AGT: New TOD Solution for Urban Transportation Issues

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In many of the cities around the world with problems such as traffic congestion, the introduction and promotion of public transportation based on TOD (Transit Oriented Development) has been planned. In many cases, however, planners have come up against the problem of high construction costs arising from securing land, and the introduction and promotion of public transportation has not gone smoothly. Existing AGT (Automated Guideway Transit) systems in cities feature good harmony with the cities due to their high environmental and running performances, and can be retrofitted to a city using urban spaces ranging from underground to elevated guideways. By anticipating the needs of the transportation system in a future city, MHI realized a transportation volume 60% larger than that of the domestic conventional system and elevated the maximum speed to 120 km/h to provide a train type mix that can cope with expanded application areas in the field of urban transportation. We will introduce our AGT as an urban transportation solution for a new age to cities around the world.

1. Introduction

TOD stands for Transit Oriented Development, and in Japan, it is known as public transportation-oriented urban development. The concept of TOD was proposed in 1991 by U.S. urban planner Peter Calthorpe. It denotes the development of a city based on compact space formation with a station located at the city center to encourage a modal shift from dependence on automobiles to the use of public transportation. TOD is defined as having the following elements[1]:

- Walkable Area development
- Encouraging the use of environmentally-sustainable mobility such as bicycles
- Create dense road networks with streets and alleys
- Area development near high-quality public transportation
- Multipurpose, multi-application land use
- Optimization of population density and transportation capacity of public transportation
- Create a compact community for short commuting time
- Promotion of environmentally-sustainable mobility by regulating parking lots or roads

In overpopulated cities in Asia, the traffic congestion and environmental issues caused by road traffic are social problems, and with TOD as the keyword, the promotion of the use of public transportation and the redevelopment of areas around stations associated with the introduction of public transportation have been active in recent years. Especially in Tokyo, where the railway transportation network is already developed and people's dependence on automobiles for transportation has decreased, is regarded as a successful example of TOD and is attracting attention as an advanced TOD city.

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2. Points at issue on TOD

(1) Two points of view on TOD

TOD has been studied and discussed from two points of view: the perspective of Peter Calthorpe who developed the concept of TOD, and that of Ichizo Kobayashi, the founder of the Hankyu Railway Corporation, who is regarded as a pioneer of the Japanese private railway business. But in some cases, these two points of view miss the point of the argument because of their differences. Both points of view aim at developing a public transportation-oriented city but their motives are different. **Figure 1** shows the differences in the two points of view.

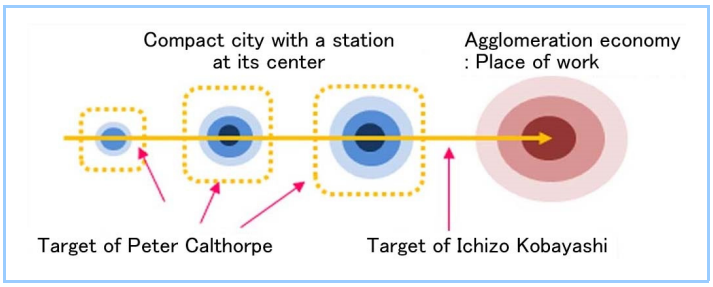


Figure 1 Two points of view on TOD

The perspective of Peter Calthorpe is on urban planning. The target of his study is the planning of a compact city with a station at the center, where the feasibility of public transportation businesses using the station as a source of passengers is not considered. In addition, the motive of the study is the proposal of a sustainable living environment while encouraging the modal shift from automobile to walking or an environmentally-friendly mode such as bicycles and the use of public transportation such as railways. TOD is sometimes explained as "to realize a compact city with a station located at the center," and many developer discussions on TOD are made with the theme of the development of areas around stations. These are considered to be based on Calthorpe's point of view.

Ichizo Kobayashi's perspective is on securing the business feasibility of a railway line connecting station to station. Discussion from Calthorpe's perspective focuses on a "point," which is a station, while discussion from Kobayashi's perspective focuses on the "flow line" of passenger demand, which connects one "point" to another "point," aiming at expanding and maximizing the feasibility of the railway business in conjunction with the planning of a city around a railway line. From the point of view of a private railway company that acquires passengers and operates its business with earnings from passenger fares, they realized the stable securement of passenger demand by providing workers with the means to commute to the workplace in the city. Needless to say, when a railway company uses TOD as a method for securing sustainable business, it would be necessary to study things from this perspective.

