Overview of Automated People Mover System in Taipei

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The $920 million automated people mover (APM) system in Taipei, Taiwan, Republic of China is part of an ambitious $17.4 billion Taipei Rapid Transit System. The 11.6-km, 12-station APM system was scheduled to open in early 1994. The fully automated, driverless, rubber tire on concrete track system is based on the French VAL system design with a maximum capacity of 30,000 passengers per hour per direction. The minimum headway is 60 sec, and the top speed is 80 km/hr (50 mph). It is estimated that 27,340 passengers will use the Taipei APM system during the peak hour in the year 2001. The peak-hour traffic is expected to more than double to 55,900 passengers in 2021. Approximately two-thirds of the passengers on the Taipei APM system are expected to walk to and from the APM stations. This is the first time that a medium-capacity trunk-line APM system has been designed to accommodate significant traveling needs in a major city of more than 2 million people. If the operation turns out to be successful, similar applications of APM as a medium- to heavy-capacity trunk-line service could be expected in other cities.

Construction of the $920 million automated people mover (APM) system in Taipei, Taiwan, Republic of China (ROC), is almost finished. The system was scheduled to open in early 1994. It is part of the ambitious $17.4 billion Taipei Rapid Transit System (TRTS) (*1*). The 11.6-km 12-station APM system is the only medium-capacity transit system of TRTS. The fully automated, driverless, rubber tire on concrete track system is based on the French VAL system design with a capacity of 5,000 to 30,000 passengers per hour per direction (*2*).

Taipei, the provisional capital and largest city of the ROC on Taiwan, has undergone dramatic economic growth in the last decade. With the highest foreign exchange reserve ($86.5 billion) in the world and one of the highest standards of living in Asia, Taiwan has slowly transformed itself from a predominantly agricultural society into a major industrial power. As a result Taipei's population has increased a minimum of 2 percent per year since 1978, when it already had a population of slightly more than 2 million (*3*).

The increase in automobile ownership during the same period of time, however, has been phenomenal. In 1980 Taipei had 182,000 cars. The figure multiplied threefold to more than 570,000 cars in 1992 and continues to grow at an alarming rate of 5,000 cars per month. In addition it has more than 860,000 motorcycles, and the number keeps on growing at a rate of 7,000 new motorcycles per month.

The concentration of people and vehicles in this densely populated city of only 274 km^2 has created a nightmare for its 2.7 million residents. Traffic jams are so common that city streets look more like parking lots than roads during rush hours. Taipei is rated as one of the busiest and most congested cities in Asia, and probably the world.

To alleviate traffic congestion, pollution, and the strain on inadequate transportation facilities in this bustling city, the government of the ROC has started an ambitious mass rapid transit system project with four high-capacity rapid rail transit lines and one medium-capacity APM line to improve traffic flow in the Taipei metropolitan area (population, 6 million; area, 1,824 km^2). The Taipei APM system is going to be the first medium-capacity automated trunk-line APM service ever been built in a major city of more than 2 million people. The purpose of this paper is to present an overview of this challenging project.

BACKGROUND

With a population density of 9,854 people per km^2 (25,226 people per mi^2), Taipei has one of the highest population densities in the world. Uneven development and overconcentration of population are major causes of excessive growth in the Taipei metropolitan area. In the last 2 years the value of urban properties has inflated an average of three times, and land value has quadrupled in Taipei. For example land in central Taipei is now worth $2,000/$ft^2$, and today the cost of an apartment averages about $900/$ft^2$ (*4*).

The kind of traffic found in Taipei would make commuters in Los Angeles decide to stay home for a day of television rather than brave the chaos. Sorting out the day-to-day traffic of a city of 3.5 million commuters, over half a million cars, 4,200 buses (operating on 300 routes), 860,000 motorcycles, and 36,000 taxis is an impossible task for any transportation engineer (*5*;*6*,p.111). A severe lack of parking spaces, crowded narrow roads, ubiquitous traffic accidents, endless traffic jams, and the smog created by the uncontrolled growth of motor vehicles are just a few items in the endless list of urban headaches in Taipei. When citizens are asked questions about political, economic, or diplomatic issues, chances are there will be as many opinions as there are people. Yet change the topic to traffic and there will be a universal agreement: the place is a mess.

