

# EVALUATION OF CONSTRUCTION OF URBAN RAPID TRANSIT COORDINATED WITH DEVELOPMENT OF RESIDENTIAL AREA

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## 1. INTRODUCTION

Recently, importance of railway transport for enhancing urban appeal and revitalizing cities has been growing more than ever. It is said that collaboration between urban development and railway development is important in order to have railways help improving functions of the city. In the past development, a project owner of urban development and a planner/operator of railway service did not always share the same objectives and collaborate on their project planning and following processes in a coordinated manner. However, as the needs for urban redevelopment grow recently, an increasing number of projects with an appropriate level of collaboration between urban development and transit service are found in construction of new railway lines and development of areas around existing stations. Due to raised awareness in environmental issues in recent years, use of railway services, which is one of environmentally-friendly means of transport and an option in modal shift, has been attracting more and more attentions.

Tsukuba Express (hereafter referred to as “TX”) opened in August 2005 is a new railway service, which was developed in accordance with “the unified promotion of land countermeasures and the development of transportation access and enacted the Special Measure Act for the Unified Promotion of Housing and Railway Development in Urban Areas” (hereafter referred to as “the Unification Act”). Development and improvement of stations connecting to other transport, station plazas aligned and creation of additional residential lands with the Unification Act, and improved customer convenience including more rapid trains have driven revitalization of the areas along TX line, leading to a steady increase of passengers since the opening of the line.

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This document is to report the method of developing urban rapid railway transit through collaboration between development of residential area along the line and railway project and to present the attribution analysis on the steady growth in transported passengers and impact on various collaboration effects as an ex-post evaluation of the TX line, referring to some findings from a questionnaire survey and passenger data.

## 2. PROCESS OF SYSTEM INTRODUCTION

### 1) Development of a transportation system in northeast part of the metropolitan area

In the course of rapid economic growth started in 1960's, residents in the Tokyo area were significantly increased. Contributed by migration to outside of the area, both time and distance to commute to school or work became longer very rapidly and a commuting area was expanded to a circle with 100 km radius. Under such circumstances, railway service as a mean of passenger transport connecting the northeast part of the metropolitan area and downtown Tokyo was solely depending on JR Joban line (see *Figure 1*), and therefore, the Joban line was incredibly crowded (congestion rate: over 200%). Not only a reduction of the conditions in the metropolitan area but also more radical solution for less crowded transportation was needed in order for smooth progress of the society and economy.

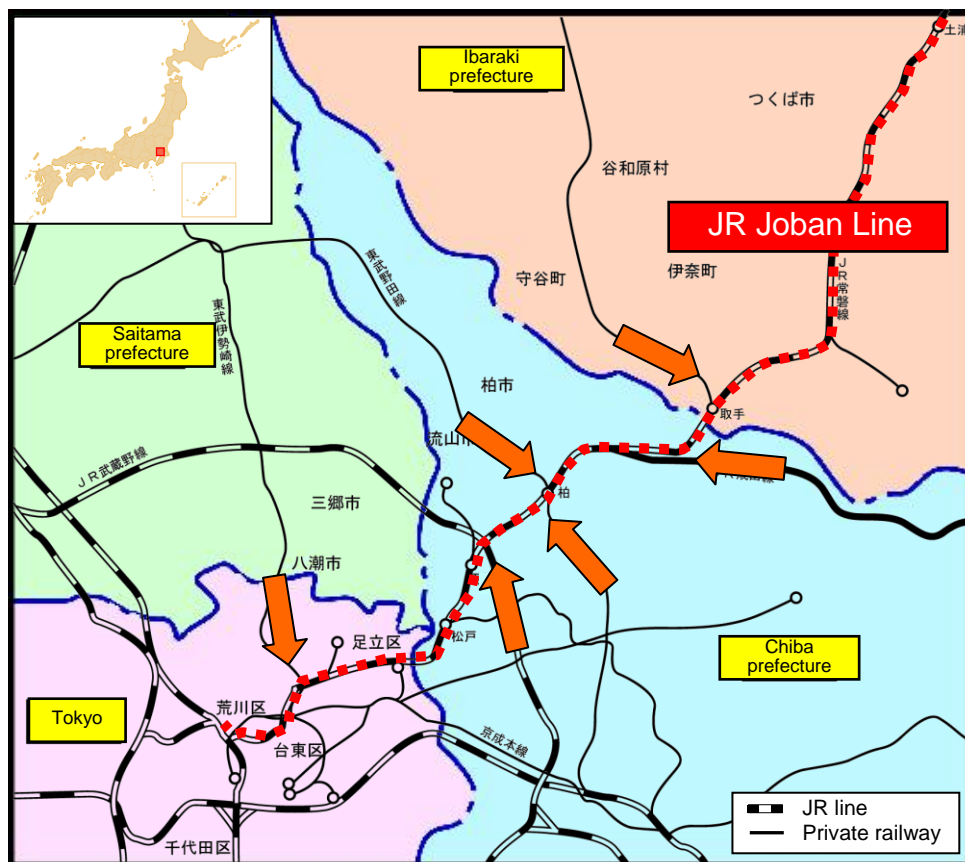
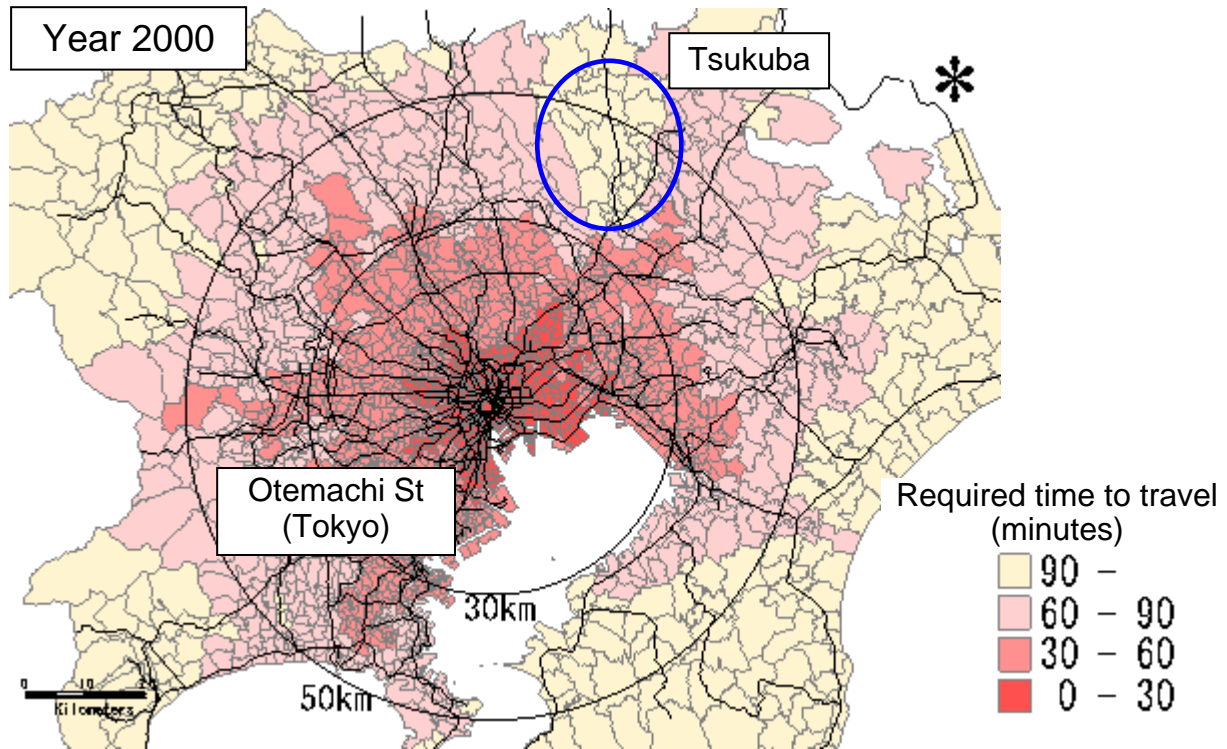


Figure 1 – Railway map of northeast part of the metropolitan area

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Although the northeast part of the metropolitan area has some residential areas with stable population due to progress of housing development, railway services for commute to school or work were not fully developed there, leaving the region a “trainless” area. *Figure 2* shows accessible areas from downtown of the metropolitan area in certain periods of time. It demonstrates that the northeast part of the Metropolitan area does not have any good access to railway transportation in a radial direction.