(2) Background of success in the private railway business model

The private railway business model implemented by Ichizo Kobayashi of Hankyu Railway is well known – even overseas – as a successful precedent case of TOD in Japan. It was intended to develop and secure passenger demand through the extension of railway lines connected with the development of residential land, support for the acquisition of housing through home mortgages, the setting up of customer attraction facilities such as amusement parks, the integration of station and commercial facilities such as department stores, etc. It is considered that behind the success of this model are the conditions such as the drift of the population to the suburban area of cities allowed by the increase in the household income associated with economic growth, the development of residential land along the line for accommodating people moving into the area and the transportation conditions where the railway was only means for commuting to the place of work in the central urban area. Commuting of workers to the locations of agglomeration economies is an important passenger demand of railway companies. **Figure 2** shows the number of transit passengers at private railway stations travelling from the Tokyo suburbs to central Tokyo based on the investigation results of the 11th transportation census of large cities conducted by the Ministry of Land,

Infrastructure and Transport (MLIT). At the major transfer stations, the number of transit passengers is decreasing, but the number of passengers travelling to central Tokyo is increasing. This shows that demand for passengers moving to central Tokyo provide substantial support for the business feasibility of railway lines.

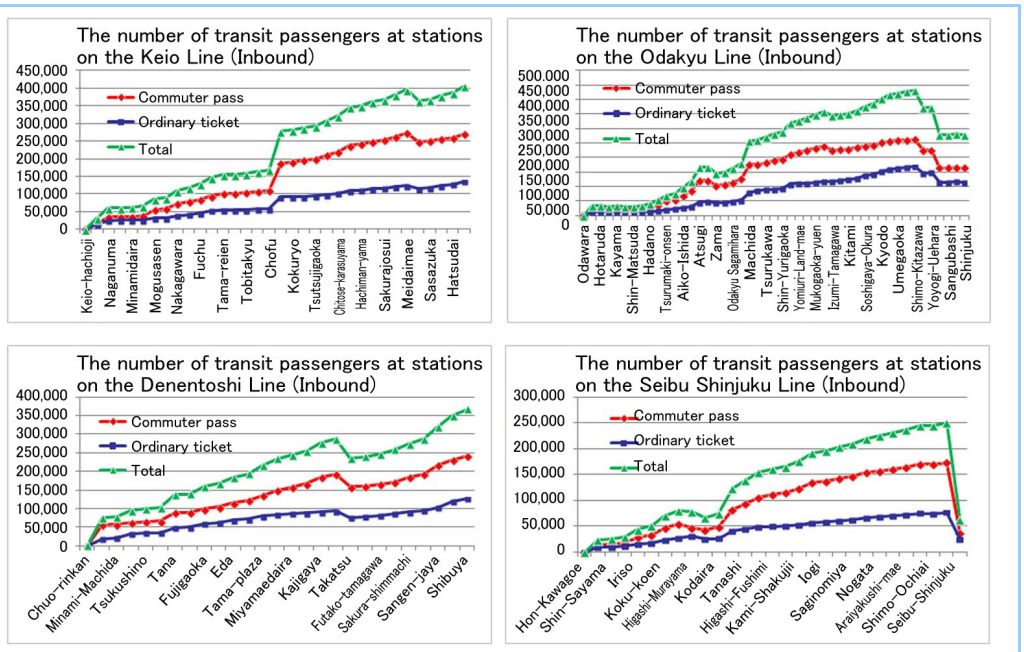


Figure 2 Number of transit passengers at stations on Tokyo inbound lines

3. TOD in the modern age

(1) TOD-focused urban development in Asian cities

For cities faced with urban environmental issue such as traffic congestion, the introduction of public transportation based on TOD is recognized as an effective measure. In cases where TOD is implemented following successful examples, the first thing to do is to secure land for the introduction of public transportation, but in actuality, the acquisition of land entails difficulties, and TOD cannot be realized as planned. Especially in Asian cities, as the income level increases, the penetration of automobiles and motorcycles increases, and then the shortage of road capacity becomes serious. To relieve the traffic congestion, investments in road infrastructure have been continued as the usual practice.

