

## Shinkansen (Bullet Train) System in Japan

Thank you Mr. Chairman and members of the Committee. It is an honor for me to be here to discuss the Japanese high-speed rail system, or “Shinkansen.” The Japanese people are very proud of this system and we are happy to share our experiences with you. In my testimony I will touch on the History of the Shinkansen, its development and financing, and finally the features and benefits of this system.

### 1. Current Situation of Shinkansen

#### (1) History and Current Operation

The high-speed railway system in Japan, the so-called Shinkansen, started its operations in 1964 between Tokyo and Osaka (Tokaido Shinkansen), followed by the continuing construction of rails to connect the metropolitan areas of Japan.

Before it was privatized in 1987, Japanese National Railways (JNR) constructed Sanyo, Tohoku, and Joetsu Shinkansen lines..

Through the privatization, the JNR was divided into 6 passenger railway companies (JRs) and one freight railway company. The operations and management of these existing Shinkansen were transferred to JR East (Tohoku and Joetsu), JR Central (Tokaido) and JR West (Sanyo). Including newly constructed Shinkansen lines, railways currently under operation in total are 1352 miles (2176km).

#### (2) Competition between Shinkansen and Other Modes of Transportation

Most of Existing Shinkansen lines run through densely populated areas in Japan, connecting most of major cities such as Tokyo, Nagoya, Osaka, Fukuoka and Sendai. The dense population along the lines is the geographic background of Shinkansen’s popularity.

Compared with other modes of transportation, Shinkansen is more competitive when distance is between 100 and 500 miles. For Example, as to the trip between 313 and 460 miles, 66% of the passengers choose railway,

while 21% choose air transportation and 11% use automobiles. Shinkansen fare from Tokyo to Osaka is 13,240 yen, or approximately 110 US dollars. Trip time is just 2 and half hours when using the fastest train. On the other hand, regular air ticket is 20,000 yen (approx. 170 US dollars) between Tokyo and Osaka, and the flight time is 50 minutes. Most of the passengers prefer Shinkansen because the fare is more reasonable, and because the trip time is not different very much taking account of access time to airports and necessary time for check in at the departing airport. Even though the fare is as cheap as 6,000 yen for a highway bus between Tokyo and Osaka, few passengers choose it due to more than 8 hours of travel.

## 2. Financial Management of Shinkansen Development

### (1) Tokaido Shinkansen and the other three Shinkansen Lines

The construction of Tokaido Shinkansen started in 1959, and the construction cost was 380 billion yen. The construction was financed by issuing bonds in Japan, borrowing from the World Bank and the Japanese Government.

The loans were expected to be returned through the revenues from passenger fares, and the management became profitable three years after the initiation of its operation. In 1970 the profit was more than 100 billion yen, and all of the initial investment was recovered by 1971. Since then, the revenue from Shinkansen has been an important resource to subsidize local lines.

### (2) Plans and Construction of New Shinkansen Lines

To expand the Shinkansen network, the “National Shinkansen Railway Development Law” was enacted in 1970. This law required the creation of a “Development Plan” for the Shinkansen Network, and the expansion of Shinkansen Railways are being conducted according to the Plan. Currently Hokkaido Shinkansen, Tohoku Shinkansen, Hokuriku Shinkansen, and Kyushu Shinkansen are under development.

Due to financial reasons, only its southern part (between Shin-Aomori and Shin-Hakodate) of Hokkaido Shinkansen is currently being developed.

The total plan of Tohoku Shinkansen was to connect Shin-Aomori and Tokyo. In 2002 it expanded from Morioka to Hachinohe, and the line beyond Hachinohe is now under construction. Hokuriku Shinkansen goes from Takasaki to Shin-Osaka, or New Osaka, via western shore of Japan. The operation between Takasaki and Nagano started in 1997, just a few months before Nagano Winter Olympic Games. And the railway between Nagano and Kanazawa is now under construction.

