THE POTENTIAL FOR AN AIR TAXI BUSINESS IN JAPAN'S SKIES

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Abstract

In this study, the changes in various Japanese public transportation systems over the past 50 years are examined quantitatively. It is found that ground transportation systems, such as the tram, bus, railway, and automobile systems, have effectively matured and reached saturation, while aerial and subterranean transportation systems have potential for growth. The hub-and-spoke system of Tokyo International Airport has already matured, and its flight routes are overcrowded. In contrast, local airports are not used efficiently. The potential of an air taxi business using small piston-engine airplanes is investigated for the Tohoku region (northern Japan). In particular, the focus of this analysis is economic considerations based on time costs. The results show the high potential for growth of an air taxi business in Japan. The evolution of Japanese transportation systems depends on the effective use of many local airports.

1 Introduction

The Japanese public transportation system has dramatically changed in the last five decades with the proliferation of automobiles and the development of roads.

In this paper, we first discuss historical changes in Japanese modes of transportation, namely, the tram, automobile, train, bus, subway, and aircraft.

Second, recent problems specifically associated with the Japanese air transportation system are clarified. In particular, to compare the convenience of each transportation mode, the relationship between travel time and travel distance is evaluated by using web-based travel estimators for individual trips.

Third, the next generation of Japanese transportation systems is proposed on the basis of these results, with a particular focus on the potential for the development of a next-generation air transportation system in Japan.

Finally, a proposal for developing air transportation using small aircraft as on-demand air taxis is outlined.

2. History of Japanese Transportation

Figures 1 and 2 show the evolution of different transportation systems in Japan, namely, the tram, automobile, bus, subway, Japanese Railway (JR), private railway, and domestic aviation systems.

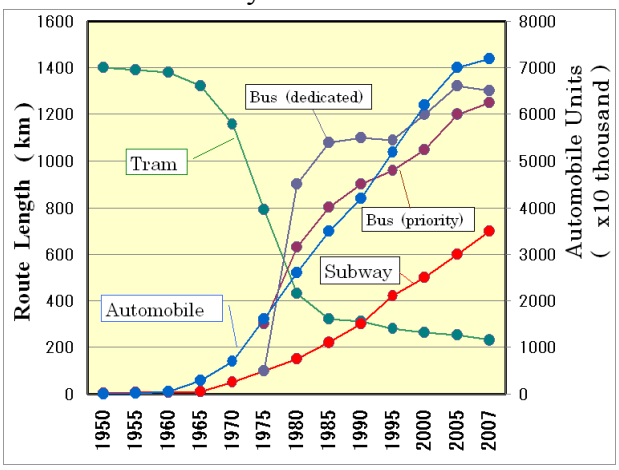

Fig. 1 Changes in Japanese public transportation. [1]

Trams were a popular mode of transportation in many major cities from 1910 until the 1960s. In the mid-1950s, compact cars were actively developed by Japanese automobile manufacturers, and the popularity of these cars (e.g., the Subaru 360) increased rapidly.

With the popularization of mid- and full-size cars from the 1960s onward, the number of

automobiles has increased rapidly, reaching 60 million units in the 2000s.

When motorization started in Japan, the lifestyle of many Japanese changed dramatically. Furthermore, the rate of increase in automobile use has been nearly constant (about 2 million units per year) for more than 30 years. Consequently, many cities have faced the problem of extremely congested roads. One cause of this congestion was trams, which operated in the middle of city roads. To improve the traffic situation, tram lines were abolished in many cities, causing the overall use of trams to decrease between 1965 and 1975, and the mode of public transportation eventually shifted from trams to buses.

At the same time, the most promising solution to the congestion problem was the development of subway systems. The number of subway lines has increased linearly in the past 30 years, and subways remain a popular urban traffic system. As shown in Fig. 1, the use of bus lines has already matured and has been decreasing gradually since the mid-1980s.

