Dual-Mode Transit Concept of Rohr Industries

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Under contract to the Urban Mass Transportation Administration, Rohr Industries developed a concept for a dual-mode transit system that combines the advantages of a flexible bus distribution system with an efficient line-haul system. Because dual mode can combine systems in this manner, it can improve transit throughout an urban area in a way that separate systems cannot. By offering scheduled service, subscription service, and door-to-door demand service, dual mode can provide convenience for the rider nearly comparable to that of the automobile. The combination of flexible schedules and routes and high-speed line-haul capabilities with automatic dispatching and control results in high system use and efficiency. An advanced new vehicle design results in excellent ride quality with minimum pollution and noise. The design objective was to develop a system that would make significant improvements in transit service for cities of varying size and would thereby reduce congestion and improve personal mobility. A second objective was to design a system along modular lines. The third objective was to design a system that is technically feasible and economically sound.

Dual-mode transportation can best serve small and medium-sized urban areas. First, it collects and distributes passengers in outlying areas much as a standard bus does; second, under automatic operation it provides high-speed transit service along corridors to central business districts; and, third, upon arrival it circulates and distributes passengers in a manual mode of operation. In this manner dual mode provides the maximum personalized service possible while still retaining a high degree of flexibility in routing and scheduling.

Basically, a dual-mode transportation system (DMTS) encompasses a minimum of four subsystems: guideway and route interconnections for automated transit; command and control capabilities during automated and off-guideway operations; facilities such as passenger stations, automobile parking areas, command and control subsystem housing, merge-diverge areas, and maintenance areas; and transit vehicles. Of these, the element that must be truly dual mode is the vehicle.

A passenger may board (or leave) a dual-mode bus within a collection and distribution region at a residence or a convenient street location. He or she may also board (or leave) the bus at a dual-mode station. Pickup by dual mode in the collection and distribution region is similar to that by conventional dial-a-ride bus. Passengers specify their destinations when they call for service, and the destination is confirmed by the driver through an on-board terminal when the passenger enters the vehicle. The vehicle design includes provisions for individuals in wheelchairs (Figure 1). To accommodate the wheelchair, an optional ramp extends from the bus to the station or surface street level to safely and comfortably provide passenger ingress and egress. The ramp operates from the driver's compartment. Grips built into the back of the seats can be used for another 10 standing passengers, for whom there is 2.3 m^2 (25 ft^2) of aisle space.

The vehicle has a capacity of 21 seated passengers plus the driver (Figure 2). The design goals for passenger accommodation were safety, comfort, personal dignity, and ease of use. Safety considerations took priority over comfort. The low floor and large window areas of the vehicle afford the passenger ease in boarding the bus and a panoramic view of the surroundings. The tint on the large windows, primarily for the control of thermal losses, has the additional value of visual insulation between the inside and the outside space.

In the driver's area is a mobile terminal to allow direct communication with the control center (Figure 3). By this means the driver confirms the entry of a passenger. Speakers located in the overhead area of the vehicle are used for communicating with on-board passengers. An exterior speaker, located at the entrance door, enables the driver to communicate with people outside the vehicle. A touch bar type of switch is on the interior panel to allow passengers to signal the driver for assistance or to speak directly with the control center when a driver is not on the vehicle.

When the vehicle leaves the manual mode, i.e., goes from a city street to the guideway system, it passes through a modal interchange (Figure 4). The dual characteristic of DMTS makes modal interchange a critical aspect of the feasibility of DMTS. At the off-guideway to on-guideway modal interchange, the driver is removed and the vehicle is put under automatic guideway control. Automatic control equipment on the vehicle must be verified in a "predeparture test" before the vehicle is committed to automatic guideway control.

The driver remains with the vehicle through checkout. Should there be a malfunction, the vehicle is prevented from entering the system, and the driver removes the vehicle manually by simply driving to a hold and transfer area. If the vehicle is "verified," the entry barrier is lowered and the vehicle moves into the station area where the driver leaves the vehicle. The responsibility for control within the stations and station areas is divided into two parts: control of the vehicles and control of the station facilities. The control center computer assigns berths for vehicles entering the station

and defines departure times to avoid merge conflicts. A small local computer, which is associated with one or more stations, controls and monitors the station facilities.