In an effort to address the above growth-related problems the government of the ROC is implementing the large-scale Six-Year National Development Plan totaling $300 billion to improve the infrastructure systems on the island for economic development into the 21st century. Nearly one-third of the expenditures will be spent on transportation projects. The $920 million Taipei APM system is part of this ambitious plan and is scheduled to be the first rapid mass transit system to open. The planned route of the Taipei APM system is shown in Figure 1. The abbreviation for the APM system is BR, which stands for brown line. Because of

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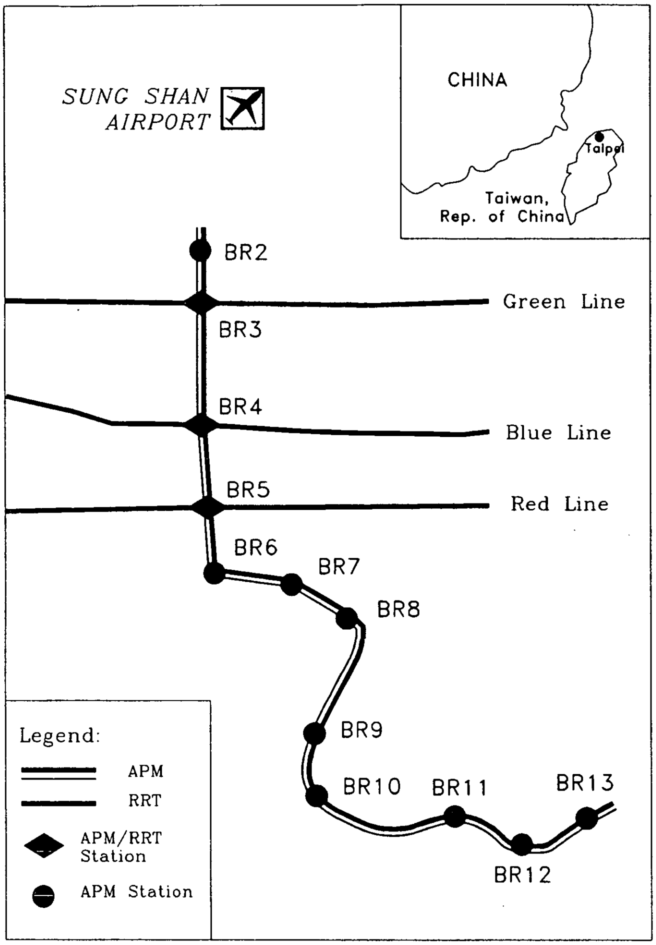

FIGURE 1 Planned route of Taipei APM system.

construction and testing problems the original opening date had been pushed from 1992 to 1994.

This is the first time that a medium-capacity trunk-line APM system has been designed to accommodate significant traveling needs in a major city: up to 30,000 passengers per hour per direction. If Taipei's APM system turns out to be successful a new chapter in mass transit is certainly going to be recorded.

SYSTEM

Except for a 0.8-km tunnel section the remaining 10.8 km of the Taipei APM system is elevated. The vertical clearance of the guideway structure is between 5 and 7 m. The span between the cast-in-place supporting columns is 25 m long. Because of the high cost of land, nearly the entire Taipei APM system is elevated over the medians of existing major arterials. For route design the minimum horizontal radius is 35 m and the maximum vertical grade is 6 percent (*7*).

The air-conditioned APM vehicle is 2.56 m wide and 3.51 m high (interior height is 2.045 m). The length of the two-car train is 27.56 m. The vehicle is powered by two 120-kW direct current motors on 750 V. The Taipei APM system is designed to operate in four-car consists. The normal capacity (4 people per m^2) for each car is 24 seated passengers and 60 standing passengers. The crash capacity (6 people per m^2) for each car is 24 seated passengers and 101 standing passengers (*2*).