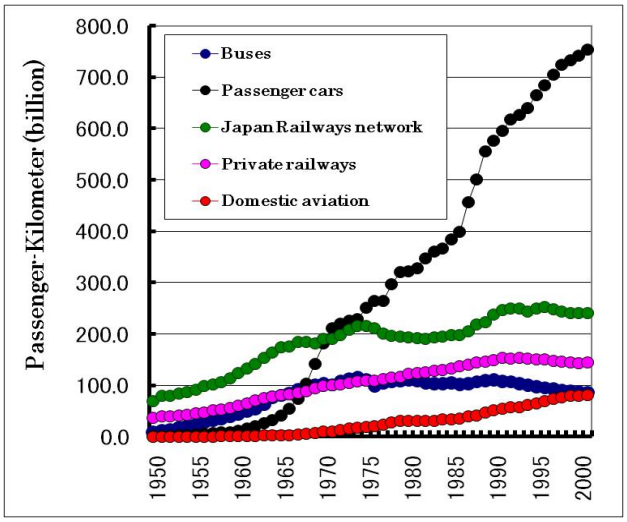

Fig. 2 Distance traveled per year by various modes of transportation. [2]

Figure 2 shows the changes in revenue passenger kilometers for five modes of transportation.

As already shown in Fig. 1, passenger cars play a critical role in Japanese transportation. The revenue passenger kilometers for passenger cars increased three-fold from 251 billion in 1975 to 741 billion in 2000. During this time, the capacity of buses and railways matured and reached saturation, with peaks in 1975 and 1992, respectively. Private railways reached a peak around 1990.

After peaking, the use of buses and railways has decreased gradually to the present levels. In contrast, domestic aviation has maintained steady growth. The evolution of automobile ownership is shown in further detail in Fig. 3.

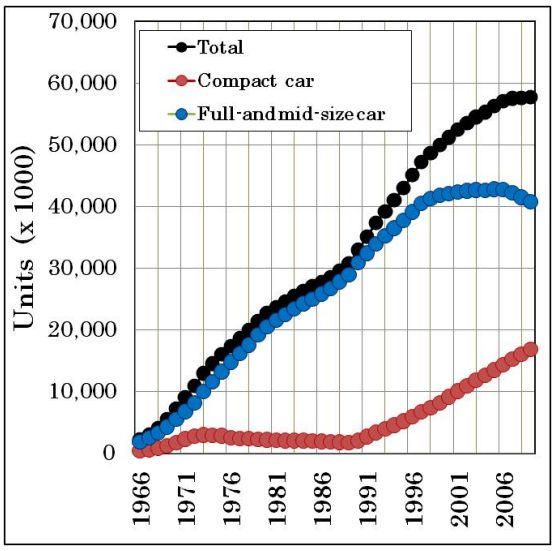

Fig. 3 Automobile ownership in Japan. [3]

The use of mid- and full-size cars matured by the mid-1990s, becoming nearly flat in the early 2000s and decreasing from that point onward. However, the use of compact cars increased again in 2000; this increase in the use of compact cars apparently came at the expense of mid- and full-sized cars, as drivers chose smaller vehicles.

The evolution of automobile use is shown in detail in Fig. 4. This figure shows the relationship between the average number of cars per household and the population growth rate of each of the 47 prefectures in Japan. At present, the average numbers of cars per household is about 1.1 in Japan. Furthermore, the average population growth rate from 1985 to 2005 was about 106%.

Two distinct groups can be seen in this figure. One group has a decreasing population growth rate and more cars per household; this group consists of rural prefectures.

The other group has an increasing population growth rate and fewer cars per household; this second group consists of the greater Tokyo area and the main prefectures in the Kansai region.

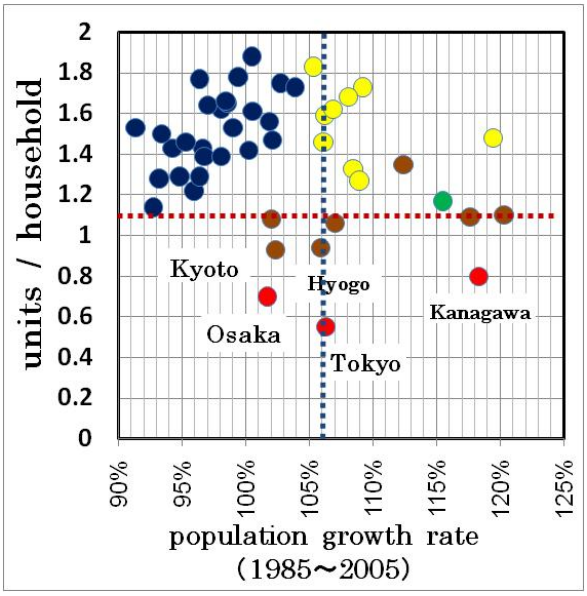

Fig. 4 Relationship between average numbers of cars per household and population growth rates of 47 Japanese prefectures. [4,5]
Red circles: greater Tokyo area and the main prefectures in the Kansai area; brown and yellow circles: main rural prefectures and satellite prefectures around the Tokyo Metropolis; blue circles: rural prefectures; green circle: Okinawa prefecture (isolated island).

