

**UIC Map of Twaiwan's High-Speed Rail Lines**

Taiwan, officially the Republic of China, is an island country located in Eastern Asia off the southeastern coast of China. Due to the mountainous terrain through the middle and eastern portion of the country, approximately 70 percent of the population is gathered along the west coast. With a population of slightly more than 24 million, the largest city is New Taipei with 3.9 million followed by Kaohsiung with 2.7 million, Taichung with 2.6 million, and Taipei with 2.6 million. Taiwan ranks 20th in the world in terms of gross domestic product (\$887.3 billion) and ranks 28th in the world in GDP per capita (\$42,300). It opened its high-speed rail line in 2007. The figure above displays the International Union of Railways (UIC) map of the line.

## SYSTEM DESCRIPTION AND HISTORY

Taiwan experienced rapid economic development between the 1960s and 1980s, which greatly increased demand on its intercity transportation system. The only north-south freeway became congested and increased air service was not a viable option due to the relatively short distance and congested airports. Another issue in selecting high-speed technology was that the conventional rail services operates on a narrow gauge system, so operating at considerably higher speeds would have required widening the gauge or introducing tilting technology; either option coming with a high price tag. A high-capacity high-speed rail system was therefore viewed as the best option to serve the country's intercity transportation needs. Construction

on the line began in 2000, with commercial operations beginning in 2007.

The Taiwan High Speed Rail (THSR) system is a 345 km (214 mile) system traveling between the two most populated cities on the western portion of Taiwan. Functioning at an operating speed of 300 km/h (185 mph) the trains traverse between the farthest points in 94 minutes. The system is operated by the Taiwan High Speed Rail Consortium (THSRC). Details of the line are contained in the table below.

**UIC Table of Taiwan's High-Speed Rail Line**

Stage	Speed		Year Opened	Length	
	km/h	mph		km	miles
<b>In Operation:</b>					
Taipei – Kaohsiung	300	185	2007	345	214

The double-tracked system utilizes Japanese Shinkansen, Class 700T trainsets that have a top design speed of 350 km/h (220 mph) and top operating speed of 300 km/h (185 mph). Overall, the THSR has 30 trainsets with each having a seating capacity of 989 passengers (66 first class and 923 second class). Weekly train service consists of 123 trains per week day and 146 trains per weekend day and achieves a 99.25 percent on-time performance. High speed train service travels between to two end termini in 94 minutes. Due to the mountainous terrain of Taiwan, the system traverses 90.3 percent of its track over bridges, viaducts, and tunnels. The type of track used is almost exclusively slab track (98.5 percent).

*Sources: The World Factbook; High-Speed Lines in the World; "Privatization Versus Public Works for High-Speed Rail Projects"; High Speed Rail Passenger Services: World Experience and U.S. Applications; Maintenance of High Speed Lines; High Speed Rail: A Study of International Best Practices and Identification of Opportunities in the U.S.*

## ECONOMICS AND FINANCE

This section addresses the public-private partnership developed between Taiwan and a private consortium, the issues associated with the model, project financing, trainset procurement, and system revenue.

### Operational Model

An agreement was signed in 1998 between the Taiwan HSR Consortium (THSRC) and the government regarding construction and operation of the system. The Build-Operate-Transfer (BOT) model granted THSRC a concession to finance, construct, and operate the system for 35 years and a



**Taiwan High-Speed Shinkansen 700T train at Kaohsiung depot**

concession for HSR station area development for 50 years. An annual fee is required by THSRC which is to be used for future high-speed rail development in the country. The fee amount is 10 percent of earnings before tax during the operating concession period regardless of the performance of the concession company. The accumulated amount over that term must be at least \$3.4 billion.

### Funding/Financing

The original concession idea in Taiwan was for the \$18 billion construction cost to be completely financed through private resources. Ernst & Young describe the financing history in their report titled *High Speed 2: International Case Studies on Delivery and Financing – A Report for HS2*. They indicate that due to massive cost overruns THSRC failed to raise the required capital. The funding gap was to be covered through bank debt; however, the private sector demanded overt financial support from the Taiwanese government in the event of default of THSRC. They received that support with a government guaranteed debt facility for the first part of the project in 2000 totaling \$10 billion. In March 2005, the Taiwanese government stepped in to buy securities worth \$237 million. In 2007, THSRC raised \$300 million from the sale of pre-IPO convertible bonds in the international market. The report indicates that public financing accounted for approximately 20.6 percent of the total cost including land acquisition, planning, design, supervision, and civil work for understructures in Taipei sections. The private investment accounted for 79.4 percent of the total cost, including civil works, stations, track work, electrical and mechanical system, maintenance bases, and financial cost.