**Figure 2** – Accessible areas from Ootemachi (Tokyo) station in certain periods of time

Taking the situation into consideration, the TX line was planned to run a route to cross the trainless area so that the extremely crowded railway service of existing lines, including JR Joban line, was improved, with an expectation to provide better comfort to train commuters to school or work as well as improved transport customer convenience in the northeast part of the metropolitan area.

## **2) Encouragement to expand housing supply in the metropolitan area**

In the metropolitan area during the period of rapid economic growth, people faced a severe difficulty in purchasing their residents in the area due to sharp increase in land prices.

The northeast part of the metropolitan area has the city of Tsukuba, an academic urban where a large number of national research and development institutes are located. However, no direct railway line connecting the city and downtown Tokyo so far existed. By directly connecting the city and central Tokyo, the TX project aimed for development of a core city for various researches and businesses to modify overconcentration in the metropolitan Tokyo coordinated with enhancement of more housing supply.

### 3) Problems in railways development

#### *Development of residential area*

In the previous railway construction projects to connect downtown Tokyo and a suburban area, collaboration between developers of residential area along the line and planner and operator of the railway service was not well established. The poor collaboration caused delays in development of residential land, stations connected to other lines, and station plazas, resulted in worse customer convenience including less convenient transportation access. Not a few disorganized processes, for example, some farmlands left undeveloped for a long period of time due to an expectation for more increase in land price in the future, were causing compromised customer convenience. Such delays in residential development projects and disorganized development prevented the area along the railway from getting a faster growth of stable population, and the smaller-than-expected number of actual railway users obstructed a balance sheet of the train operator from being profitable in its railway business.

#### *Stable population*

A railway construction project with a view to develop residential areas along the line connecting downtown Tokyo and a suburban area requires a vast amount of construction cost. In addition, with a small demand by passengers at the early stage of the residential land development and a considerably long period of time required to grow the demand, such project has to face a difficulty in achieving sufficient profitability in the railway business or other heavy factors of uncertainties such as delays in the development. Considering the above, it is a project which is unlikely to be completed solely by a private railway operator.

#### *Railway construction funding*

In a new rail construction project, where no revenue is expected during the construction period, neither principal nor interest can be paid off until the rail service starts operating. If the payable interest during the construction accumulates and snowballs the interest-bearing liabilities, operating profit of the company would not be even enough to cover the interest. Such financial conditions may eventually force the rail operator to increase its fares, resulting in lower level of railway services.

#### *Acquisition of land for railways*

In some cases, projects face difficulty in land acquisition because of negotiation with land owners who do not accept the offer. This causes delay in the project schedule, resulting in increase of interest burden. It could make the railway business unprofitable.

In order to solve such problems, the TX project was designed to be based on a new scheme including “the Unification Act” and be carried out through the development of improved

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access to transport coordinated with further housing supply in the northern part of the metropolitan area.

### **3. DEVELOPMENT OF THE SCHEME**

#### **1) The Unification Act**

In order for prevention of delays in development of residential area along the line and unorganized development of the area as well as for facilitation of easier acquisition of planned railway sites, the Unification Act sets out the following.

1. Local governments (e.g. Tokyo metropolitan government, Ibaraki prefecture government) engaged in the development of residential area along the relevant railway line are required to take initiative in the project and fully collaborate with the national government, railway operator(s), construction companies to make well-organized coordination among them, in order to advance the residential land development in accordance with the progress of the railways development.
2. Each of the relevant local governments is required to formulate a basic action plan to make comprehensive advancement of the project, designate a focus area and specific region for a certain purpose, establish a council to hold talks among municipalities in the region and land reallocation project operators, and make adequate discussions required for the urban development and railways construction.
3. The act includes a specific mechanism of a coordinated land reallocation project to facilitate smoother acquisition of railway sites.

*Figure 3* shows an overview of the coordinated land reallocation project. Using the mechanism, even in the case that acquisition of the planned railway sites ran into troubles, the sites could be acquired earlier and more securely than other means, by way of integrated substitution of land lots as far as there are enough lands already purchased in the section of the rail development. It makes it possible to reduce time to complete the project and drive the development of the urban residential area coordinated with development of railways service.

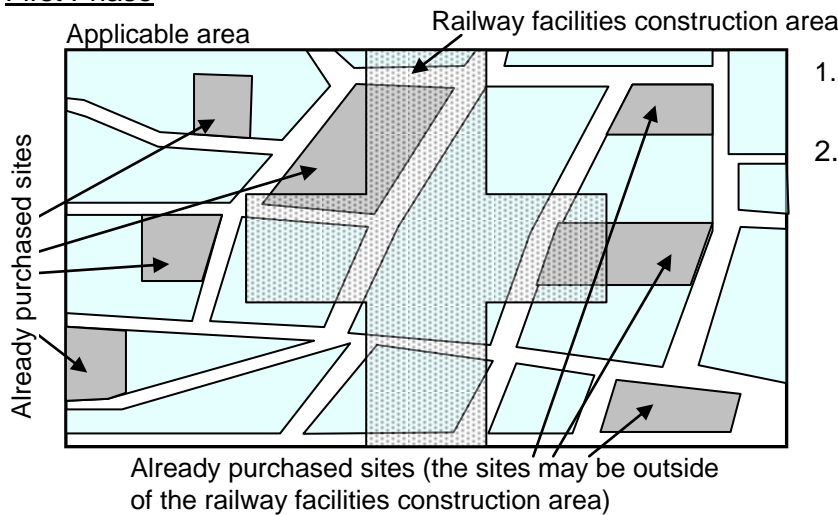
#### **2) Financial support for railway construction**

In order for stable operation of the railway business, the TX project took advantage of a subsidy program, in which approximately 80% of the construction cost (40% by national government and 40% by local governments) is loaned at a nil rate of interest as a biannual amortizable loan with equal installments over 35 years including a 5-year period of deferment. Using the support program, the initial investment burden incurred by the railway operator and a proportion of loan interests were successfully reduced. (The remaining 20% of the construction cost was financed by private investments and other sources.)

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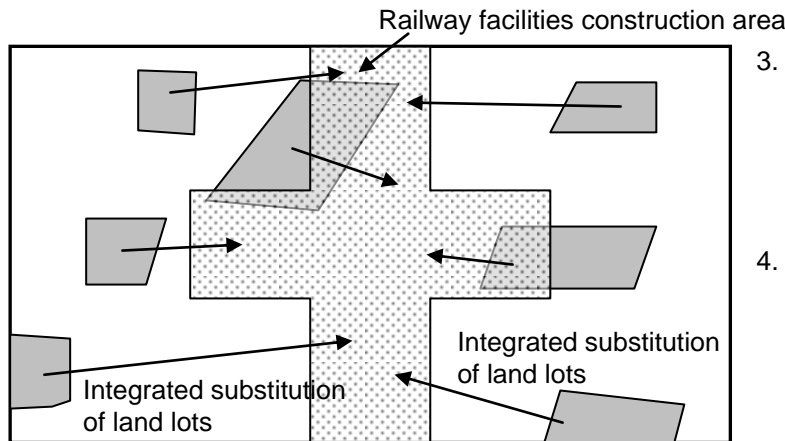
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First Phase



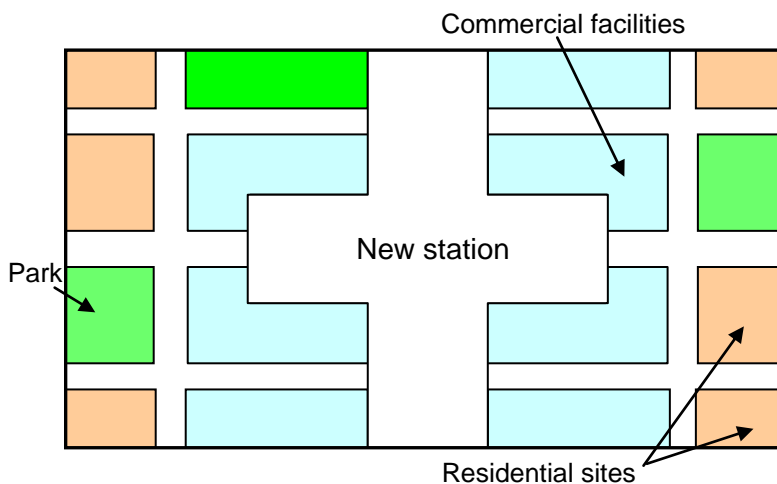
1. Designate a railway facilities construction area.
2. To produce residential sites, public facilities sites, and railway sites, a developer of residential area along the new rail line and railway operator purchase some lands in the applicable area in advance.