Other data has shown that in the many rural prefectures, the average number of compact cars per household has also increased. Households began purchasing compact cars as a second car only recently.

The total population of Japan started to decrease in 2006, and Japan is currently facing an aging society coupled with a declining birthrate. Therefore, it is difficult to account for the increase in the average number of cars per household.

In 2009, the popularity of hybrid automobiles marked a major qualitative change in Japanese motorization. More than 300,000 units of hybrid automobiles were sold in Japan in 2009. At the same time, in the bicycle market, sales of electrically assisted bicycles overtook those of motorized bicycles (Fig. 5).

In summary, Japanese motorization has already matured and reached saturation quantitatively, but qualitative changes of motorization, with a shift from the internal combustion engine to electric motors, have occurred.

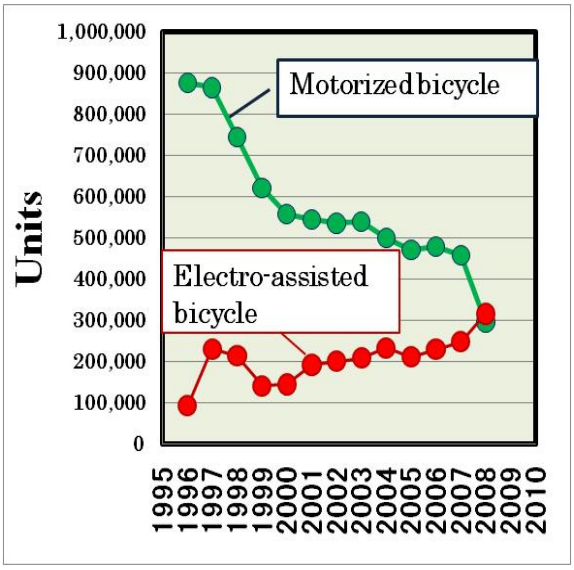

Fig. 5 Sales of motorized bicycles and electrically assisted bicycles in Japan.

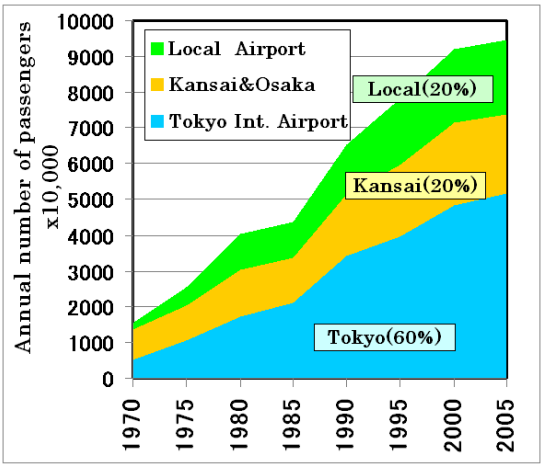

Fig. 6 Changes in the number of domestic airline passengers in Japan. [8]

Figure 6 shows the changes in the annual number of domestic airline passengers. The civil aviation system has experienced relatively steady growth for 40 years, during which the number of passengers travelling via the hub-and-spoke system has quadrupled. The total number of passengers is currently about 100 million, which means that, on average, almost every Japanese citizen uses a domestic airline at least once a year.

Furthermore, this figure indicates that there are two major hubs for domestic flights in Japan, namely, Tokyo International Airport (Haneda) and two airports in the Kansai region (Osaka International Airport and Kansai International Airport). Sixty percent of passengers use Tokyo International Airport and another 20% use

Osaka and Kansai. The remaining 20% of passengers use other local airports.

To summarize the above data, most ground transportation systems, including the tram, bus, railway, and automobile systems, have matured and reached saturation. In contrast, air and subterranean transportation systems, such as subways and airplanes, have potential for growth, as their common characteristic is the lack of congestion. Subways will continue to develop in urban areas, while air transportation systems will continue to develop in suburban areas.

3. Problems of Air Transportation System in Japan

At present, there are about 100 airports and about 300 air routes in Japan. Figure 7 shows the major air routes for which the number of passengers exceeds 1 million per year. There are only 23 such routes. These routes account for around 10% of the total number of air routes in Japan, and 16 of these 23 flight routes are centered at Tokyo International Airport.