When a vehicle enters the station entry ramp, a message from the vehicle alerts the station that docking information is required. The station determines from the data base the berths that are unoccupied and sends a berth assignment to the vehicle, which is then guided to the designated berth. After the loading and unloading of passengers, the doors are closed and a departure-ready message is dispatched. The earliest dispatch time that will avoid merge conflicts downstream is then determined. At that time, the vehicle resumes its tour

Figure 1. Dual-mode vehicle.

Figure 2. Interior of dual-mode vehicle.

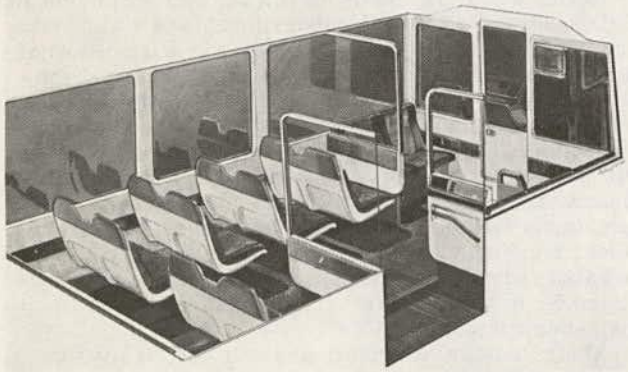

Figure 3. Cab area of dual-mode vehicle.

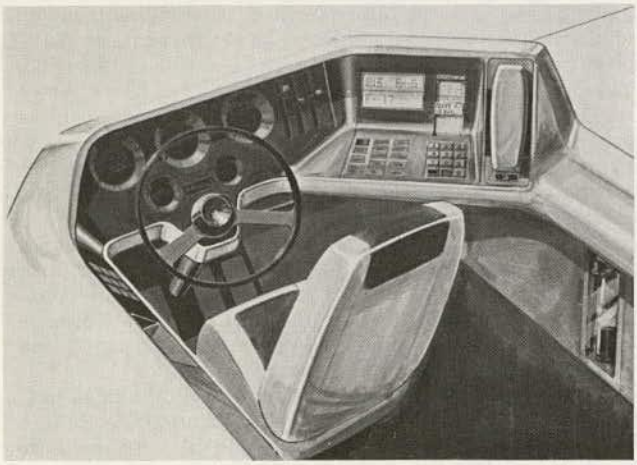

Figure 4. Modal interchange.

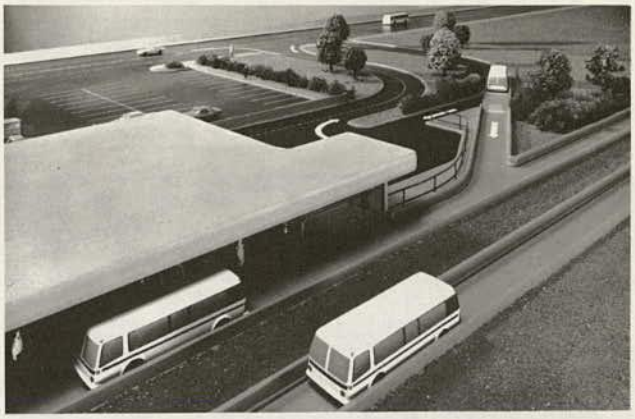

Figure 5. Station entry area.

Figure 6. Station interior.

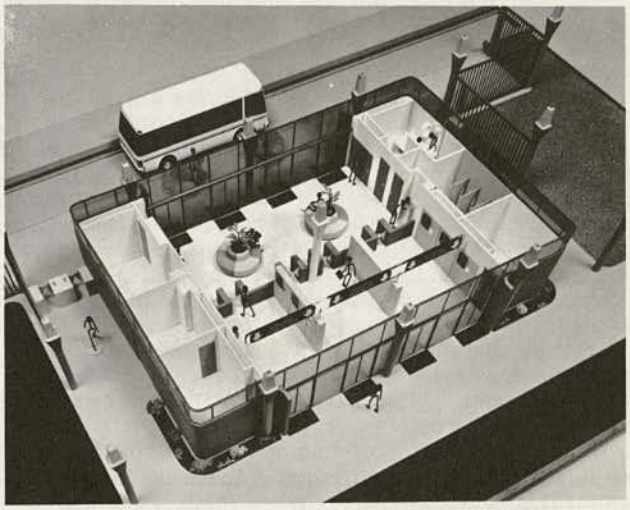

Figure 7. Passenger-loading area.

