People-friendly, Eco-friendly Next-generation Tram (Light Rail Vehicle)

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The LRV (Light Rail Vehicle), which takes advantage of a tramway's characteristics such as ease of use, zero emissions and high energy efficiency, has evolved its user-friendliness and is attracting attention as a next-generation method of daily transportation for urban residents. Mitsubishi Heavy Industries, Ltd. (MHI) developed an independent wheel bogie that is essential in the implementation of a 100% low-floor, barrier-free LRV and delivered the first domestic fully-flat 100% low-floor LRV, the Green Mover Max, to Hiroshima Electric Railway Co., Ltd. together with Kinki Sharyo Co., Ltd. and Toyo Denki Seizo K.K. in the U3 Project in 2005. MHI has delivered the "JTRAM R" (called 1000-series Vehicle in Hiroshima), which carries on the barrier-free characteristics of Green Mover Max while having a smaller length. This document presents an overview of the new system.

1. Specifications

Table 1 shows the general specifications of the 1000-series.

Table 1 Main specifications of 1000-series vehicles

Configuration	3 car, 2 bogie, low-floor vehicle
Track gauge	1435 mm
Electric mode	DC600 V
Number of passengers	86 (33 seats provided)
Weight	24.3 t
Size	L 18600 x W 2496 x H 3645 mm
Bogie	Independent wheel bogie
Main motor	100 kW 3-phase induction motor x 4 units
Driving system	Right angle Cardan type
Control system	VVVF inverter control
Brake unit	Regenerative and generative electric brake, spring type hydraulic disc brake system, track brake
Auxiliary power unit	Static power inverter AC220 V/DC24 V
Floor	Exit/entrance 330 mm, aisle 360 mm
Running speed	40 km/h (design maximum speed 80 km/h)
Acceleration	3.5 km/h/s
Deceleration	Normal 4.8 km/h/s, emergency 5.2 km/h/s

The 1000 series is 18.6 m long and has a 3 car, 2 bogie configuration. This compact system enabled the introduction of the low-floor LRV to rail lines where long systems cannot enter and only single car systems ran. As a result, low-floor systems can run on all lines of Hiroshima Electric Railway Co., Ltd., which led to improved service.

2. Features

2.1 Independent Wheel Bogie

MHI developed the independent wheel bogie (**Figure 1**) and realized a floor height that is low enough that it doesn't require steps in order to improve the safety and ease of boarding and alighting at tram stops. The right and left wheels of ordinary cars are connected with each other by

an axle shaft, and therefore the floor height depends on the axle shaft height. The independent wheel bogie that MHI developed eliminates the axle shaft, and enables significant lowering of the floor. As a result, the exit/entrance floor height 330 mm has been realized (**Figure 2**), enabling step-less boarding into the car from tram stops. In addition, the bogie structure allows an aisle width of 880 mm in the area directly on the bogie and contributes to the smooth movement of passengers boarding and alighting.