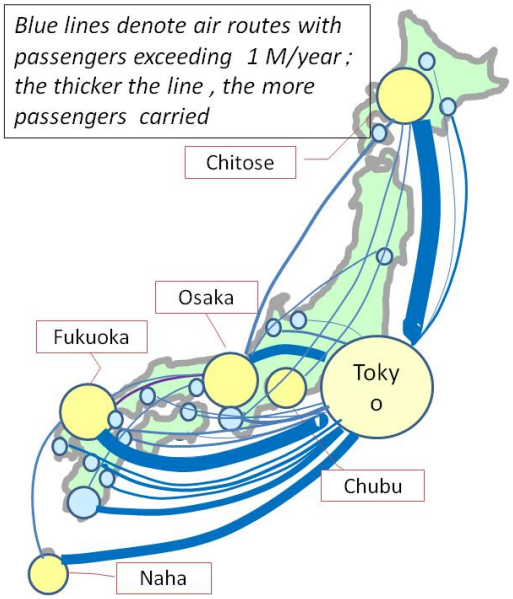

Fig. 7 Major air routes in 2008. [9]

Flight routes have consequently become overcrowded at Tokyo International Airport, and overcrowding is a defining feature of the Japanese air transportation system.

Thus, the hub-and-spoke system has already matured and exceeded its capacity. The over-concentration of traffic in Tokyo is a major problem of the Japanese air transportation system. Tokyo International Airport currently has only three runways, although an additional runway is scheduled to be constructed in 2010 as a countermeasure against congestion.

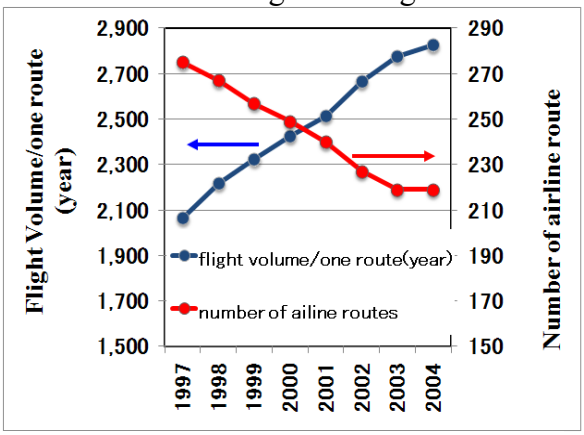

Fig. 8 Changes in airline routes and flight volume. [10]

Furthermore, the number of airline routes decreased between 1997 and 2003, owing to economic issues, with airline companies cutting services to unpopular destinations. Meanwhile, flight volume (frequency of flights) is inversely proportional to the number of airline routes for the same period. This shows that airlines have abandoned unprofitable routes, transferring airplanes to profitable routes. Making the matter worse, Japan Airlines declared bankruptcy in 2009. Consequently, the number of airline routes further decreased.

These facts indicate that the Tokyo Metropolis is the most convenient city in Japan in terms of location and other local airports are seriously underutilized. Therefore, a solution is needed to use these airports efficiently.

Next, the convenience of Japanese air transportation is evaluated quantitatively. To compare the convenience of the three main transportation systems, we examine the relation between the travel distance and the travel time required for the various trips using the Shinkansen and the connected JR network, using the Shinkansen network only, and using air transportation and the connected JR network (Fig. 9).

Tokyo JR station was chosen as the starting point for these trips. This station is located in the central part of Tokyo Metropolis, and is one

of the most convenient locations in the city in terms of travel.

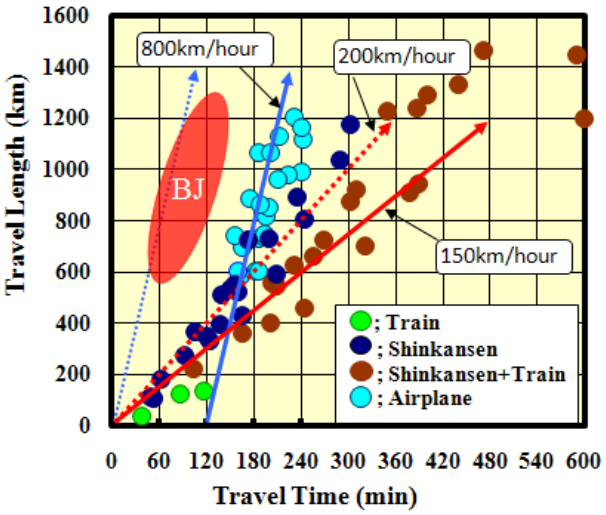

Fig. 9 Relation between travel time and travel distance from Tokyo to various cities. [11]

The destinations are 44 typical JR stations located in prefectural capitals (except Naha City in Okinawa prefecture, which is located on an isolated island). In the case of the air transportation network, the travel times include the access times from the airport and the JR station, as well as wait times. Actual ground times were determined by using web-based ground travel estimators for each individual trip, and actual airline flight times were used for commercial airline gate-to-gate times, which were also determined using a web-based search system.

