as other companies and public/private organizations to widely utilize the test center and present “all Japan” transportation systems to the world in order to expand and maintain Japanese railway technologies and promote their expansion overseas.