REVIEW OF TECHNICAL AND OPERATIONAL ASPECTS OF SEVERAL FIXED-GUIDEWAY PUBLIC TRANSPORTATION SYSTEMS

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The purpose of this paper is to review the major technical and operational characteristics of several contemporary fixed-guideway public transportation systems and to determine the functional distinctions among them. Six systems are compared with respect to the following characteristics: nature of the vehicle-guideway interface, station layout, vehicle spacing control, general operating specifications, and specifications for nominal levels of vehicle performance. The 6 systems considered range from urban rail transit systems to monorail systems. Although they are unlike one another in many respects, they nonetheless function in much the same manner when contrasted to personal rapid transit systems currently being developed.

•THIS PAPER summarizes a review (1) of several contemporary fixed-guideway public transportation systems. The 6 systems are identified and their physical distinctions are delineated in the following section. Subsequent sections describe distinctions in station layout, vehicle spacing control, general operating specifications, and vehicle performance. The concluding section compares these systems with the general technical and operational characteristics of the Morgantown personal rapid transit system currently being developed by the Urban Mass Transportation Administration.

THE SYSTEMS AND THEIR PHYSICAL DISTINCTIONS

The systems considered here include the urban rail transit system of advanced design developed by the San Francisco Bay Area Rapid Transit District and opened to the public in 1972; the Japanese National Railways New Tokaido Line, an example of advanced design for conventional railroads; several subway lines in Paris where vehicles are equipped with both rubber tires and flanged wheels used in other urban rail transit systems; a monorail system with vehicles supported from below (Alweg); a monorail system with vehicles supported from above (Safege); and the transit expressway system. A summary of system characteristics is given in Table 1.

The San Francisco and Japanese designs involve the same steel wheel-steel rail concept that has traditionally characterized railway systems. The Paris subway lines are of interest because the subway vehicles are equipped with rubber tires, which provide the normal mode of vehicle support and roll on flat concrete slabs. Although the Paris subway vehicles are also equipped with flanged steel railroad wheels, those wheels are used primarily to provide guidance through switches by interacting with conventional steel railroad rails that extend the length of each subway line. The Alweg monorail system involves rubber-tired vehicles that straddle a concrete box beam.

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Page 72, in Table 1, under the ''System'' column, the 3rd entry should read: Paris Transportation Authority lines with rubber-tired trains; under the ''Safety Acceleration'' and ''Jerk'' columns, each of the 2nd entries should read -[b].

Table 1. Summary of system characteristics.

System	Station Layout	Vehicle Spacing Control	General Operating Specifications: Minimum Headway (sec)	Station Dwell Time (sec)	Train Length (ft)	Specifications for Nominal Vehicle Performance: Maximum Velocity (mph)	Deceleration (mph/sec): Operational	Deceleration (mph/sec): Emergency	Starting Acceleration (mph/sec)	Jerk (mph/sec^2)	Jerk Derivative (mph/sec^2)
San Francisco Bay Area Rail Transit	On-line	Automatic block system	90	20	700	80	3.0	3.0	3.0	3.0	—[a]
Japanese National Railways New Tokaido Line	Off-line and on-line	Automatic block system	300	120 to 300	1,312	130	0.9 to 1.6	1.3 to 2.4	—[a]	—[a]	—[a]
Paris Transportation Authority rubber-tired trains	On-line	Automatic block system	180	—[b]	200	37	3.2	5.6	3.1	1.8	2.2
Alweg monorail	On-line	Automatic block system	90	—[b]	201	53	3.3	5.7	2.5	—[b]	—[a]
Safege monorail	On-line	Automatic block system	90	—[b]	118	75	3.3	6.5	3.3	—[b]	—[a]
Transit expressway	On-line	Automatic block system	120	20	305	70	2.5	5.0	2.5	—[b]	—[a]

[a]No specification issued. [b]Specification not available.