The figure shows three distributions of travel times and distances, corresponding to the three systems. It is clear from the distribution along the red line that the combined Shinkansen and railway network system is the slowest, as the dotted red line indicates a travel speed of about 200 km/hour. Although the maximum speed of the Shinkansen recently reached 300 km/hour, the actual average speed is lower. The statistics for the air transportation network is distributed along the blue line, with travel times of 150 to 240 minutes and travel lengths of 600 to 1200 km. The dotted blue line indicates that the travel speed is equal to 800 km/hour, which is the typical speed of commercial airline aircraft. The time statistics for the air transportation network are shifted to the right of the dotted blue line and shown as a solid blue line in this figure

. The time difference between the solid blue line and the dotted blue line is 120 minutes, which indicates that there is much wasted time when air transportation is used.

For distances ranging from 600 to 1000 km, there is little time difference between the air transportation network and the Shinkansen network, in spite of the fact that the average speed of airplanes is four times that of the Shinkansen.

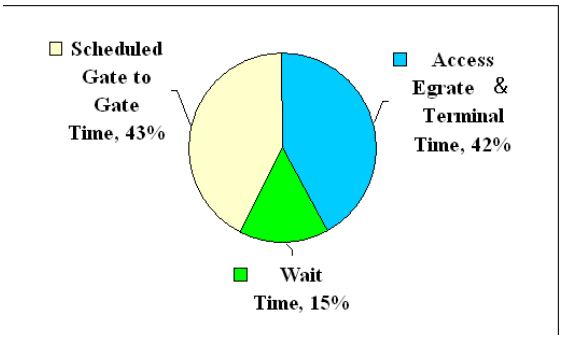

Fig. 10 Distribution of access, wait, terminal, and travel times for air transportation. [11]

Figure 10 shows details of the time differences between trips using these networks. These data are averaged over 23 trips from JR Tokyo station to local JR stations using the air transportation network, as shown in Fig. 9. The distribution includes the total time required for actual scheduled gate-to-gate travel, as well as the access times between the stations and the airports, the wait times at airports, and so on. The scheduled gate-to-gate time is only 43% of the total time of the trip, while the sum of the access time and the wait time is 57%. According to this calculation, the average access time is about 80 minutes using trains or buses. Thus, we can infer that local airports are located far from cities, and that air transportation involves a considerable amount of inefficiently utilized time.

Nowadays, many local airports in Japan are maintained for commercial airline aircraft, which are large, heavy, and require long runways. To meet the space requirements for long runways, local airports are constructed in locations far from cities.

Figure 11 shows the geographic distribution of major airports. In particular, airports with runways greater than 2500 m in length are located far from major cities. The distances to access these airports are between 30 and 60 km.

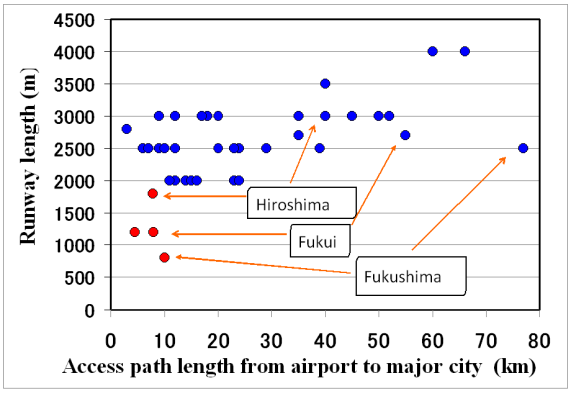

Fig. 11 Geographic characteristics of major Japanese airports. [12]

Accordingly, the access time by car is between about 45 and 90 minutes, which is not particularly convenient. In this figure, it can be seen that although Hiroshima, Fukui, Fukushima, and Okayama have second airports with relatively short runways of between 800 and 1800 m in length (red circles in Fig. 11), these airports are not used by commercial airlines. These airports with short runways are located close to the downtown areas of major cities, and thus using small aircraft is potentially highly convenient.