Studies on the introduction of railway transportation start when environmental issues become obvious as a social problem. When such studies are started, however, the land is already filled with structures, and in many cases, there is no other choice but to introduce subways, which is one of the most expensive options.

The flow chart in **Figure 3** represents the flow of the introduction of transportation infrastructure. In a city where roads are saturated with vehicles as a result of an increase in the number of vehicles, the road capacity is increased to accept the extra vehicles. It is assumed, however, that an increasing number of vehicles will fill up the road again in the future. We think that in order to break this vicious cycle, it is necessary to introduce a transportation system using a dedicated guideway that does not affect the road traffic. We propose that when investment in road infrastructure is considered, the introduction of a transportation system using a dedicated guideway should be considered as an effective option.

Concerning the concept of public transportation-oriented urban development devised by Ichizo Kobayashi and Peter Calthorpe, a business model for promoting the use of public transportation and the requirements of the transportation system needs to be further developed in order to solve the issue of the sustainability of the public transportation business in the present social environment.

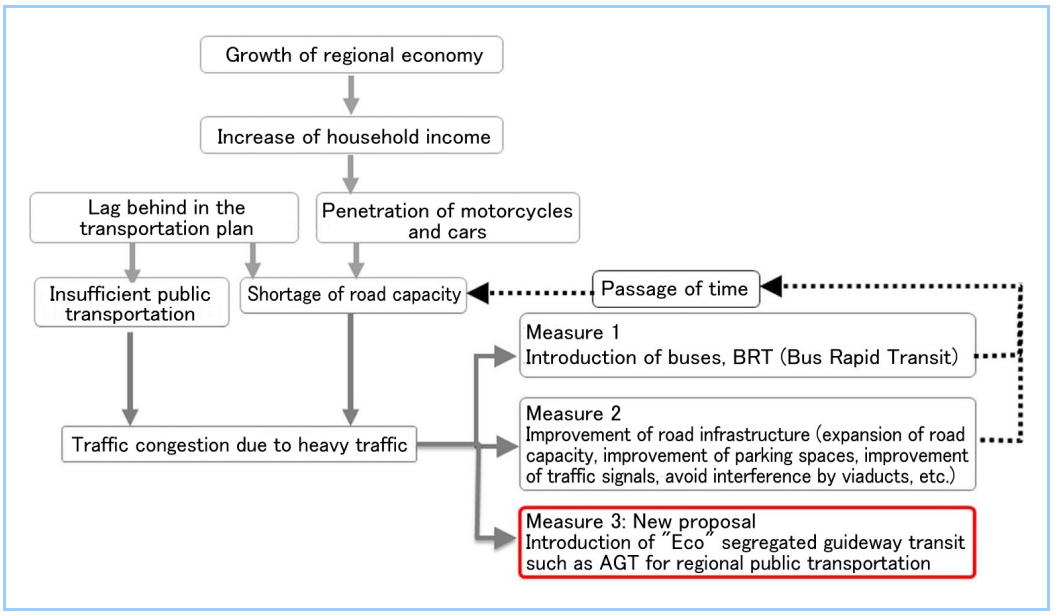


Figure 3 Flow of introduction of transportation infrastructure

(2) Development of business model

Figure 4 is a schematic diagram of a business model that grows with the development of passenger demand, real estate, the space inside stations and the region in connection with public transportation such as railways. In many cases, the public transportation business cannot be sustained with only the income from passenger fares of public transportation. Housing land along railway lines cannot be developed in the same way as in earlier business models, and therefore advertisements in vehicles, shops, tenants and stations are also a major source of revenue for the business. If stations and areas around stations are redeveloped from the aforementioned perspective on "points," stations and towns with similar functions may be constructed, which may impair passenger demand to travel between stations. The strategic development of demand to travel between stations is needed. In other words, efforts for the purpose of encouraging travel demand between stations through the diversification or differentiation of the functions of stations and areas around stations are required.