Kyushu Shinkansen is divided into two routes. The southern part of Kagoshima Route has been under operation since 2004. Its northern part is currently under construction. Nagasaki Route is another route of Kyushu Shinkansen. Its construction has not started yet because the coordination among local communities has not been finished yet.

### (3) Funding of New Shinkansen Railways

The cost of New Shinkansen railway construction projects is shared by the national government and local governments along the railway lines. Two thirds of the funds are from the national government and one third from local governments. The total budget for the construction of New Shinkansen Railways in FY 2007 is 263.7 billion yen, and the national government budget is 175.8 billion yen, and that of local governments is 87.9 billion yen.

The railways are constructed and owned by Japan Railway Construction, Transport and Technology Agency (JRTT), and operated by JRs. JRTT, an independent administrative agency, charges these JRs for the usage of its property, but the maximum charge that can be made is equal to the profits from the New Shinkansen operations.

A little more than half of the national government funding comes from the payments for the procurement of existing Shinkansen Railways. The rest comes from the General Account.

It can be said that Shinkansen construction projects are based on a public-private partnership, where JR operations are supported by funding from both national and local governments.

#### (4) Operational Figures of Shinkansen Railways

The number of passengers at Tokaido-Sanyo Shinkansen hit its peak in the early '90s, when the Japanese economy experienced a "bubble." Throughout these fifteen years the number stagnated around slightly below 200 thousand. One of the reasons for this slow-down is the condition of Japanese economy in the '90s. The severe competition between Tokaido-Sanyo Shinkansen and air transportation is another reason. The Japanese government deregulated air transportation industries in the '90s and airlines began to introduce competitive fares targeting Tokyo-Osaka and Tokyo-Fukuoka services, between which the Shinkansen is operated. Furthermore, the expansion of Haneda Airport in Tokyo increased the number of domestic flights, thus attracting more passengers.

At Tohoku and Joetsu, on the other hand, the number of passengers continued to increase until late '90s, while growth slowed in the 2000s.

Operational Figures of Shinkansen Railways (FY 2004)

	Miles (km) of Operation	Number of Passengers (thousand)	Passenger-miles (km) (million)	Average Daily Number of Passengers
Tokaido-Sanyo	668(1,069)	195,197	34,723(55,869)	534,786
Tohoku	369(593)	80,401	8,301(13,356)	222,726
Joetsu	168(270)	35,337	2,631(4,233)	101,079
Hokuriku	73(117)	9,558	498(802)	29,849
Kyushu	79(127)	3,796	255(410)	10,400

### 3. Features of Shinkansen Railways

#### (1) High Speed

When Tokaido Shinkansen started its operation in 1964, the maximum train speed was 130 mph (210km/h). With the technical development and improvement of the railway structure, the maximum speed of Tokaido Shinkansen is now greater than 168 mph (270 km/h). In 1996 one of the newest rolling stocks achieved the fastest record of

275.3 mph (443km/h) at a speed trial. Since 1997 Sanyo Shinkansen's highest operational speed has been 186 mph (300km/h).

Before 1964 conventional trains had to spend more than 6 hours traveling between Tokyo and Osaka (322 miles (515km)). With the introduction of Tokaido Shinkansen, the traveling time has been reduced to 3 hours and 10 minutes. Now the fastest Shinkansen connects Tokyo to Osaka in just 2 hours and 30 minutes.

One of the keys of its high speed operation is light-weighted rolling stocks. Aluminum alloy in a honeycomb or hollow structure is widely used, enabling a lighter weight while maintaining strength and durability.

Another key is the usage of powered rolling stocks instead of locomotives, enabling more efficient acceleration. Furthermore, removing heavy locomotives means there is better weight allocation within a train.

## (2) High Density and High Level of Services

Shinkansen is proud of the density of its operation. The system can dispatch trains every 3 minutes. An ordinary Shinkansen passenger car can accommodate as many as 1,323 passengers, and the number of annual Shinkansen passengers nationwide was as high as 291,258 thousand in FY2004.