Safege monorail system vehicles are suspended from rubber-tired trucks that operate within an overhead beamway that is enclosed except for a slot on the underside for the linkage that connects the trucks and the body of the vehicle. The transit expressway system involves vehicles that are supported from below by rubber-tired trucks. Another distinction of those vehicles is that their lateral guidance is through horizontally mounted rubber tires that are suspended below each vehicle's body so that they roll on opposite sides of a steel I-beam mounted over the guideway's centerline.

STATION LAYOUT

Station layout may be categorized as being either on-line or off-line. On-line stations are those that involve locations for vehicle stops that are directly on the main guideway facilities. A vehicle consequently cannot pass through an on-line station if another vehicle is standing in the station. The nature of the activity in the station therefore determines the line or guideway capacity. Off-line stations on the other hand involve locations for vehicle stops that are on sidings, thereby enabling vehicles that need not stop at the station to pass it without delay. All of the 6 systems reviewed here involve on-line stations, and only one of them—the New Tokaido Line—involves some off-line stations (Table 1).

VEHICLE SPACING CONTROL

The control of minimum spacing for each of the 6 systems enforces a requirement that the gap between 2 vehicles be not less than the following vehicle's stopping distance. An automatic block system, similar in operation to contemporary railroad signaling systems, is used on each of the systems. Basically such a system divides the length of the guideway into segments, referred to as blocks, and records information on the presence or absence of a vehicle in each block. The information is then transmitted to upstream blocks where it is processed and transferred to vehicles in those blocks.

GENERAL OPERATING SPECIFICATIONS

Table 1 gives the specifications for minimum headway, station dwell time, and train length for each of the 6 systems. Values for each of those parameters vary considerably. However, the minimum headway specification is dependent on station dwell time in the case of on-line stations and more generally on vehicle length and the various specifications for vehicle performance. A review of this interrelation is given in another report (2).

VEHICLE PERFORMANCE

Specifications for nominal vehicle performance levels are also given in Table 1. The 2 systems without rubber-tired vehicles generally have lower decelerative capabilities because of the reduced levels of adhesion existing between the vehicle wheels and the running surface. The Paris subway system involves a specification on the maximum rate of change of jerk. Such a specification, extremely unusual in other fixed-guideway transportation system designs, should contribute to passenger comfort at the outset and at the termination of periods of vehicle acceleration and deceleration.

CONCLUSION

This paper concludes with a comparison of the characteristics of the 6 systems described with those of an experimental personal rapid transit system located in Morgantown, West Virginia, and described in a recent report (3) and in a letter to me from the project director. This system was dedicated in October 1972 and is scheduled to be in operation in 1974. All Morgantown stations are off-line. Control of minimum vehicle spacing for the Morgantown system has some similarity to that for the 6 systems described in that the stopping distance spacing criterion is followed and enforced by an automatic block system. Despite the similarity in control concepts, placing all stations off-line has allowed the designers of the Morgantown system to reduce the minimum headway between successive vehicles on main-line guideway to 15.0 sec for operational purposes and 7.5 sec for test purposes. Station dwell times are variable, and vehicle length is approximately 15 ft. Vehicle performance specifications include the following: maximum velocity, 30 mph; operational deceleration, 1.4 mph/sec; emergency deceleration, 6.6 mph/sec; and maximum acceleration, 2.7 mph/sec.

Perhaps the Morgantown system's most dramatic design departure is the employment of off-line stations throughout the system and exploitation of the resultant capability to substantially decrease headways. This departure is principally operational or functional in nature. In many respects, technology for the Morgantown system is not fundamentally different from that for the newest of the 6 systems described above.

The 6 systems considered here all function in much the same manner, given their general utilization of on-line stations. Of course the inclusion of on-line stations is not required by other aspects of the designs. Thus, system-wide use of off-line stations for these 6 systems appears to be a distinct possibility. The resulting effect on operational capabilities is a matter meriting detailed review.

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