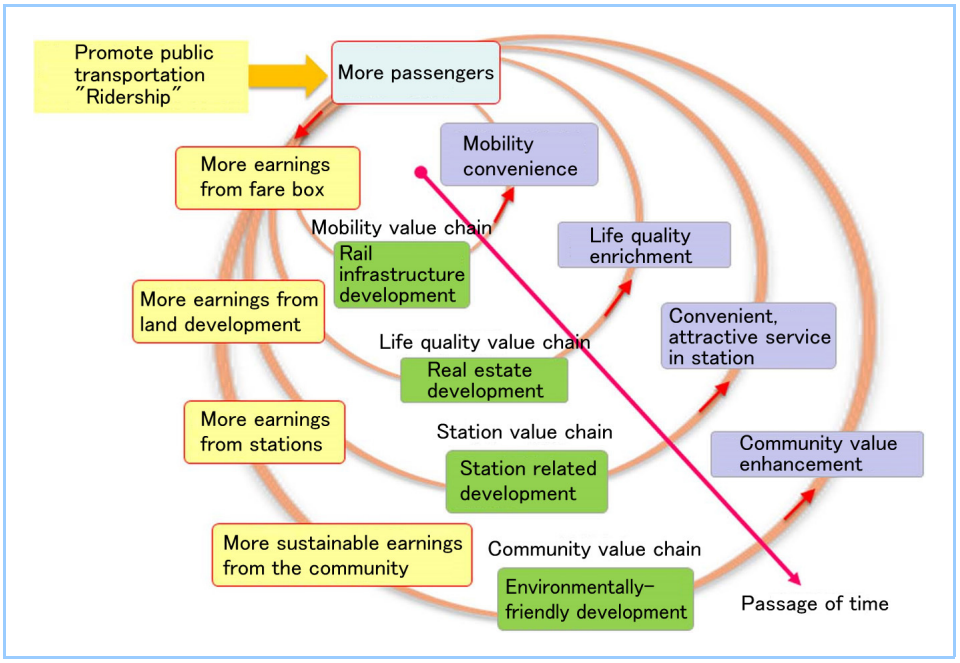


Figure 4 Evolution of transportation business model

(3) Advancement of urban transportation solution

It appears that new functions and performances are in demand for transportation systems to be introduced in a city. Is there any other choice but to introduce subways at a high cost for the reason that land cannot be acquired in cities where motorization has penetrated, as can be seen in emerging countries in Asia and South America? AGT is a system that can be retrofitted in harmony with existing cities. AGT has the following features:

- The minimum curve radius of 30 m enables a horizontally flexible track design.
- The high hill-climbing ability enables a flexible track design in the height direction from underground to ground level and elevated guideways.
- Rubber tires enable silent running, low noise and low vibration, achieving high environmental performance.
- Light-weight vehicles enable the low-cost and feasible construction of elevated guideways and introduction to existing elevated roads.

4. AGT

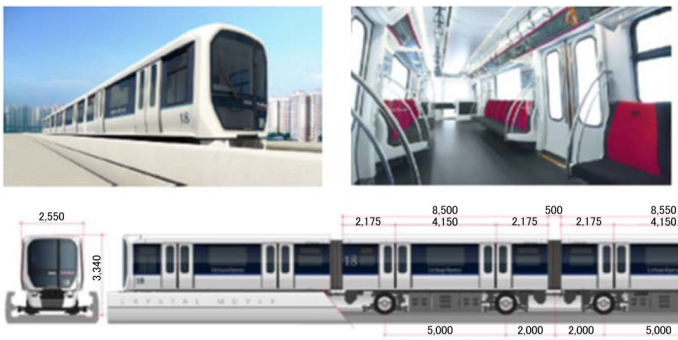
In designing the updated rolling stock for the Yurikamome Line for which MHI received the order in May 2010, we made efforts to reconstruct the values of the new transportation system which had been established since the beginning of the 1980s and to reinforce the weak points. A larger transportation volume and uniform interior air conditioning temperature were required for the updated vehicle. Concerning the transportation volume, there were problems with the existing vehicle in that the floor area of the passenger standing area was small, and the passenger capacity was insufficient because the seats were arranged as cross seats. An effective measure for solving these problems was to adopt a longitudinal seat arrangement as found in commuter train vehicles. But this required the reduction of the vehicle weight by more than 10% corresponding to the increase in the number passengers due to increased transportation volume. Therefore, with the top priority given to the reduction of the vehicle weight, we fundamentally reviewed the existing vehicle design and achieved the weight reduction. Concerning the uniform interior air conditioning temperature, we adopted air conditioning ducts for the first time in a new transportation system vehicle and achieved comfortable air conditioning that maintains the cabin at almost uniform temperature. In addition, we also improved the quality of the vehicle interior space through the uniform design for the seat form and sleeve screen, ceilings with air conditioning ducts and LED lighting, screw-less interior panels, baggage racks, hand grips and hand holds. As a result of these efforts, the updated vehicle received a special award for its “wonderful design for renovated public transportation” in the Good Design Awards 2014.