The Ernst & Young report also points out that by March 2009 THSRC had accumulated losses of \$2.13 billion,





**New Taipei City Hall, Banqiao, Taiwan**

amounting to over 65 percent of the firm's capital. The Taipei Times reports that on July 13, 2009, the Ministry of Transport and Communication announced that it had signed a memorandum of understanding with THSRC and the Bank of Taiwan to refinance the project that resulted in the reorganization of the company in September 2009 in which the government took majority control.

### **Infrastructure and Operation**

Originally, the infrastructure was designed and constructed to European trainset design specifications. THSRC even contracted with Eurotrain, the European rolling stock consortium. However, the Japanese Shinkansen trainset was ultimately chosen for operations. This switch to Shinkansen trainsets required adjustments to the signaling, electrification, and driver training that delayed the opening to 2007. Multiple sources speculate the trainset switch was political in nature, but one legitimate factor could be the Shinkansen design considerations for opera-

tional response during earthquakes; a familiar occurrence in Taiwan. Several sources point to this change in technology as a contributing factor in the early cost overruns. Additionally, in November 2004 THSRC had to pay \$65 million (\$89 million with interest) compensation to Eurotrain following this decision.

*Sources: High Speed Rail Passenger Services: World Experience and U.S. Applications; High Speed Rail: A Study of International Best Practices and Identification of Opportunities in the U.S.; High Speed 2: International Case Studies on Delivery and Financing – A Report for HS2*

### **RIDERSHIP AND TRANSPORTATION SYSTEM IMPACTS**

This section addresses ridership and market share of the Taiwan high-speed rail, along with modal connectivity of the Taipei Main train station located at the northern terminus of the high-speed rail line.

## Ridership

The THSR served 32.3 million passengers in 2009. Seat occupancy is reported as only 46 percent and the ridership levels remain well below projected levels; some reports indicate levels are around 30 percent of estimated ridership numbers.

After the opening of the THSR in 2007, the Ministry of Transport and Communications conducted a survey. It categorized the passenger trip characterizations as:

- 40 percent business trips.
- 30 percent tourist trips.
- 22 percent family trips.
- 8 percent induced demand trips (new trips).

Only three of the stations (Taipei, Taiching, and Zuoying) are located in the city centers, developing the need to provide feeder services out to the other stations. One source indicates that these feeder services have not been fully developed and speculates that this delay has contributed to the lower than expected ridership levels. THSRC is providing free bus shuttles out to the stations in order to improve access.

## Mode Share

The mode choice options for the relatively short Taiwan corridor are mainly between the ground transportation options with air only competing for the longest segments. A report for the Southwest Region University Transportation Center (SWUTC) compiles the travel times and fare prices for the high-speed rail segments for rail, bus, and air for trips with Taipei as the origin for each, as shown in the table below. Travel time and price over the different segments is relatively the same for conventional rail and bus. High-speed rail offers a tremendous time saving compared to conventional rail and bus, even at the shortest distance; but comes at a premium price generally about twice that of conventional rail and bus. Over the longer segments,

air and rail offer similar prices with air offering a shorter travel time. However, factoring in security and other airport-related requirements likely not incorporated in this calculation, total time savings will be less than presented.