Second Phase



3. The land reallocation project coordinated with rail development is approved and land use purposes are determined.
4. The sites purchased in advance are transferred into the railway facilities construction area by way of integrated land substitution.

Third Phase



5. In the stage where development of the railway and public facilities has progressed, construction of buildings starts. Additional facilities for public interests are also developed, leading to completion of integrated urban development.

**Figure 3** – An image of the integrated land readjustment project

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3) Tax break

In the TX development project, specifically for the purpose to allow the railway operator to bear lower burden in its initial years of new railway service, a tax break was provided to lower taxable basis for property tax to 25% in the initial 5 years and to 50% between the 6th and 10th years.

4) Establishment of rail operator based on third sector scheme

The original TX railway project was planned and investigated as a part of an expanded Joban line project (the Second Joban line) of Japanese National Railways. However, as the railway company was privatized in 1987 to become Japan Railways (JR), some concerns over a vast amount of financing and management risks emerged. Therefore, it was determined that the TX project should be developed based on a third sector scheme mainly funded by local municipalities.

In March 1991, a third-sector company called “Metropolitan Intercity Railway Company” financed by local governments of Tokyo, Saitama, Chiba, Ibaraki and other municipalities along the line was established to start the project.

The MIR holds assets and properties as a railway business operator and is responsible for operating trains. The 40% of the entire construction cost to be financed by the local public bodies was shared among them as shown below, proportionate to the number of stations in each municipality (see Figure 4, Tokyo: Saitama: Chiba: Ibaraki = 4: 1: 2: 3).

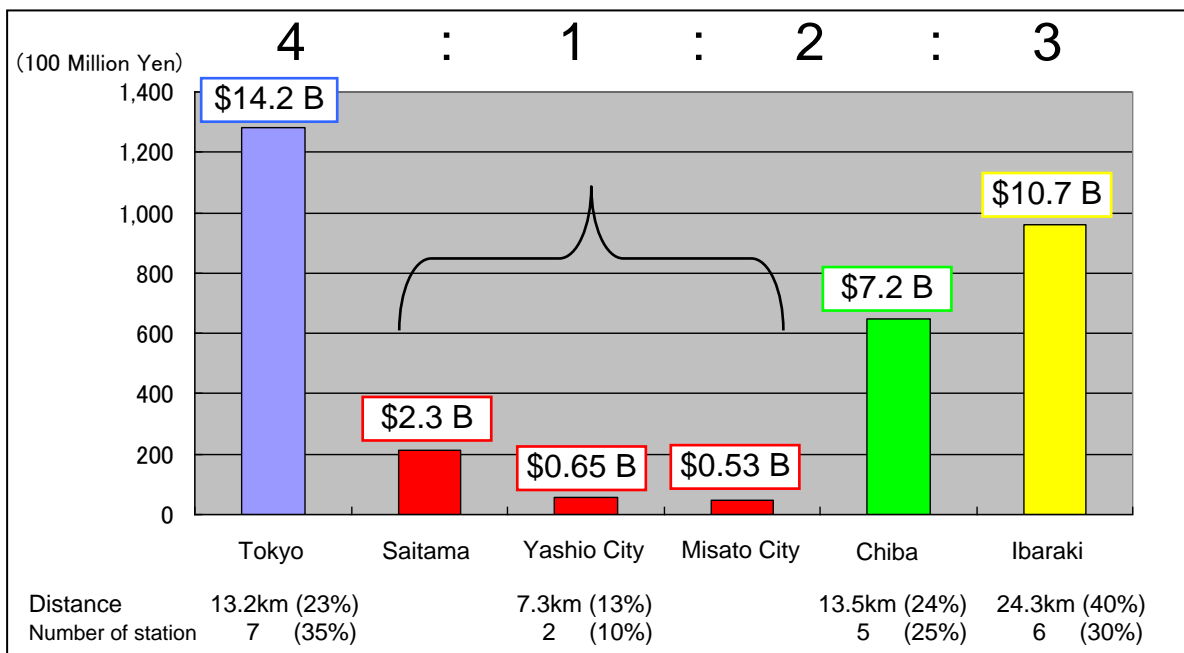


Figure 4 – Proportion of no-interest loans provided by local governments (40% of total construction cost; \$3.5 billion)

## 4. OVERVIEW OF TX PROJECT AND DEVELOPMENT OF RESIDENTIAL AREA

### 1) Construction project overview

The construction of TX was started in October 1994, having Japan Railway Construction Public Corporation (currently called Japan Railway Construction, Transport and Technology Agency) as its main constructor. Contributed by the impact of the Unification Act on the sites acquisitions completed in a scheduled period of time, the construction project was completed to allow the opening of the new express service in August 2005, as originally planned.

The construction cost amounted to approximately 810 billion yen (\$9 billion), reduced by 130 billion yen (\$1.4 billion) from the original plan due to some beneficial technical developments and other factors.

### 2) Planning Route

The basic route plan was determined to fulfill the conditions

- connect between the metropolitan area and Tsukuba within 60 minutes;
- the new railway line must be connected to existing railway lines;
- an increase in transportation demand is expected;
- the railway development must be coordinated with the land development plan around the station fully utilizing intended purpose of the land use in the area; and
- a grade separated crossing must be built for any crossing with a road or any other constructs in the entire railway line.

As a result, it was determined that the new express line extending to a total distance of 58 km between Akihabara and Tsukuba would have 20 new stations, including 7 stations connected to existing lines (see *Table 1, Figure 5*).

Akihabara is an area positioned as an important hub for global ICT industry in terms of urban policy of Tokyo metropolitan government, while Tsukuba is an academic city where a great number of national research institutes are intensively located. It was expected that connecting the two regions, Akihabara and Tsukuba, would establish core cities for research and business and further lead to improvement of overconcentration in the metropolitan area due to expected creation of new industrial infrastructure along the line.

**Table 1 – Standards of TX**

Total rail route distance	58.3km
Gauge	1,067mm
Number of stations	20 stations
Type of railway	Electrified double track railway
Block system	ATC, ATO
Number of cars	6 cars (planned to be 8 cars)



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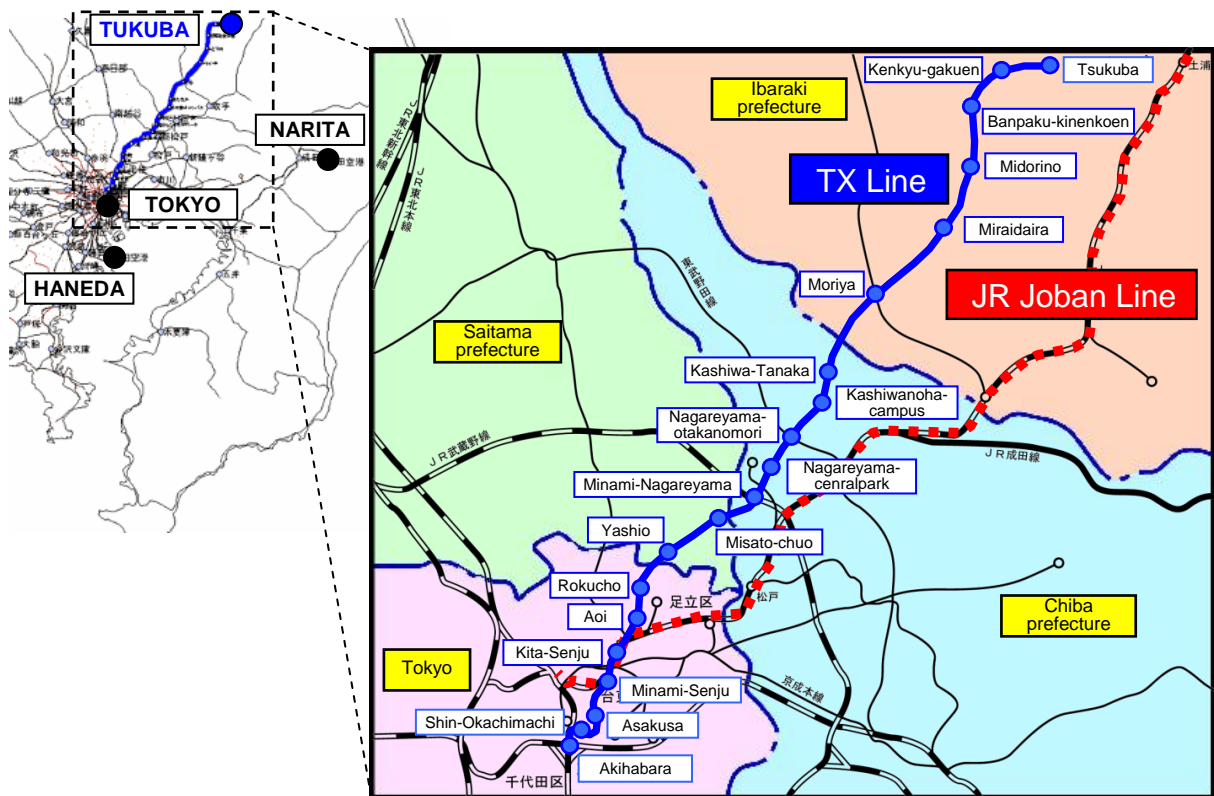