Following the Yurikamome 7300 Series (on the right in the title photo) that started commercial operation in January 2014, the Nippori-Toneri Liner 330 Series (on the left in the title photo) started operation in October 2015, and the New Shuttle 2020 Series (in the center in the title photo) went into service in November 2015. These vehicles have received a good reputation, with many people commenting that their image of conventional new transportation systems was renewed.

Japan has been attracting attention as one of the successful TOD countries. To introduce the AGT lines in the Tokyo area to people in countries with urban transportation issues, we organized the AGT vehicles into four lineups so that we could propose an optimum solution tailored for the transportation demand and the purpose of the line.

(1) Urbanismo-18

MHI introduces the vehicle with a maximum load of 18 tons under the brand name of Urbanismo-18 to markets overseas (**Figure 5**). It can transport 20,000 passengers in one direction per hour, and it fully satisfies the demand of the Yurikamome line in Tokyo with 110,000 passengers a day and 180,000 passengers a day at the peak. The maximum speed is 60 km/h, which is the optimum speed for an urban transportation line with a distance between stations of 1 km or less and many small curves. Compared to a subway vehicle of an equivalent size, it consumes less power and makes less noise and vibration through the effective use of the characteristics of a rubber tire vehicle. The Nippori-Toneri Liner presents its high environmental performance by satisfying the noise and vibration regulations in the Category 1 low-rise exclusive residential districts along the line.



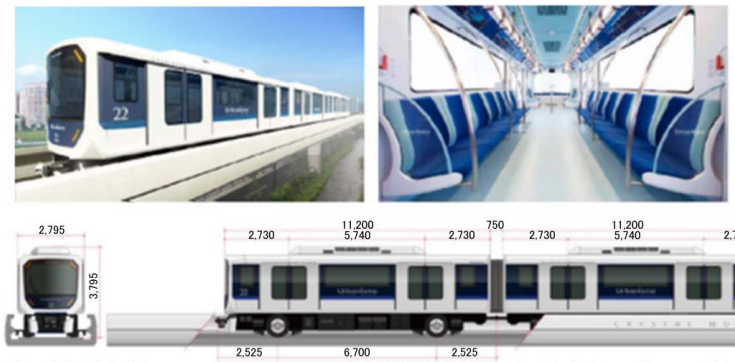
Empty weight: 10,500 kg/vehicle
Full-load weight: 15,900 kg/vehicle
Design maximum speed: 60 km/h
Minimum radius horizontal curve: 30 m
Train operation system: Fully-automatic (driverless)

Seating capacity (lead vehicle): 49 passengers (20 seats) <according to JIS E7103>
Full capacity (lead vehicle): 84 passengers (20 seats) <6 passengers/m²>
Seating capacity (intermediate vehicle): 52 passengers (19 seats) <according to JIS E7103>
Full capacity (intermediate vehicle): 90 passengers (19 seats) <6 passengers/m²>
Space dedicated for wheel chair: One in intermediate vehicle

Figure 5 Design of Urbanismo-18

(2) Urbanismo-22

A vehicle with a transportation volume about 1.6 times larger than that of Urbanismo-18 developed for the domestic market has been put on the overseas market under the name of Urbanismo-22, and is going to be operated on the Macau LRT (Light Rail Transit) system (**Figure 6**). This vehicle is based on the one introduced for the Sengkang Punggol LRT (Light Rapid Transit) lines in Singapore in 2002 and is intended for a railway line with a transportation volume of 32,000 passengers in one direction per hour. The maximum speed is increased to 80 km/h to reduce the travel time between stations. Urbanismo-22 has a hill-climbing ability equal to that of Urbanismo-18, which has a curve radius of around 30 m.