A common feature of Japanese airports is that long runways for large aircraft must be constructed far from major cities and thus are inconvenient to access from the downtown areas of major cities. However, airports with short runways have clear advantages, including their proximity to major cities and their suitability for small aircraft such as business jets and piston-engine airplanes.

Such use of local airports would save a considerable amount of time (mainly access time and consequently total travel time). We refer to this system as the "next-generation air transportation system". The results in Fig. 9 provide insight into the potential utility of the proposed next-generation air transportation system. The red oval (BJ: Business Jet) represents the key concept of the present proposal: travel times in this area are, on average, half the current travel times. In other words, the travel times corresponding to distances between 400 and 1200 km are between 60 and 120 minutes, respectively. If this system proves to be cost-effective, it has the potential to be extremely convenient and useful.

The realization of such a transportation system depends on finding solutions to two critical issues, namely, shortening access times from airports to major cities and reducing wait times (security checks, etc.). Until now, the solution to the inefficient use of airports has been the construction of new airports closer to the major cities, or searching for other airports closer to these cities. If shorter runways (less than 1200 m) are constructed, it will be possible to build airports closer to cities, and small business jets (very light jets) will be able to use such airports. Only a few airports in Japan currently meet these requirements. In this regard, the proposed solution is based on a new approach, which is not familiar to the users of the current Japanese transportation system. This new approach requires the use of corporate-owned business jets or air taxis.

4. Next-Generation Air Transportation System

The next-generation air transportation system will depend on the effective utilization of many local airports. The Tohoku region was selected for evaluating the proposed next-generation air transportation system. Located in northern Japan, the Tohoku region has the especially notable geographical characteristics. Many mountain ranges run from north to south parallel to the coast, and it is inconvenient to travel across these mountain ranges using the present transportation systems. As examples, the travel times for trips from cities on the Pacific Ocean side to cities on the Japan Sea side were estimated by for two of the fastest modes of transportation, namely, trains (including the Shinkansen) and airplanes.

Figure 12 shows the routes of the target trips. Four prefectural capitals on the Pacific Ocean side and five prefectural capitals on the Japan Sea side were selected. The starting points and the destinations of these trips were JR stations, and the same calculation method was used as described in Section 3. However, the distances between the cities were measured as straight lines.

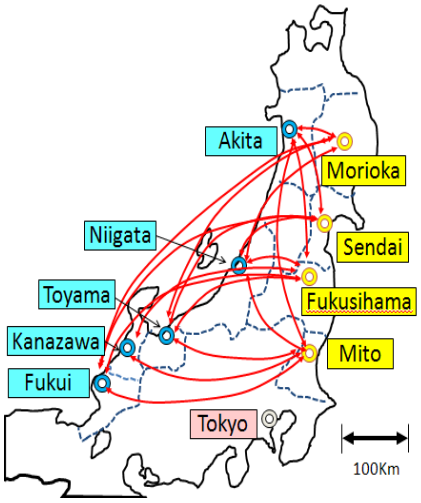

Fig. 12 Air routes from cities on the Pacific Ocean side and to cities on Japan Sea side of the

Figure 13 shows the results of the calculations, as well as the relationship between travel time and direct distance for the two transportation systems.

Blue circles indicate trips using the train and Shinkansen networks, while red circles indicate the simulated trips on small airplanes, such as the Cirrus SR22 or Cessna Skyhawk (cruising speed: 300 km/hour in this calculation).

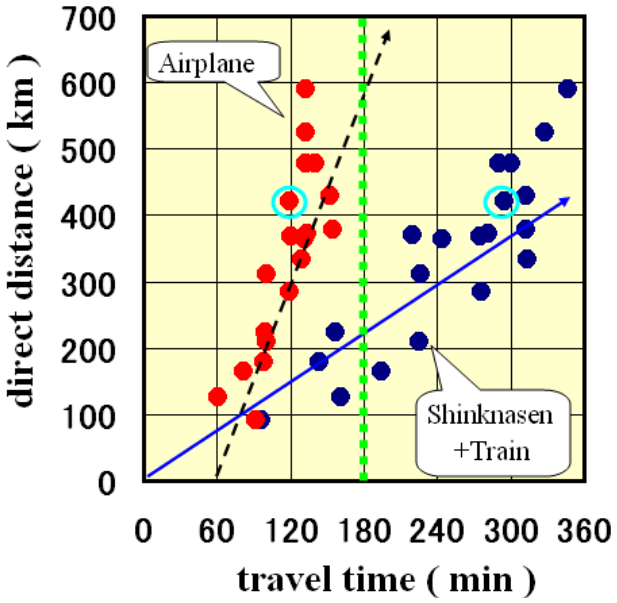

Fig. 13 Relation between travel time and direct distance in Tohoku region. [11]