This frequent mass transit service is also fit to its commuters. Approximately 47,000 businesspersons and students commute using Shinkansen. Many residents living in local cities as far as 60 miles (100km) away from Tokyo enjoy a mere 30 minute commute using Shinkansen. To accommodate these commuters, JR East introduced double decker cars focusing on rush hours.

Responding to the needs of passengers is also very important. Since most of the passengers use local trains to access Shinkansen, reducing connection time has a high priority. In most stations, local trains start just a few minutes after the arrival of Shinkansen so that the passengers do not have to wait a long time for the connecting services. However,

demanding Japanese passengers are not satisfied even with this efficient diagram. At Shin-Yatsushiro Kyushu, Shinkansen connects to the local express going to Hakata (Fukuoka). A local train waits for the Shinkansen coming into the station just across the same platform, so that passengers can change trains simply by crossing it. Furthermore, some Shinkansen rolling stocks are operated through local lines. Local lines to Yamagata and Akita, both of which are local cities in Tohoku region, has the same gauge as Shinkansen's, and the Shinkansen rolling stocks can go directly to local lines. With this feature passengers do not even have to change trains to go to local lines.

The Shinkansen service offers many benefits, but interestingly enough the speed of the trains can limit its offerings. For example, cafeteria cars had been very popular in Shinkansen. However, with the increase of speed, most of the passengers arrive at their destinations before they become hungry or would even have time to get food and eat it. Therefore there is no cafeteria in Shinkansen now. But please do not worry. Passengers can use available food cart services and enjoy lunch boxes with varieties of local foods along the railway lines.

### (3) Safety

It is worth noting that there has never been a fatality due to a train accident in Shinkansen since the beginning of its service in 1964. This remarkable safety record of the Shinkansen is chiefly attributable to its basic design concepts and the ingenious ideas underlying its operations.

Shinkansen rails are totally separated from conventional railways and operate without any grade crossings. With this structure any collisions between Shinkansen trains and conventional trains or automobiles cannot occur.

All the operations of Shinkansen trains are surveyed and controlled by the Traffic Control System. This system is at the center of the traffic control of Shinkansen, enabling high-speed and high-density operations. The Traffic Control System constantly monitors the Shinkansen operation, and recognizes if the operation is not running as scheduled.

It also simulates the operating conditions when an operator makes a change in his actions and is then advised to make an adjustment.

The Automatic Train Control (ATC) System is the key system in eliminating human errors. If there is an irregular movement of a train that may result in an accident, ATC automatically recognizes it and stops the train.

Shinkansen is the only high speed railway system that was proved to be safe and manageable during severe earthquakes. A seismograph is installed every 12miles (20km) along the railway, and it is connected to the Urgent Earthquake Detection System (UrEDAS). When an earthquake occurs, the UrEDAS recognizes its initial (relatively weak) waves, estimates the magnitude of the earthquake, and determines whether to stop the running trains. Furthermore, the structures of Shinkansen facilities, such as railways, are reinforced against earthquakes.

#### (4) Reliability

Let me give you a piece of trivia about the punctuality of Shinkansen: When asked what you think the average delay is on the Shinkansen lines, what would you think? The answer is 6 seconds.

This means just about all of the trains departing every few minutes, as many as 300 trains daily, are perfectly under control. You would also be amazed to see all the trains stop at exactly the same position when they come to a station. Any differences are within only a few inches.

This accuracy is the result of sophisticated control systems such as the Traffic Control System as well as very skillful drivers and operators.

#### (5) Environment

Most of the noise from Shinkansen comes from the friction between air and train. To reduce the noise from pantographs, their number has been reduced. Simultaneously their shape was also improved. The Streamlined design of rolling stocks not only contributes to high-speed, but also to noise reduction..