Empty weight: 15,400 kg/vehicle
Full-load weight: 23,860 kg/vehicle
Design maximum speed: 80 km/h
Minimum radius horizontal curve: 30 m
Train operation system: Fully-automatic (driverless)

Seating capacity (lead vehicle): 83 passengers (19 seats) <according to JIS E7103>
Full capacity (lead vehicle): 141 passengers (19 seats) <6 passengers/m²>
Seating capacity (intermediate vehicle): 83 passengers (22 seats) <according to JIS E7103>
Full capacity (intermediate vehicle): 141 passengers (22 seats) <6 passengers/m²>
Space dedicated for wheel chair: One in lead vehicle

Figure 6 Design of Urbanismo-22

(3) High-speed AGT

For Urbanismo-22, elevated guideways can be laid over existing roads while almost the same body cross section as that of an urban commuter vehicle is secured. By enhancing the speed of Urbanismo-22, we developed a high-speed AGT with a maximum speed of 120 km/h not only for urban transportation, but also for satisfying the needs of lines connecting regional hub cities and satellite cities (**Figure 7**). For high-speed AGT, a high-speed vehicle was developed, inheriting the characteristics of the Urbanismo-18 and Urbanismo-22 bogies, such as high-reliability and high riding comfort, 10% gradient hill-climbing ability, lightweight, long-lasting consumable parts and easier maintenance. Various data have been accumulated at the MIHARA Test Center in the Wadaoki Plant of MHI Mihara Machinery Works, where running tests can be performed with a maximum speed of 120 km/h. High-speed AGT is also

expected to be applied as a transportation system connecting a city and its airport located in the suburbs.

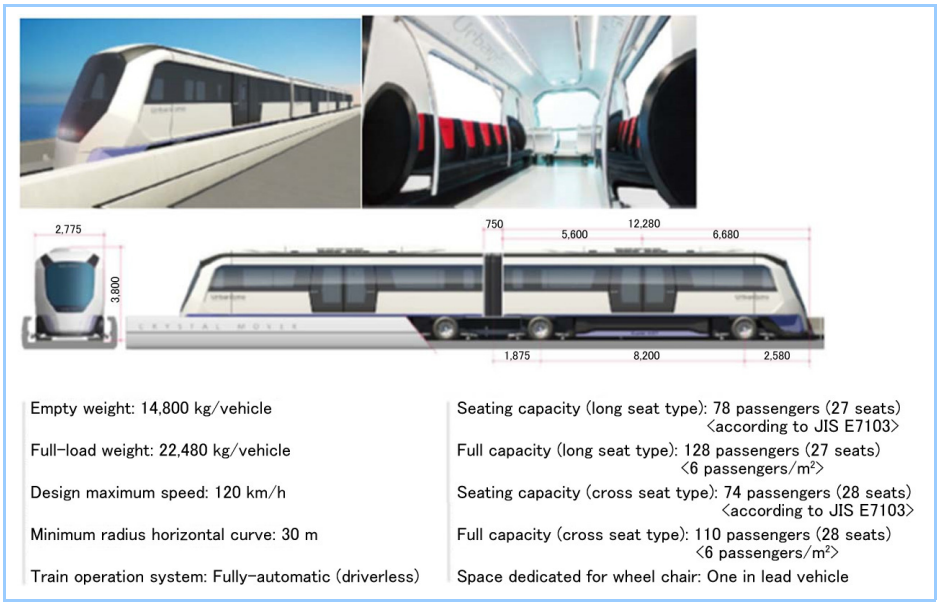


Figure 7 Design of High-speed AGT

(4) CFT-400

The aforementioned Urbanismo-18, Urbanismo-22 and High-speed AGT are designed for fully-automatic unmanned operation with both interiors and exteriors featuring the quality of commuter train used in Japan. For developing countries in need of financial support, an AGT with simplified specifications is offered as CFT (Congestion Free Transit), separately from the Urbanismo brand, so that AGT can be introduced and operated at a lower initial cost and running cost (**Figure 8**).

Figure 8 Design of CFT

5. Conclusion

AGT has advantages in that it runs silently on rubber tires, features lightweight vehicles that enable cost reduction in terms of elevated infrastructure, offers high hill-climbing performance and a small curvature radius, is an urban transportation system that can be retrofitted to a city through the use of the space over existing roads, etc. In the situation where various transportation systems have been introduced in cities around the world under the concept of TOD, AGT has the possibility of becoming the main player in urban mobility. It can be said that the age of AGT has arrived.

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