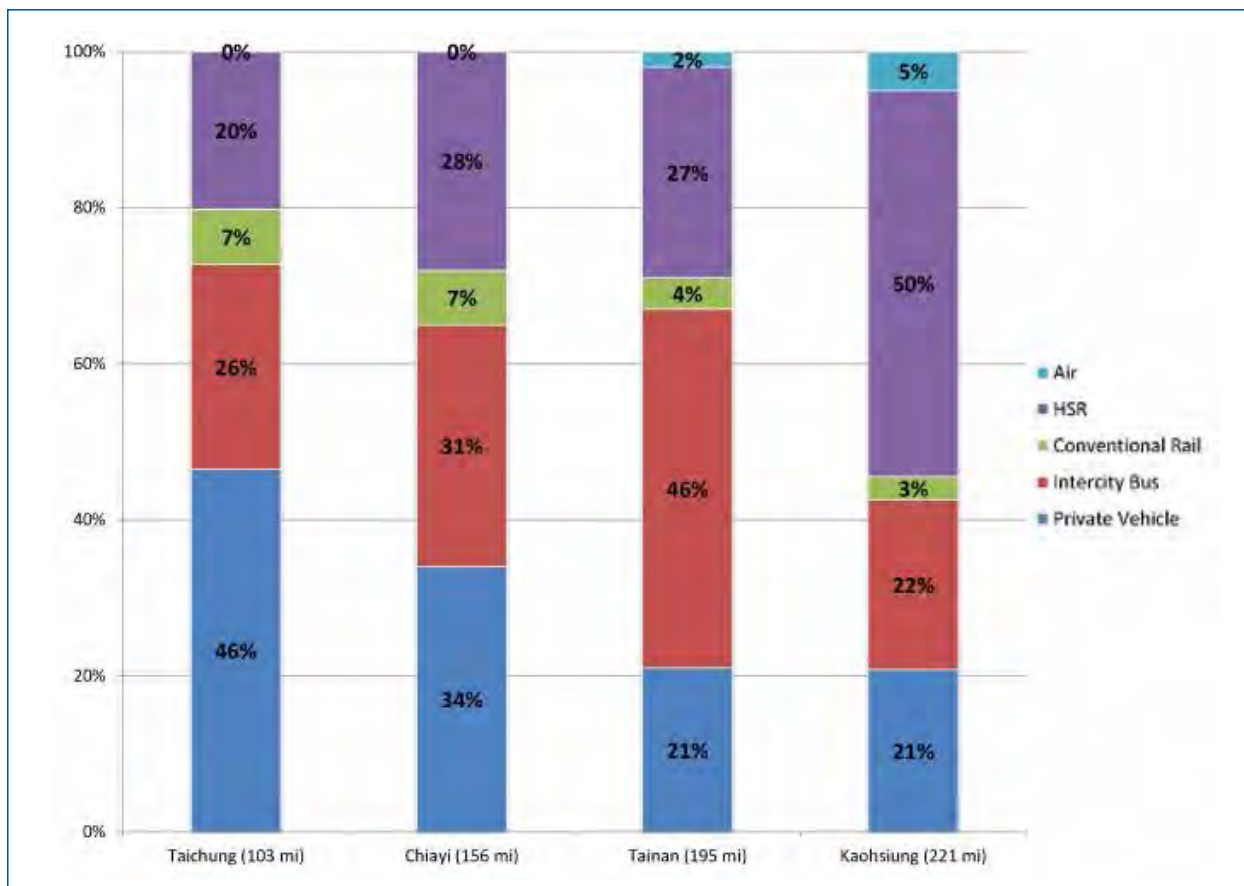
The figure on the following page displays the mode share related to these corridors, including the influence of the private auto on the overall travel scene (see Figure 2). The distances represent the distance away from the Taipei station to the identified city. The overall length of the island is not conducive for air to be a major mode choice. Even the longest segment at 220 miles only experiences a 5 percent share for air. What is clearly shown in the graphic is that private auto and intercity bus are major factors in the movement of people in Taiwan. Even with a doubling of travel time compared to the THSR, intercity bus controls 46 percent of the market between Taipei and Tainan. As seen in the table at the bottom, the intercity bus service is provided at half the high-speed rail fare price. The high speed rail service does capture 50 percent of the overall market share for the longest segment.

## Modal Connectivity – Station Focus: Taipei Main

Taipei has a city population of over 2.6 million people located in the northern part of the island. The Taipei Main train station is located in the Zhongzheng District in downtown Taipei and serves both high-speed and subway lines. The UIC points out that 2.2 million passengers utilize bus daily in Taipei; no doubt with service to the Taipei Main train station. To accommodate the addition of high-speed trains, the station was expanded underground at a cost of approximately \$508 million. The UIC reports that the Taipei Main station handles over 400,000 passengers on about 140 total trains per day. The station and surrounding area are experiencing intensive renovation and redevelopment, which includes plans for two skyscrapers adjacent to the station. The UIC *High Speed and the City* report notes the travel times and fares related to the service

**Travel Time Durations and Fare Prices by Mode**

Trip	Conventional Rail		HSR			Bus		Air	
	Travel Time	Fare Price (\$USD)	Fare Price (\$USD)			Travel Time	Fare Price (\$USD)	Travel Time	Fare Price (\$USD)
			Travel Time	Business	Standard				
Taipei – Taichung	2 hr 15 min	11	53 min (direct)	30	21	2 hr	12	–	–
Taipei – Chiayi	3 hr 30 min	18	1 hr 34 min	44	33	3 hr	10	–	–
Taipei – Tainan	4 hr 14 min	22	1 hr 55 min	54	41	4 hr	18	55 min	41
Taipei – Zuoying	4 hr 40 min	25	1 hr 34 min (direct)	59	45	–	–	–	–
Taipei – Kaohsiung	4 hr 50 min	26	–	–	–	5 hr	22	50 min	52



Mode Share along HSR Corridor

between the Taipei Main station and the “first station”; in this case the farthest station from Taipei, which is Zuoying Station in Kaohsiung City located 345 km (214 miles) away. As shown in the table to the right this source provides values that differ from the previous table in that they reflect a lower fare for the high speed rail service compared to airline service.

Sources: *High-Speed Rail: A Study of International Best Practices and Identification of Opportunities in the U.S.*;

*High Speed and the City; Table 50 – Revenue-Earning HS Traffic; Taipei Times.*

UIC Taipei Main to Zuoying Station Modal Comparison

Travel Mode	Travel Time	Travel Fares
High Speed Train	1 hr 36 min	22.5 Euro (\$29)
Car	4 hr	34 Euro (\$43)
Plane	50 min (only travel time)	50 Euro (\$64)

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