Shinkansen is a very energy-efficient mode of transportation. When comparing on a passenger-miles basis, Shinkansen's energy consumption is only a fourth of that of air transportation, and one sixth of automobiles. Taking into account the fact that electricity is also generated by nuclear power, CO2 emission from Shinkansen is significantly lower than other modes of transportation. Its emissions are only one fifth of that from aircraft, and one eighth from automobiles. It can be said Shinkansen contributes to energy savings as well as the fight against global warming.

#### 4. Conclusion

The Japanese high speed railway, Shinkansen, is an excellent mode of transportation in speed, safety, reliability, density and from an environmental point of view. These features can only be achieved through the integration of different elements of the railway system. Rolling stocks, signals and the Traffic Control System are mutually linked and work in a perfectly coordinated manner. This enables the Shinkansen operation every 3 minutes in more than 180 mph, without any fatal accidents.

It should also be noted that, even with the privatization of the JNR proven to be a success, the high speed railway network cannot be developed without the public-private partnership. Shinkansen and the conventional train network operationally and financially support each other. Passengers access Shinkansen using conventional trains, and the revenues from Shinkansen support the operation of the local railway network.

I believe Shinkansen can be successfully introduced even outside of Japan. It can be an ideal intercity transportation for distances between 200 and 500 miles with high demand. Finally I would like to emphasize lessons learned by the Japanese experience. The keys of success for Shinkansen are the integrated system and efficient private operations supported by public sponsorship. Thank you very much for listening.

## Appendex

### Specifications of Shinkansen Lines

- Tokaido Shinkansen
  - Operation Inauguration: 1964
  - Major Cities with Service: Tokyo, Nagoya, Kyoto, Shin-Osaka (Osaka)
  - Route Length: 322 miles (515 km)
  - Maximum Operational Speed : 169 mph (270 km/h)
  
- Sanyo Shinkansen
  - Sections under Operation : Shin-Osaka – Okayama (1972)  
Okayama –Hakata(Fukuoka) (1975 )
  - Route Length: 346 miles (554 km)
  - Maximum Operational Speed : 188 mph (300 km/h)
  
- Tohoku Shinkansen
  - Sections under Operation : Omiya – Morioka (1982)  
Ueno – Omiya (1985)  
Tokyo – Ueno (1991)  
Morioka – Hachinohe (2002)
  - Route Length under Operation: 370 miles (593 km)
  - Maximum Operational Speed : 172 mph (275 km/h)
  - Section under Construction : Hachinohe – Shin-Aomori (51 miles (82 km), to be completed in March, 2011)
  
- Joetsu Shinkansen
  - Operation Inauguration : 1982 (Omiya – Niigata)
  - Route Length : 169 miles (270 km)
  - Maximum Operational Speed 172 mph (275 km/h)
  
- Hokkaido Shinkansen

- Section under Construction : Shin-Aomori - Shin-Hakodate (93 miles (149 km), to be completed in March, 2016)
  - Section under Planning Stage : Shin-Hakodate - Sapporo)
- Hokuriku Shinkansen
- Operation Inauguration : 1997 (Takasaki – Nagano)
  - Route Length under Operation : 73 miles (117 km)
  - Maximum Operational Speed : 163 mph (260 km/h)
  - Section under Construction : Nagano – Kanazawa (143 miles (228 km), to be completed in March, 2015)
  - Section in Planning Stage : Kanazawa - Shin-Osaka
- Kyushu Shinkansen
- Operation Inauguration : 2004 (Shin-Yatsushiro – Kagoshima-Chuo)
  - Route Length under Operation : 73 miles (117 km)
  - Maximum Operational Speed : 163 mph (260 km/h)
  - Section under Construction : Hakata – Shin-Yatsushiro (81 miles (130 km), to be completed in March, 2011)
  - Section under Preparation for Construction : Shin-Tosu -  
Nagasaki