Figure 5 – Route map of the TX railway

### 3) Maximum speed and operation plans

Aiming to improve time to travel between the metropolitan Tokyo and the academic town of Tsukuba, an ATC (Automatic train control) signaling method, which was equivalent to the mechanism for Shinkansen (bullet train), was adopted to allow a maximum speed of 130 km/h. The following figure shows a comparison of scheduled speed between TX and other railways (see Figure 6). While the scheduled speed of other lines is mostly around 50 to 60 km/h, the speed of TX (rapid train) is 78km/h, demonstrating its outstandingly high speed compared to others.

Figure 7 shows an operation plan and Number of trains per day. To improve railway service, TX has revised diagram 4 times so far.

### 4) Feature of structure

The overall structure of the TX is designed to run underground in Tokyo and mostly on elevated tracks from Saitama prefecture to the north, without having any level crossing in the entire line. Every station has automated platform gates to prevent train users from dropping from the platform, securing higher safety of passengers (see Figures 8 and 9). The safety measure has reduced disturbances in transport, contributing to safer passenger transit.

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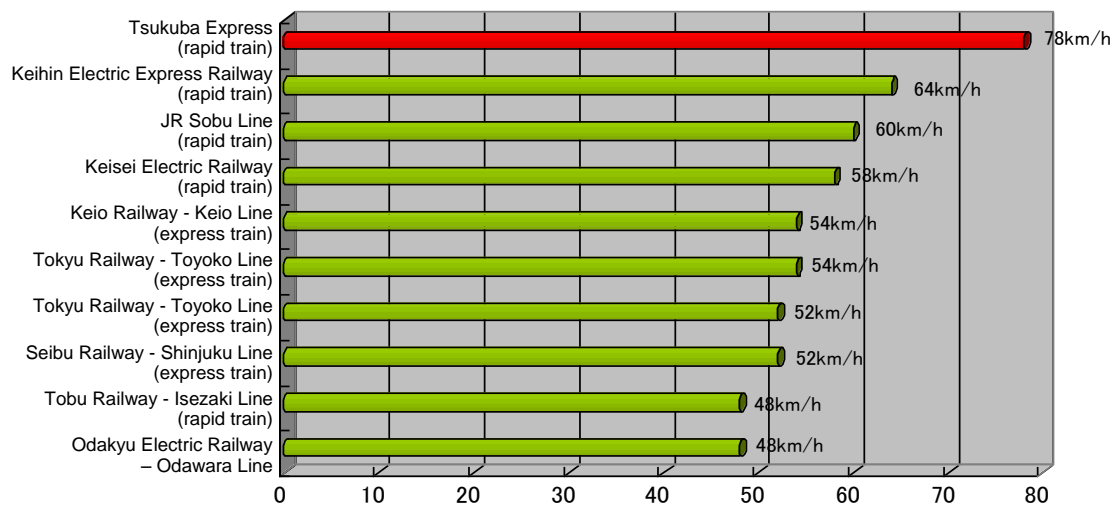


Figure 6 – A comparison of scheduled speed between different railways in the Metropolitan area

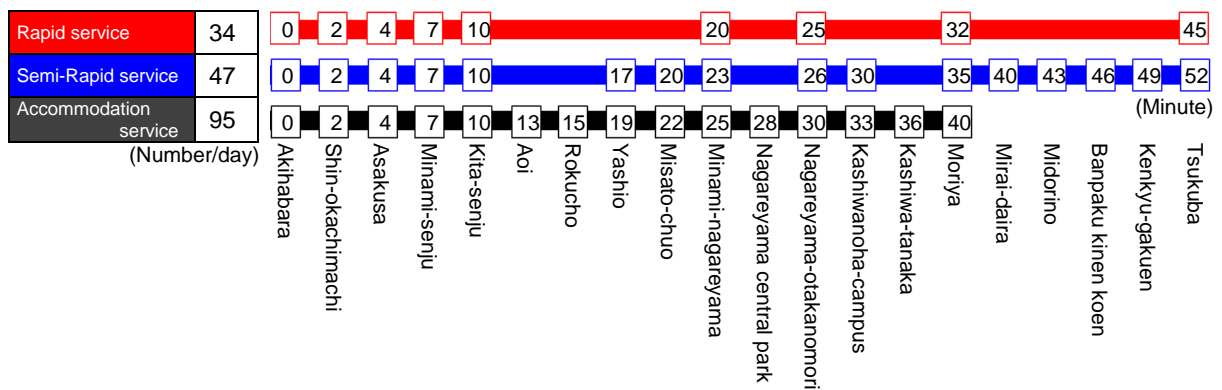


Figure 7 – Operation plan and number of trains

Source: Website of Metropolis Inter-city Railway Co. (as of December 2006)



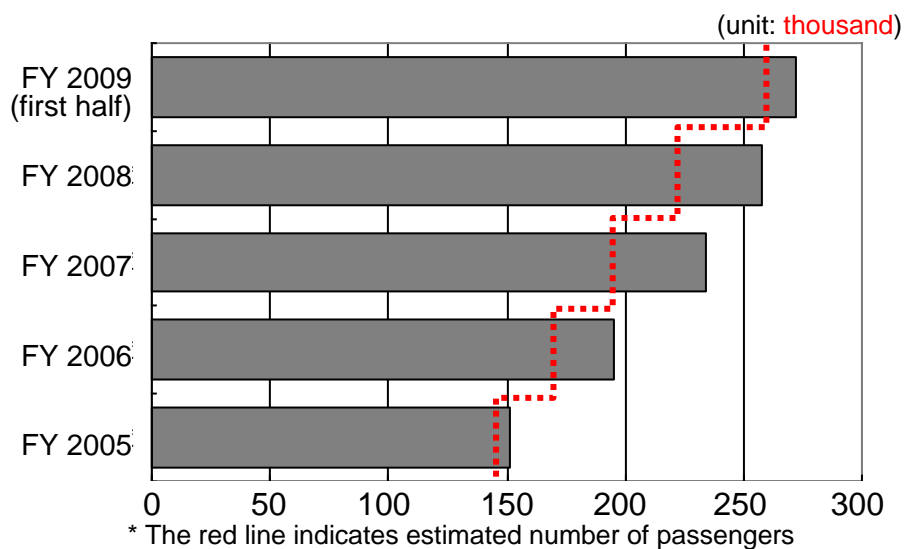
Figure 8 – TX train running at high speed on the line without being disturbed by any level crossing (Left), Figure 9 – Automated Platform Gate at Aoi Station (Right)

## 5. IMPACT OF THE RAILWAY DEVELOPMENT

### 1) Development of transport system in northeast part of the Metropolitan area

*The number of TX user and congestion mitigation of existing line*

Figure 10 shows the number of passengers transported in a day. The number has shown a steady increase since the TX line opened, amounting to 272 thousands on average in the first half of 2009. It is expected that the 2010 target (270 thousand/day) is going to be achieved a year earlier.



**Figure 10** – Changes in transported passengers (average passengers per day)



**Figure 11** – A scene of the Akihabara station during commuter transporting time zone

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According to closing financial statements for the fiscal year 2008, operating income was 33.4 billion yen (\$0.37 billion) and operating expense was 33 billion yen (\$0.36 billion) (including 19.7 billion yen (\$0.22 billion) of depreciation), with surplus of 0.4 billion yen (\$4 million) operating profit. These figures show that the financial condition is stable due to good number of transported passengers and effective subsidy programs.