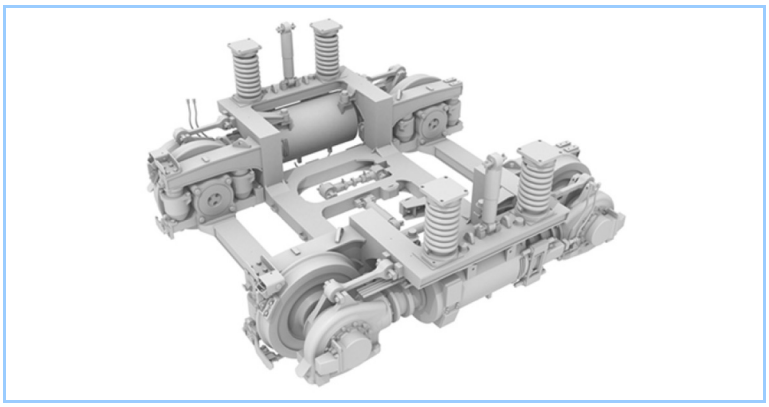

Figure 1 Independent wheel bogie

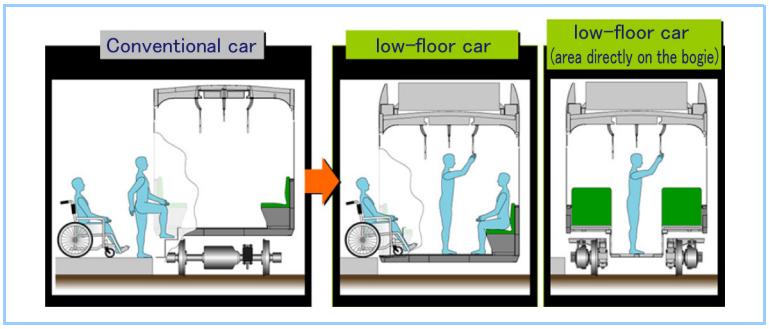

Figure 2 Comparison of ease of boarding/alighting between bogie structures

2.2 Articulated Car

A central car, with no bogie floats between the front and rear cars that are equipped with the bogie, is connected to the two cars at the articulations. When running through a curve, the bogie does not turn horizontally and separately from the car body, but each car swivels with the articulation as a fulcrum. Therefore smoothness in running through the tight curves unique to tramways can be attained (**Figure 3**). The minimum curve radius that the system can run through is 18.6 m.

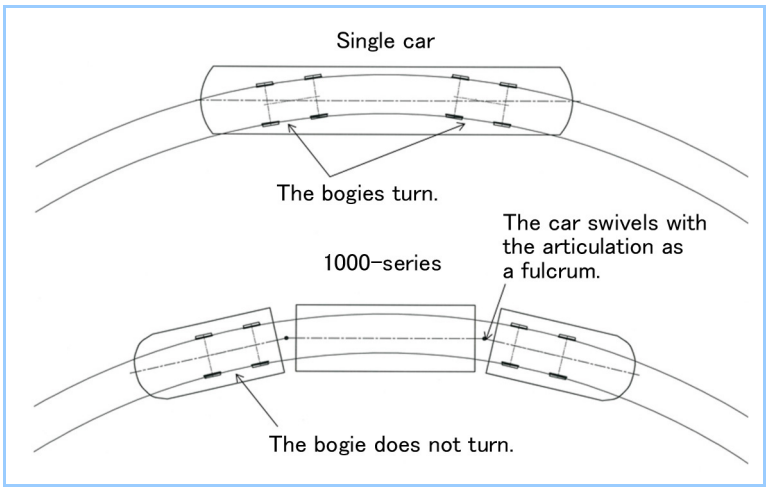

Figure 3 Comparison of running through a curve between a single car and 1000-series

2.3 Train Information System

The 1000-series is equipped with the Train Information System, with the monitor mounted on the control platform. The control platform console was made compact by centralizing the less frequently used switches and instruments, such as the voltmeter and the ammeter, into the monitor (**Figure 4**). Driving and maintenance are also supported through the settings, maintenance and trouble indications that use the monitor. As a result, the work load of the driver, who is responsible for both conducting and driving, is reduced.

Figure 4 Control platform and instrument panel

2.4 Driver Only Operation

The 1000-series is equipped with a CCTV (video image monitoring) system that displays on a monitor images taken by cameras mounted outside of the car and installed near the doors inside the car to allow the driver to confirm the situation in the rear. In addition, the switches for door operation, announcements and other functions are centralized on the control platform. Thus the system can be operated by the driver only.

2.5 Passenger Cabin

The design of the passenger cabin having brown seats provides calm space. There is one wheelchair space near the door of the central car. It can also be used as a stroller space. A guidance sheet for the wheelchair/stroller space is affixed on the floor in order to mark it clearly (**Figure 5**).

LED lighting is used in order to reduce electric power consumption. There is an LCD information display system on the back of the control platform that clearly shows information about transfers, surrounding facilities, fares and other pertinent facts.

Figure 5 Passenger cabin and wheelchair space

3. Future Prospects

Now MHI has a 100% low-floor LRV lineup consisting of the 5 car, 3 bogie system with mass transport capability (30 m long, 149 passengers, operated with a conductor) and the 3 car, 2 bogie system, which is compact and can be operated by a driver only (18.6 m long, 86 passengers). As a result, MHI can provide a wider array of solutions to tramway operating companies in various cities and new LRT plans. We expect that our 100% low-floor LRVs will be introduced in many cities in the future.