In the case of the train and Shinkansen networks, the times for many of the trips are quite long, between 180 and 360 minutes. This means that it is usually difficult to make a return trip on the same day. These travel routes are therefore highly inconvenient, as can be reasonably expected for such long trips over the mountain ranges that run along the Japan archipelago. Crossing these mountain ranges by train is highly inconvenient, but few commercial airlines operate in these regions because of the short distances between the cities.

On the other hand, trips on small airplanes would require shorter times than trips using the Shinkansen. The red circles show travel times that are one-half or one-third the current travel times, ranging between 60 and 150 minutes, which would allow for a return trip on the same day.

The open blue circles in Fig. 13 indicate a trip from Fukushima to Fukui by Shinkansen and by airplane. These cities have second airports whose runways are short in length. The travel time in the case of Shinkansen is about 300 minutes, while that for an aircraft is about 120 minutes. The advantage in terms of time is 180 minutes (3 hours), which could be used, for example, as productive time on a business trip.

In the following section, economic considerations are taken into account for this trip scenario.

The economic considerations related to these trips are based on the time cost, the fare, and the total cost. The time cost is equal to the total time multiplied by the value of time (4795 yen/hour), as calculated by the Ministry of Land, Infrastructure, Transport and Tourism, MLIT). [13]

The fare for travelling by airplane is calculated on the basis of the present open price of sightseeing trips on a piston-engine airplane (about 40,000 yen/hour for a seat on a Japanese domestic flight).

Figure 14 shows the difference between the two cases. The fare of a train trip is one-third the fare of an airplane trip, while the time cost of a train trip is twice that of an airplane trip. In addition, the total cost of an airplane trip is 1.5 times that of a train trip.

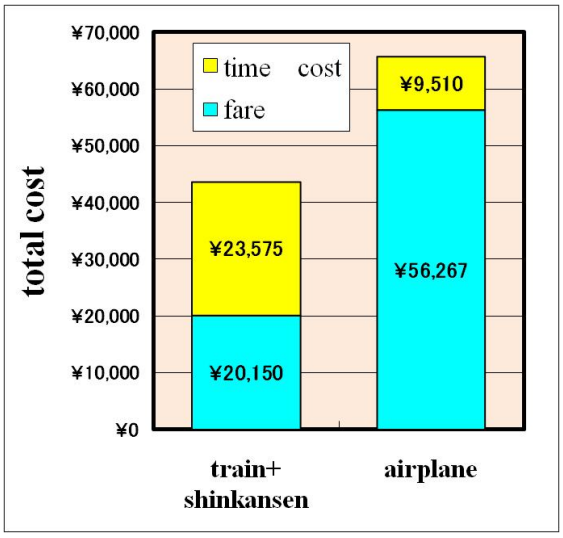

Fig. 14 Estimated costs of travelling by train and by airplane from Fukushima to Fukui.

The economic efficiency is evaluated in greater detail in the following section, where we attempt to utilize the difference between the fare and the time cost.

Figure 15 shows the total cost of the trip, considering the value of time and the fare.

The value of time increased six-fold (from 4795 yen/hour to 28,770 yen/hour), and the fares for an airplane trip are 20,000 yen/hour-seat (red circles), 40,000 yen/hour-seat (green circles) and 60,000 yen/hour-seat (magenta circles). In each case, the total costs increase linearly as a function of time.

In the figure, the four lines intersect at three points, and for a fare of 40,000 yen/hour-seat, the value at the intersection point is 2.5 times larger than the basis value of time (time cost = 12,000 yen/hour).

In the upper region of the graph in Fig. 15, the total cost of a train trip is more expensive than the total cost of an airplane trip. This means that airplane trips are economically efficient in comparison with train trips. Similarly, for a fare of 20,000 yen/hour-seat, the total cost of a train trip is more expensive than the total cost of an airplane trip.