Meanwhile, after the opening of the TX line which connects the northeast part of the metropolitan area with the downtown Tokyo, significant number of passenger of JR Joban line have shifted their transport mode to the new line, resulting in lower concentration on the JR Joban line and decrease of congestion rate of the line at peak hour from 180% (2004) to 160% (2008) (See Figure 12). This means that the launch of the TX service has contributed to making the trains in northeast part of the metropolitan area less crowded.

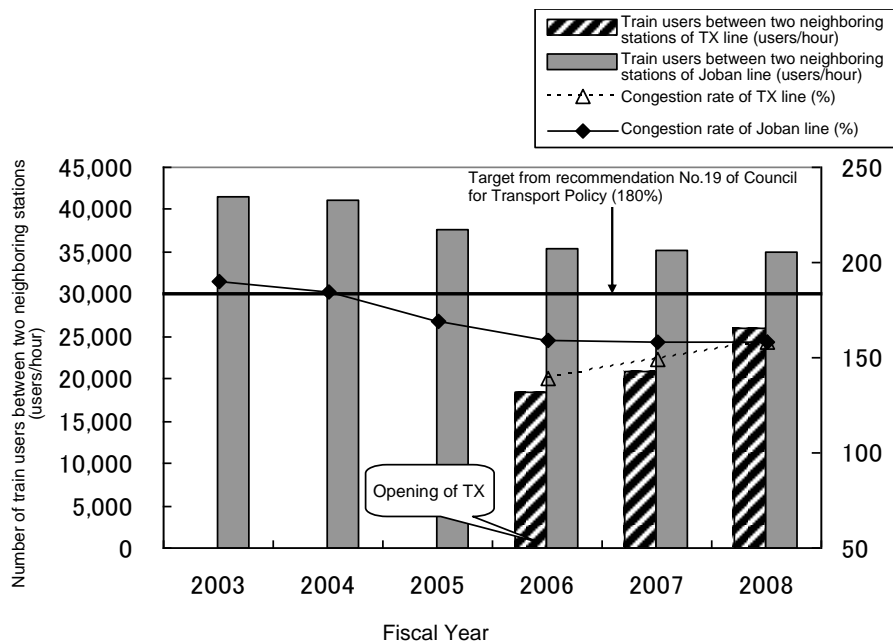


Figure 12 – Changes in number of passing passenger in a peak hour and congestion rate (TX and rapid train of Joban line)

Improved customer convenience

a. Reduced travel time

Figure 13 shows a time-reduction effect which the TX railway construction has given to the travel time from Akihabara station. The most prominent impact on the time reduction is seen in the Tsukuba area. In the area, there was no railway network before the TX project was launched, and the residents had to take an express bus or a local bus to a station on the JR Joban line in order to travel to the direction towards downtown Tokyo. However, the opening of the new express train service made a direct access from Tsukuba station to the downtown available, which contributed to the significant time reduction.

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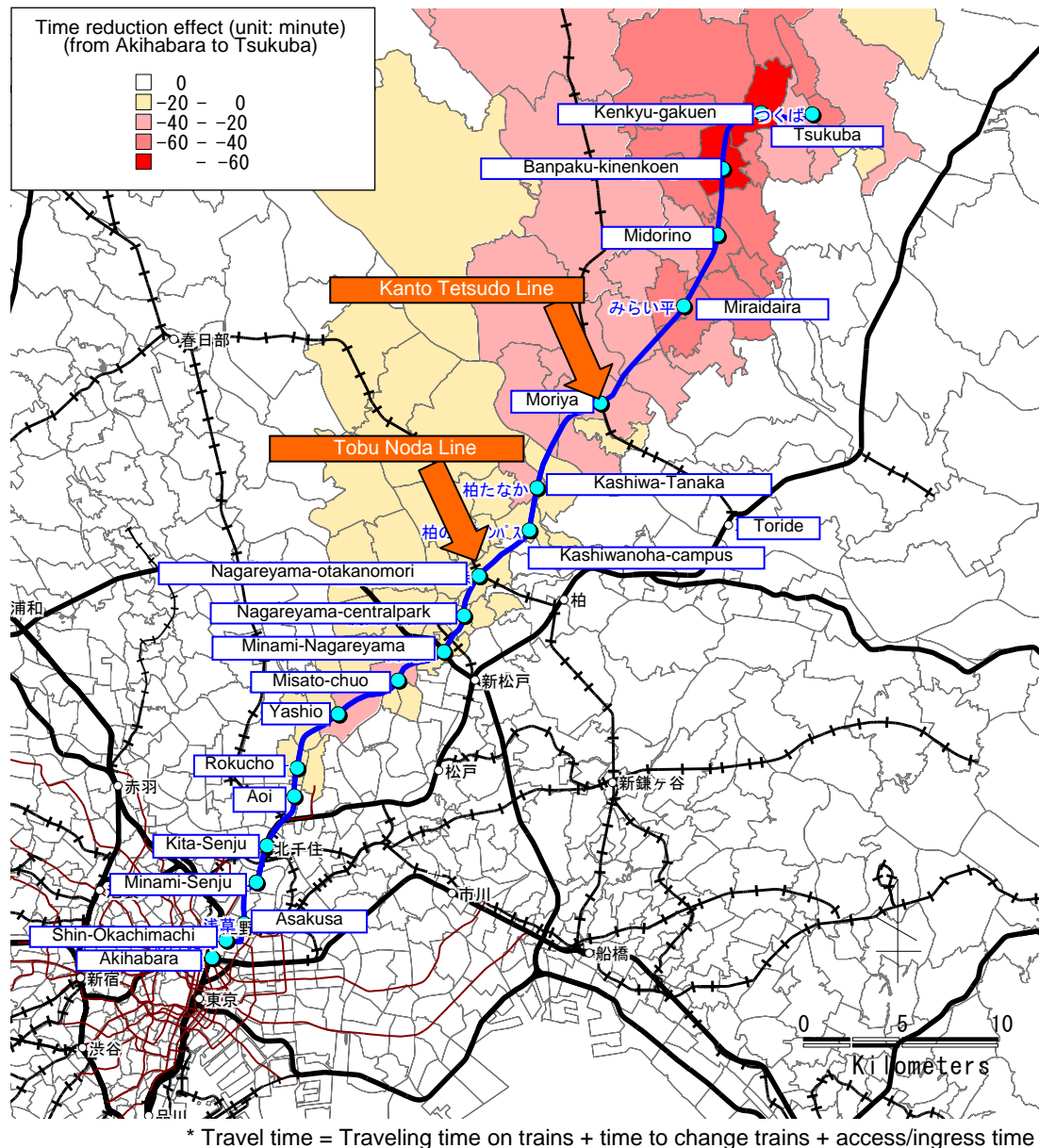


Figure 13 – Effect of the opening of the Tsukuba Express to reduce the travel time

Next, Figure 14 shows time to travel from Tsukuba station to Tokyo station in different means of transportation. Compared to the TX railway, other means of transportation required additional time for about 30 minutes and, in fact, the extra time could be even longer due to traffic congestion. Considering such factors, the TX trains are highly effective in terms of not only shorter time to travel but also reliability in arrival time. A large time-reduction effect is also seen along Kanto Railway line. Before the TX line was constructed, people who were heading to the direction towards the downtown Tokyo had to firstly take a Kanto Railway train to Toride station of JR Joban line to change trains. However, the new express train service has allowed train passengers to change trains at Moriya station without taking an extra route to Toride station, resulted in the shortened travel time. In addition, the user-friendliness for the passengers changing trains at TX stations connected to other lines seems to have further

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contributed to the reduced time to travel. For the similar reasons, favorable time-reduction effect is also seen along Tobu Noda line.