The driverless vehicle is fully automated. The minimum headway is 60 sec. The maximum capacity is 30,000 passengers per hour per direction. The average operating speed is 34 km/hr. The cruising speed is 60 km/hr. The top speed is 80 km/hr (*2*).

All station platforms are of lateral design. The $263 million vehicles and system contract awarded to MATRA of France calls for 102 air-conditioned, wide-body VAL 256 vehicles to be operated initially in four-car consists; to accommodate future traffic all stations are designed for six-car consists (*8*). Elevators and escalators are provided at all stations to facilitate the use of the stations for disabled people. There are two types of station design (*9*).

1. *Type I: Elevated station over the street median.* The entrance and exit are located at the building adjacent to the roadway, and the building is connected to the station by an enclosed pedestrian bridge. For passengers who want to change the direction of their travel, they must take the elevators or escalators to the third floor, which is above the track, to complete their changes. Station BR 6 at the Science and Technology Building is an example of Type I design (Figure 2). Except for Stations BR 9 and BR 12, all stations are of Type I design. The cross-section diagram for Station BR 12 (Mucha Station) is shown in Figure 3. The profile diagram for Mucha Station is shown in Figure 4.

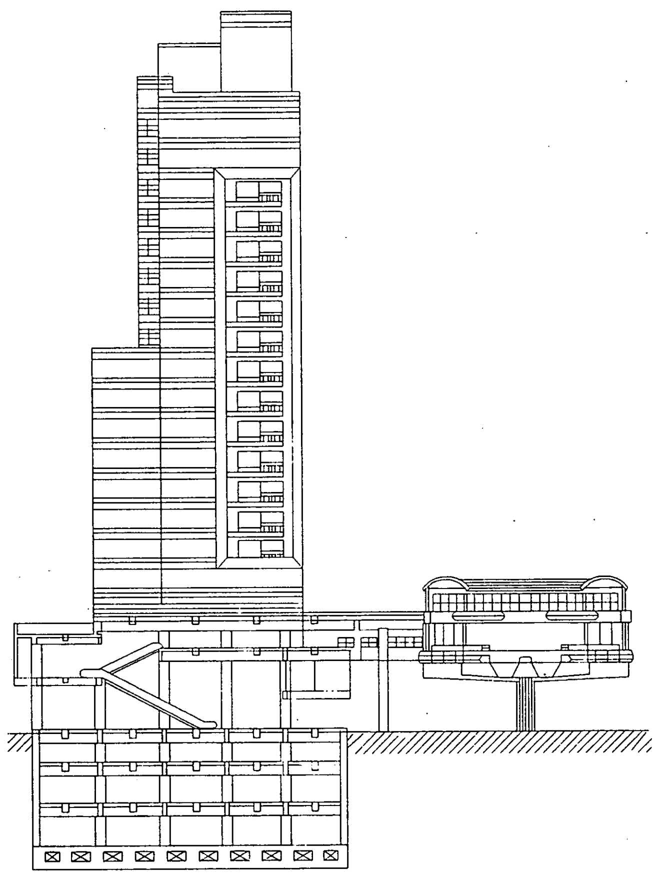

FIGURE 2 Cross-section diagram of Science and Technology Building Station.