In this regard, the value of time depends on the objectives of the trip and the time cost of the traveler. In any case, a reduction in the cost of airplane trips is necessary in Japan.

In summary, Japan's skies have high potential for development, which can be realized by using general aviation options such as business jets and piston-engine airplanes as on-demand air taxis.

The evolution of the Japanese transportation systems depends on the effective use of Japan's skies.

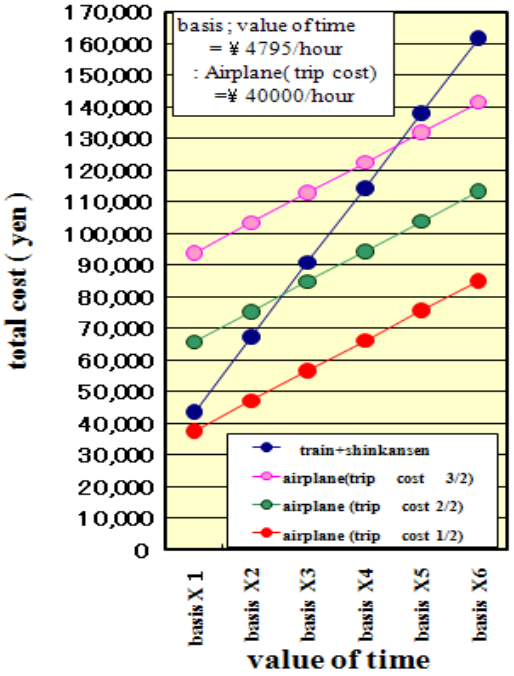

Fig.15 Total cost of an airplane trip, considering the value of time and the fare.

5. Conclusion

This study quantitatively explored the changes in various Japanese public transportation systems over the past 50 years. It was found that ground transportation systems, such as the tram, bus, railway, and automobile systems, have effectively matured and reached saturation, while aerial and subterranean transportation systems have potential for growth.

Japanese transportation systems are grouped into the four stages in Fig. 16.

Historically, transportation systems usage changed from Stage 1 to Stage 2, and then from Stage 2 to Stage 3. The progression of transportation systems is counter-clockwise in the figure. However, the movement from Stage 3 to Stage 4 is still not complete for the Japanese aviation industry.

In the case of modes of transportation in Stage 1, the vehicles have undergone notable qualitative changes with widespread adoption of electric motors as a replacement for internal combustion engines.

	Short& Middle distance	Long distance	Features and merit
Private Transportation Mode	[stage-1] Walking Bicycle Auto-bicycle Automobile	[stage-4] *Automobile (High way)* Business Jet Piston Aircraft	On demand *(Anytime) (Anywhere)* Active-transportation
Public Transportation Mode	[stage-2] Tram Bus Subway Railway	[stage-3] Civil Aircraft Shinkansen Railway	Scheduled *(fixed time) (fixed route)* Passive-transportation

Fig. 16 Changes in Japanese modes of transportation.
Red: internal combustion engine driven;
Blue: electric motor driven; Green: human powered.

Furthermore, in the case of Stage 3, it is difficult to meet the demand for public air transportation using local airports. Notably, general aviation (Stage 4; business jets and small piston-engine air taxis) has recently become widely used for private transportation in the United States. This means that the air transportation mode shifted from the public mode to the private mode because of the advantage for convenience and on-demand travel.

In this paper, the possibility of the private air transportation mode (Stage 4) was investigated for many Japanese local airports. Consequently, it was found that Japanese skies have high potential for development, which can be realized by using general aviation options such as business jets and piston-engine airplanes as on-demand air taxis.

Research into general aviation has started in Japan. As part of this work, major problems facing general aviation in the United States should also be considered, for example, ensuring the safety of small aircraft.

The safety technology should be developed with a focus on three considerations: human skill, aircraft technology, and infrastructure. This three-part approach is shown in Fig. 17.

The evolution of Japanese transportation systems depends on the effective use of Japan's skies, and the next-generation air transportation system will depend on the efficient utilization of many local airports.

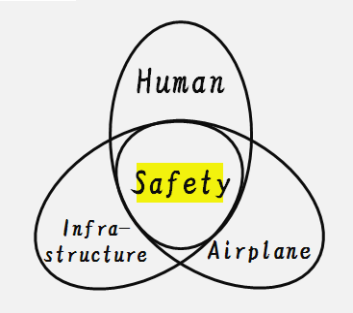

Fig. 17 Three-part approach to safety in general aviation research.

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