(Route 1)						Travel time (min)
Tsukuba	<Tsukuba Express> ■■■■	Akihabara	<Yamanote line> ■■■■	Tokyo		
	45	8	3			56

(Route 2)			Travel time (min)
Tsukuba Bus Center	<Bus> ■■■■	Tokyo	
	85		85

(Route 3)						Travel time (min)
Tsukuba Bus Center	<Bus> ■■■■	Arakawa-Oki	<Joban line> ■■■■	Ueno	<Yamanote line> ■■■■	Tokyo
	44	6	63	6	6	125

Figure 14 – Travel time from Tsukuba to Tokyo

b. Expansion of accessible range

Figure 15 shows an accessible range from Otemachi (Tokyo) after the opening of TX (2005). Almost entire section of the TX is within the range, and even the furthestmost Tsukuba station requires only 65 minutes at the shortest. The launch of the TX service has released some area from the “trainless” problem and the transport system in the northeast part of the metropolitan area was improved and well organized.

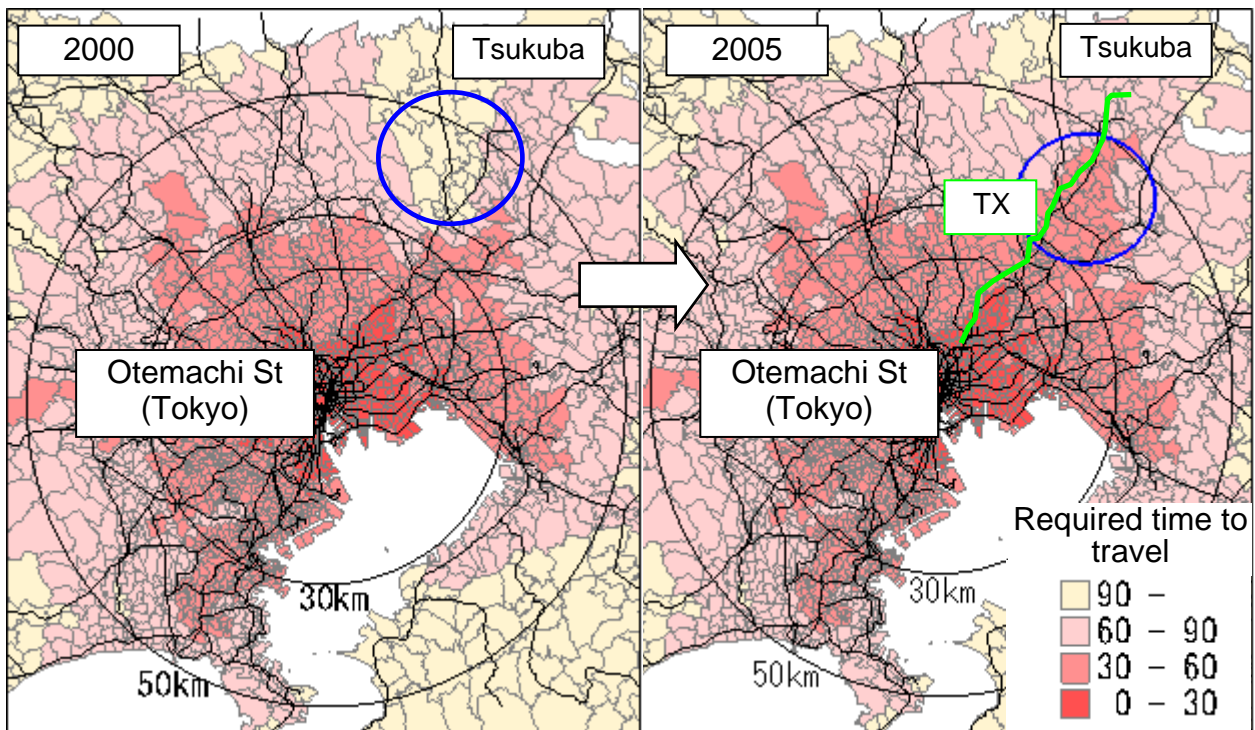


Figure 15 – Changes in accessible areas within 60 minutes from Otemachi (Tokyo) station

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**2) Encouragement to expand housing supply and development of residential area along the line in the metropolitan area**

*Overview of development of residential area along the line*

In accordance with the Unification Act, land reallocation projects for total area of 3,200 ha over the metropolitan area are currently underway. The residential area development is different from prior projects, such as creation of a “new town” in a suburb to ease overconcentration of population in metropolis, in which a great number of developments were concentrated in a limited area. In the new project, the residential areas for the development are distributed in a long range along the TX line, providing a variety of residential environment meeting characteristics of the area. *Figure 16* shows a couple of photos of Miraidaira station before and after the land reallocation project and the photo of 5 years after the opening. By comparing the photos, the organized development of the area is well understood.

As a part of the coordinated development, a bus station was established at each train station of the line and the bus lines in the area were reorganized in time for the opening of the new express railway line, aiming to attract more users. Even after the opening, the number of bus services and new routes has been continuously increased along with the progress of the station area development. Currently, all the 20 stations are accessed by regularly operated busses.

Compared to the original plans, needs for a great deal of suburban residential land were relatively reduced due to falling of land prices and other factors. However, such suburban residences are still going to be needed considering the facts that concentration of population in metropolitan Tokyo and Tokyo area is expected to continue and many people seek for a more comfortable and relaxed lifestyle in an better nature environment.

*Population growth ratio along the line*

*Figure 17* illustrates population growth ratios along the TX line before and after the opening of the line (for 2010 and 2000). Almost all residential areas along the line showed an increased growth ratio, especially in the areas around stations, where a land reallocation project was completed. The growth ratio is also high along the lines connected to the TX line. It demonstrates that the improved customer convenience of the TX line has impacted on some areas not subject to the land reallocation project.

*Figure 18* shows a comparison of growth ratio in land prices between three cities holding the TX line and other three cities without the line, before and after the launch of the express railway service (2009 and 2003). It clearly illustrates that the land prices have risen after opening of the TX service. A virtuous circle along the new railway service (the railway development coordinated with residential development along the line → favorable number of passengers gained → improved railway services → population growth along the line → more increase in passengers) has made the areas more attractive, which has led to the increase in land prices.

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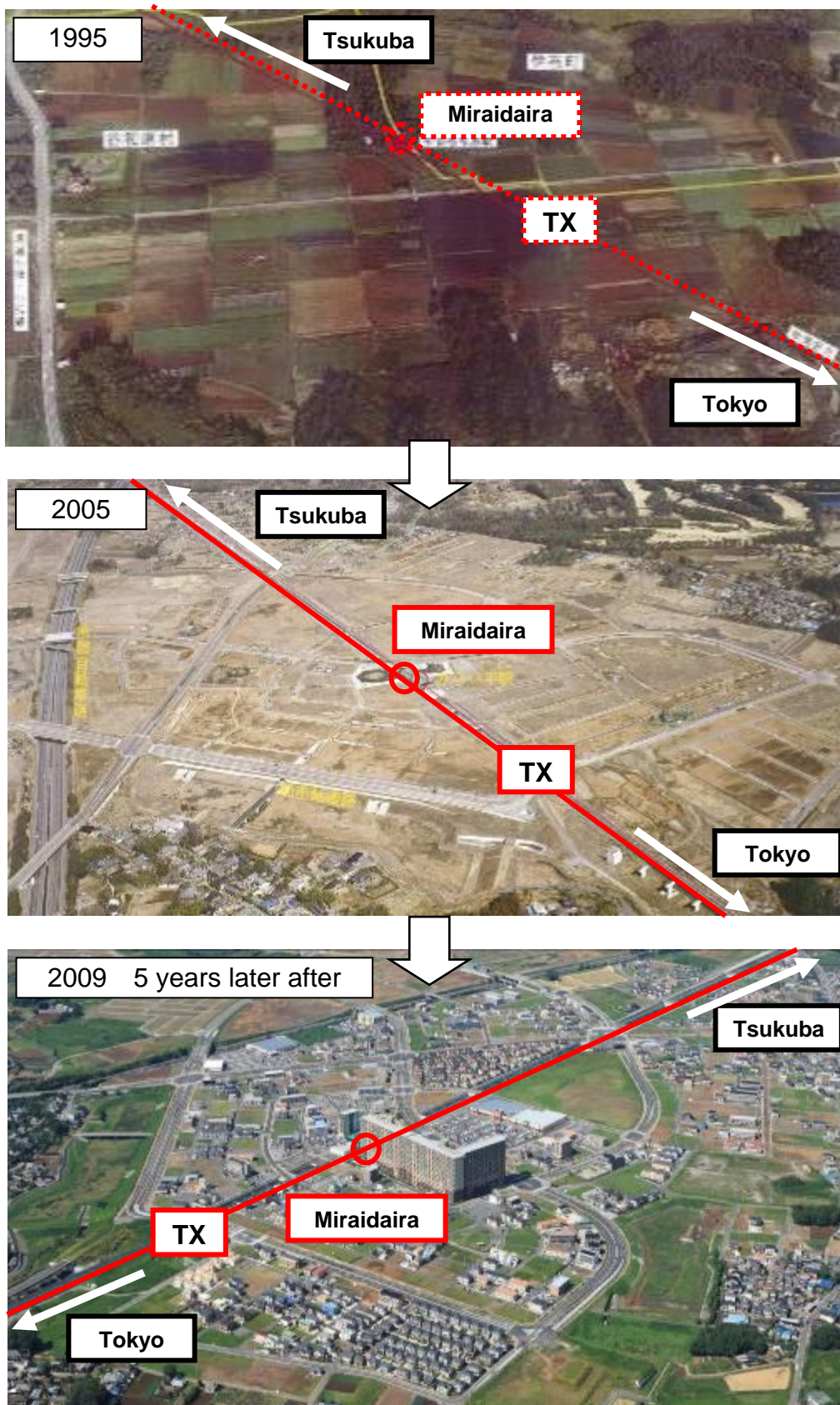