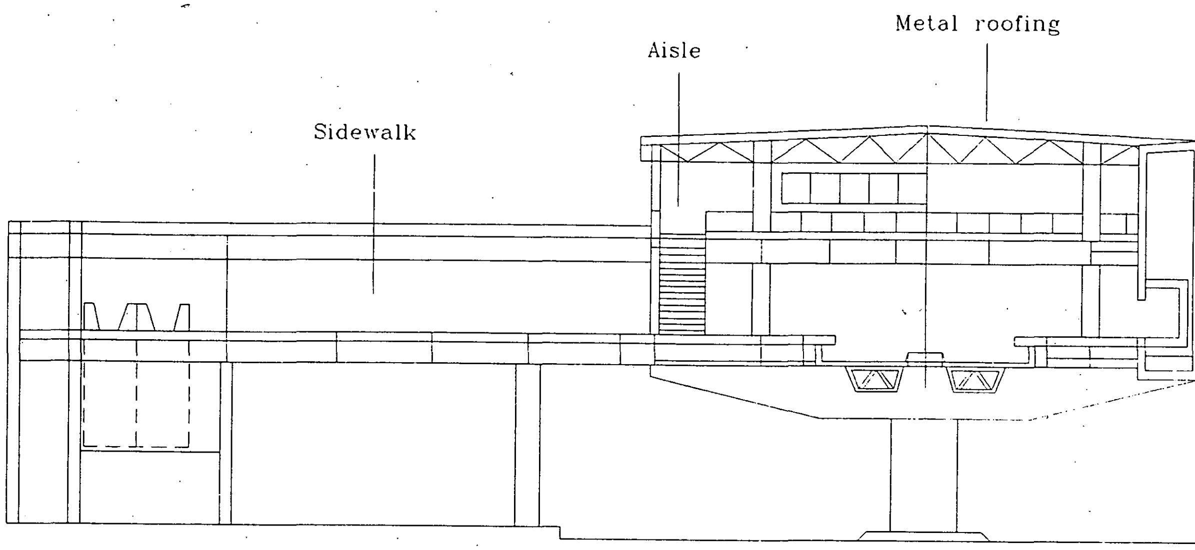

FIGURE 3 Cross-section diagram of Mucha Station.

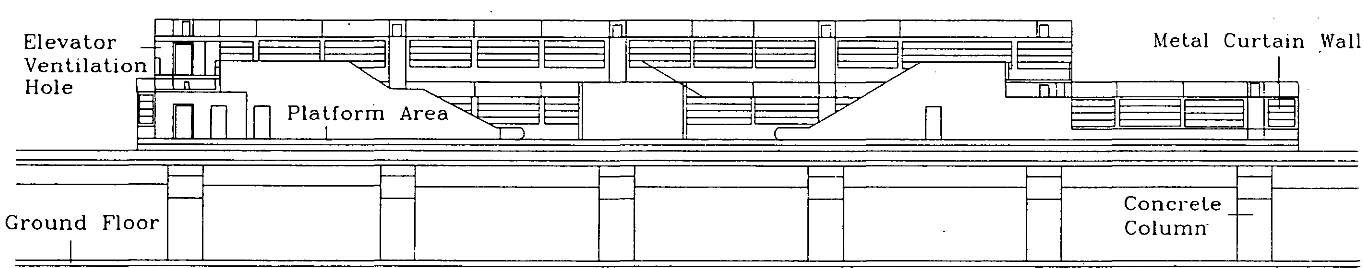

FIGURE 4 Profile diagram of Mucha Station.

2. *Type II: Integrated station.* The entrance and exit are located at the ground floor of the same station building. Stations BR 9 and BR 12 are of such design.

It is estimated that 27,340 passengers will use the Taipei APM system during the peak hour in 2001. The peak-hour traffic is expected to more than double to 55,900 passengers in 2021 (*7*). This kind of heavy peak-hour traffic is unheard of for any existing APM system. However because of the high population density and extremely crowded streets in Taipei, these figures have a high possibility of becoming reality. The peak-hour passenger traffic forecast for the 12 stations in Taipei's APM system is shown in Table 1.

When it opens in 1994, approximately two-thirds of the APM system's passengers are expected to walk to and from the APM stations. The remaining one-third are expected to use bus, taxi, park-and-ride, and kiss-and-ride as feeders for this medium-capacity transit system (*7*). The proposed operating schedule for the Taipei APM system is shown in Table 2 (*10*).