Figure 16 – Around Miraidaira station before and after the land reallocation project



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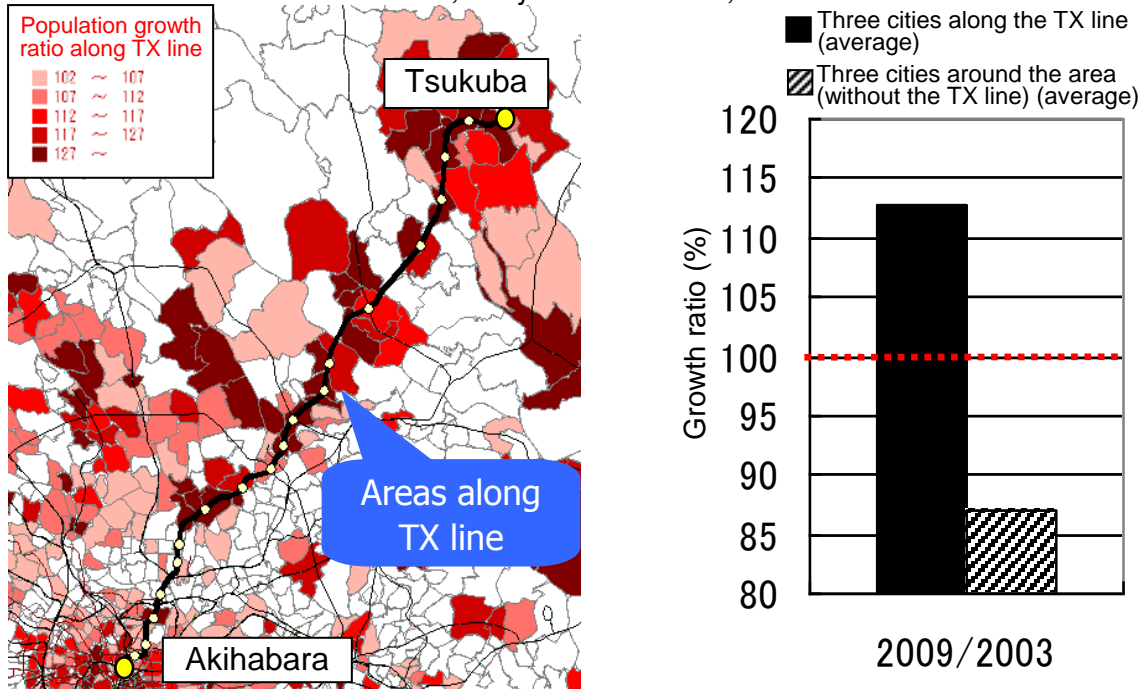


Figure 17 –Population growth ratio along TX line (for 2010 and 2000) (Left), Figure 18 – Land price growth ratio (Right)

Economic indicators

Figure 19 illustrates a comparison between the cities along TX and the areas around the cities in the amounts of local tax income, annual sales of retail shops, and the number of new residential constructions started, before the opening of TX (2002) and after the opening (2007). The 7 cities along the TX line showed a larger growth compared to the areas around the cities, especially in the number of new residential constructions which was almost doubled. It is thought that the population growth led by launch of the new express railway service has encouraged the development of the residential areas along the line.

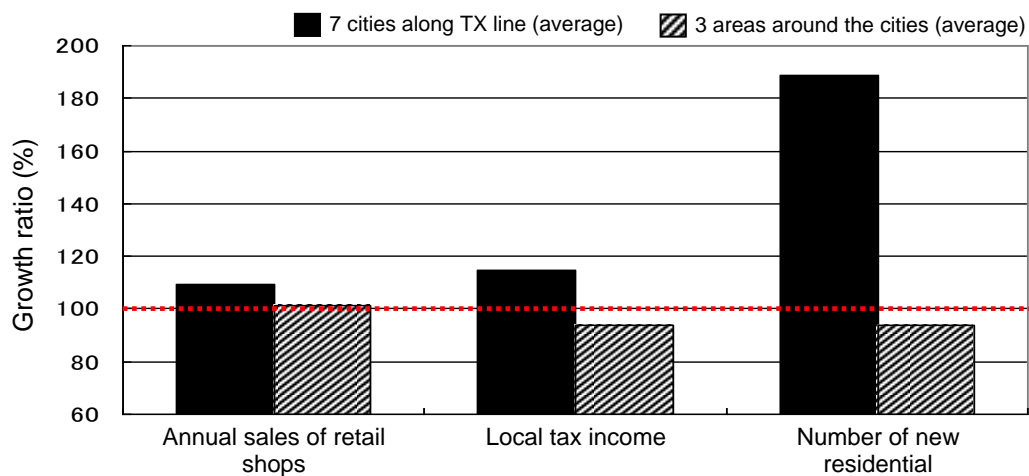


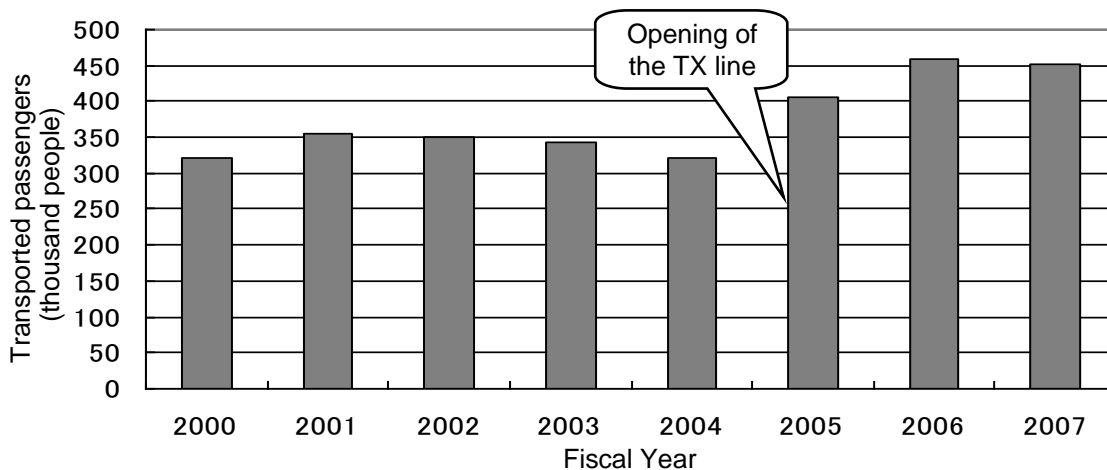
Figure 19 – Comparison of economic indicators

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Number of tourists

Impacts of the launched TX service on sightseeing business include a significant increase of mountain climbers visiting to Mt. Tsukuba, which is one of 100 Famous Japanese Mountains. After the opening of the rapid railway, operation of a new shuttle bus service from Tsukuba station to the mountain started. Another impact is that the number of users of Tsukuba Sightseeing Railway, which operates rail service including a cable car at Mt. Tsukuba, has also grown by a large margin after the TX line was opened (see *Figure 20*). These facts demonstrate that the new rapid train service has enhanced the tourist businesses in the local community.