SUMMARY

The $920 million Taipei APM project is only part of a bigger government plan—the $300 billion Six-Year National Development Plan—that is looking ahead to Taiwan's infrastructure requirements for economic development into the 21st century. This is the first time that a medium-capacity trunk-line APM system has been designed to accommodate the significant travel needs of a major city of more than 2 million people. Because of construction and testing problems the original opening date had been pushed from 1992 to 1994. However if the operation is successful similar applications of APM as medium- to heavy-capacity trunk-line service could evolve in other cities.

TABLE 1 Peak-Hour Passenger Traffic Forecast for Taipei APM System

Station Name	Station No.	Year	Entering Passengers	Exiting Passengers
Sun Yat-Sen Jr. High	BR 2	2001	680	1,290
		2021	6,600	17,800
Nanking E. Rd.	BR 3*	2001	4,130	8,460
		2021	5,900	18,600
Chunghsiao E. Rd.	BR 4*	2001	1,440	2,870
		2021	4,900	14,200
Ta-An	BR 5*	2001	2,210	2,580
		2021	6,900	10,600
Science-Tech Bldg.	BR 6	2001	3,170	2,970
		2021	5,200	5,100
Liuchangli	BR 7	2001	480	440
		2021	4,400	2,200
Linkuang	BR 8	2001	3,040	960
		2021	4,800	2,800
Hsinhai	BR 9	2001	850	240
		2021	1,500	500
Wanfan Hospital	BR 10	2001	6,150	2,550
		2021	9,300	2,900
Wanfan Community	BR 11*	2001	1,200	100
		2021	1,800	400
Mucha	BR 12	2001	2,840	1,300
		2021	2,400	600
Taipei City Zoo	BR 13	2001	1,150	510
		2021	2,200	1,400
	Total	**2001**	**27,340**	**24,270**
		2021	**55,900**	**77,100**

* Transfer station to Rapid Transit (RRT) lines.

TABLE 2 Proposed Operating Schedule for Taipei APM System

Station to Station	Distance (meters)	Travel Time (seconds)	Dwell Time (seconds)
Northbound Train			
BR 13 - BR 12	680.12	60.20	17.00 (BR 13)
BR 12 - BR 11	514.02	49.20	17.00 (BR 12)
BR 11 - BR 10	1137.64	98.10	17.00 (BR 11)
BR 10 - BR 9	758.19	101.30	17.00 (BR 10)
BR 9 - BR 8	1598.09	118.70	17.00 (BR 9)
BR 8 - BR 7	821.42	65.50	17.00 (BR 8)
BR 7 - BR 6	1132.43	113.70	17.00 (BR 7)
BR 6 - BR 5	745.00	59.50	17.00 (BR 6)
BR 5 - BR 4	891.99	67.40	17.00 (BR 5)
BR 4 - BR 3	1268.01	86.80	17.00 (BR 4)
BR 3 - BR 2	931.00	69.50	17.00 (BR 3)

Station to Station	Distance (meters)	Travel Time (seconds)	Dwell Time (seconds)
Southbound Train			
BR 2 - BR 3	931.00	69.40	17.00 (BR 2)
BR 3 - BR 4	1267.99	86.70	17.00 (BR 3)
BR 4 - BR 5	892.01	67.60	17.00 (BR 4)
BR 5 - BR 6	745.00	59.70	17.00 (BR 5)
BR 6 - BR 7	1135.57	113.40	17.00 (BR 6)
BR 7 - BR 8	821.59	65.70	17.00 (BR 7)
BR 8 - BR 9	1593.06	119.60	17.00 (BR 8)
BR 9 - BR 10	763.71	103.70	17.00 (BR 9)
BR 10 - BR 11	1140.32	100.90	17.00 (BR 10)
BR 11 - BR 12	513.01	48.10	17.00 (BR 11)
BR 12 - BR 13	683.28	61.50	17.00 (BR 12)

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