**Figure 20** – Passengers transported by Tsukuba Sightseeing Railway

User benefit

*Figure 21* shows an illustration of user benefit. The user benefit refers to effectiveness and impact given to railway users, converting beneficial effects from time reduction, cost saving, and less crowded passenger cars into dollar amount. The value was measured by calculating a difference in effectiveness of railway transport for train users between the cases where the TX service had been developed (“with TX” case) and where the service had not been developed (“without TX” case) in dollar amounts and totalling the amounts for all users. The higher user benefit is generated mainly along the express line, but also the areas along the other railway lines connected at some of the TX stations.

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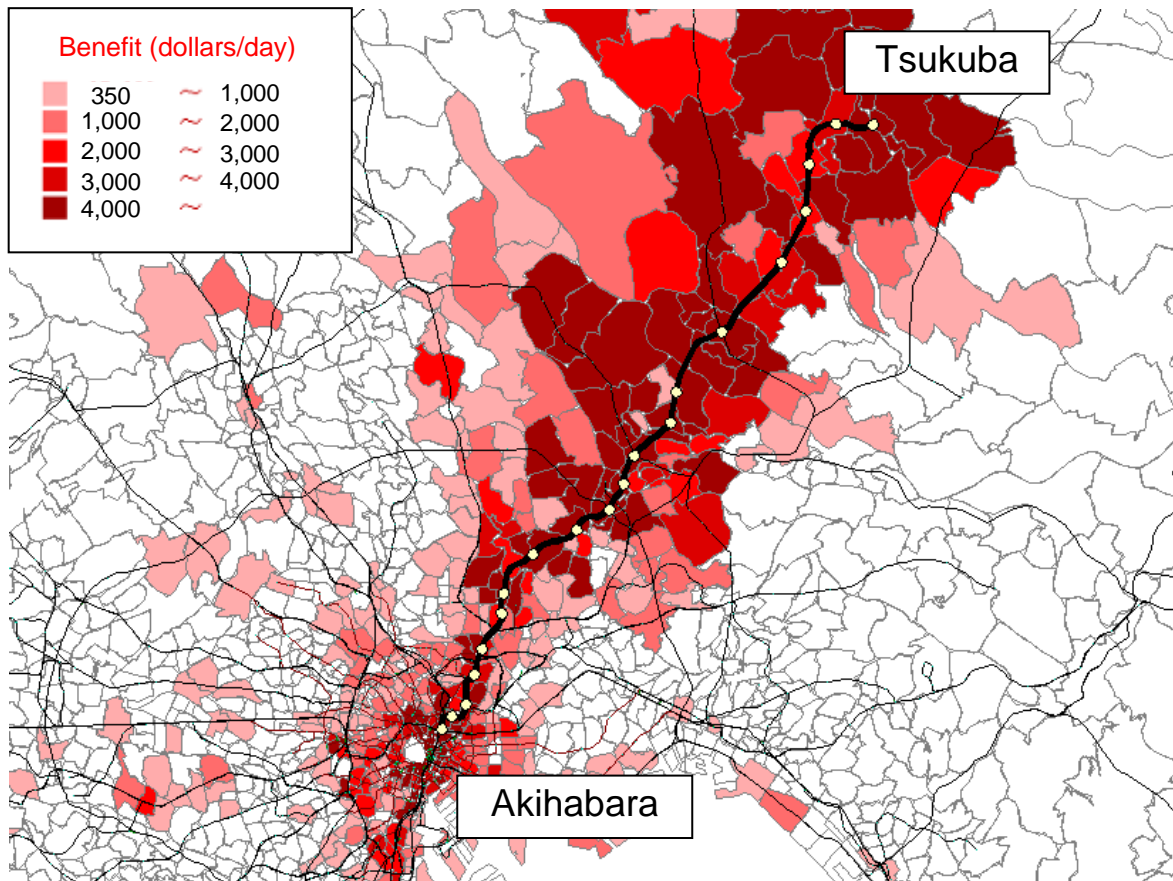


Figure 21 – User benefit

### 3) Evaluation by TX users (questionnaire survey)

Recognition for shorter time to travel: “Able to arrive the destination earlier than other ways” (ranked the 1st place) accounted for the largest share of 83%, showing that this factor was highly evaluated by most of the train users.

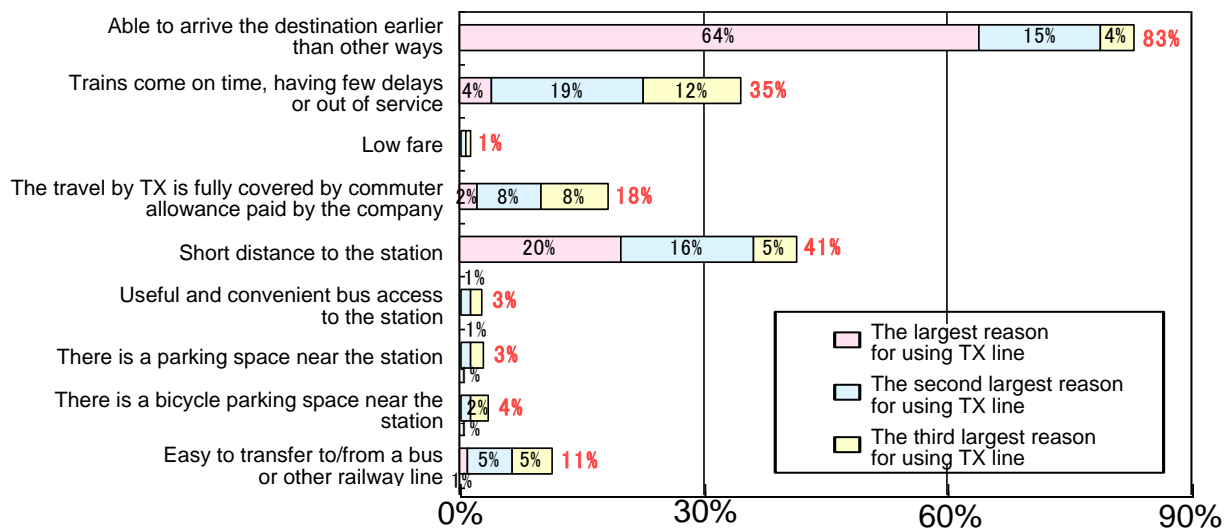
Recognition for residential development along the line: “Short distance to the station” (2nd place) accounted for 41%, demonstrating the impact of the coordinated urban development in accordance with the Unification Act. There were some respondents who gave improved services around the station as their reasons, including “Useful and convenient bus access to the station”, “There is a parking space near the station”, and “There is a bicycle parking space near the station”, although each of them represented a small share. These are another indicators of the effective impact of the Unification Act which prevented unorganized development of the area.

Recognition for the railway facilities: “Trains come on time, having few delays or out of services” (3rd place) accounted for 35%, “Able to take a seat, or the passenger cars are less crowded” (5th place) accounted for 19%, and “Comfortable ride” (7th place) accounted for 17% indicate that safety, stability, and comfort of the TX railway operations have been highly appreciated.

Other reasons: “Able to directly access to Akihabara” (4th place) means that the improved railway access which allows direct travel to downtown Tokyo has been appreciated.

## EVALUATION OF CONSTRUCTION OF URBAN RAPID TRANSIT COORDINATED WITH DEVELOPMENT OF RESIDENTIAL AREA

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**Figure 22** – Reasons for taking TX trains (total of the first to third largest reasons)

## 6. CONCLUSION

Aiming for improvement of transport system in the northern part of the Tokyo area and supply of a large volume of quality housing in the area, the TX project was developed and carried out through a close collaboration among parties related to railway operations and urban development. For the purpose of achieving the objective, they worked together toward the same goal and in accordance with the established the Unification Act designed for construction of railways coordinated with development of residential area. The development based on the law has demonstrated its effectiveness in smooth acquisition of sites for the planned rail service; improvement of areas connected to the new railway line, such as a station plaza; and prevention of unorganized land development, resulted in fully planned and coordinated urban development along the line. In addition, because of the well-planned and well-designed railway structure allowing higher and safer transportation compared to other train lines in the metropolitan area, the number of the TX passengers has been growing steadily. As the positive effect of TX is also seen in population increase in the areas along the line, land price and the questionnaire result, the project is considered successful.

From the above findings, in a project where the residential areas are developed along with the railway construction, it is thought to be very effective to establish a system to form an agreement between railway operators and developers of residential areas to make a coordinated approach in accordance with a specific law, such as The Unification Act in this case.