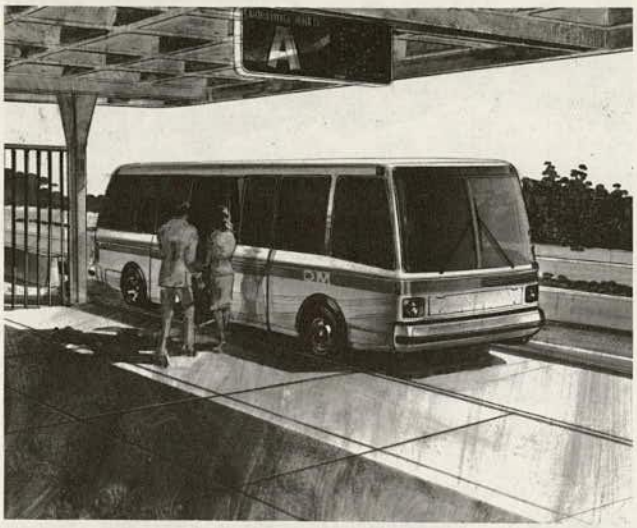

Figure 8. Station and guideway in central business district.

under automatic control.

At the station, passengers may also enter the system by specifying their destinations and actuating, by coin or token or other means, a fare-collection device in the entry area (Figure 5). In the stations are displays that inform the passenger of bus routes, schedules, and services; ticketing equipment; coin change and fare collection devices; waiting areas for paid passengers; boarding and disembarking platforms; fare verification, coin-change, and add-fare equipment; and "red phones" at the barriers to passenger exit corridors (Figure 6).

Station size is scaled by the peak rate of passengers per minute entering a station and the fraction of them engaged in each of the boarding or exiting procedures. Of those buses upstream from a line-haul station, only a fraction will switch off-line to stop at a given station. Of those buses that either access or egress between automated guideway and surface streets, most will carry on-board passengers through the transition. Thus, pedestrian traffic through a station is a small proportion of that passing a station on the guideway or streets.

A room is reserved in the stations for bus drivers awaiting their next assignments to drive buses onto the surface streets. The drivers thus assist in security surveillance of the station interior by means of a glass partition. The station also houses computer equipment for traffic supervision and automatic vehicle control operations.

Passengers board or leave buses, traveling the automated dedicated lanes of the dual-mode system, at transit stations. At most of the stations provision is made for access and egress of buses between the automated guideway and public surface streets. At the time that the central control computer chooses the berth for the incoming vehicle, it communicates information to the station that causes the new tour number to be displayed at the designated berth for the benefit of waiting passengers (Figure 7). In addition, the other station display equipment is updated to reflect the current status. Information from the entrance and exit gates to the berth is sent to central control to update the passenger information.

At most of the stations, provision is made for access and egress of buses between the automated guideway and the surface streets. The function of the guideway and grounds adjoining the station structure is to provide switching and an off-line shunt from the main-line guideway to the station; short guideway segments that allow buses to access or egress between the guideway and the surface streets and undergo a safety check-out before proceeding; parking for passengers; storage for spare buses to replace those that fail in revenue operation; and queuing lanes for buses entering and leaving the station. When stations serve automated buses only, the access and egress guideway, check-out stops, and queuing lanes are not required.

Station design is site dependent for both main-line and CBD locations. The major determinants of station configuration are the elevations of guideway surface and arterial street, relative to each other, and land and construction costs. The most probable geometry on the line-haul corridor may be the location of the guideway lanes along the expressway median. An elevated ramp will be required to allow buses to pass over the freeway lanes to reach the station platform. The ramps reduce investment costs by shortening the acceleration and deceleration distances for a given change in bus velocity and also reduce annual expense by decreasing propulsion power for bus acceleration from a station stop up to main-line speed.

Along line-haul corridors and on loops circling the perimeter of the central business district, stations will usually be two-level structures. In the CBD, stations may be underground, and passenger circulation would be by driver-controlled buses on city streets. Stations in the CBD may also be above ground, serving passengers who travel on elevated guideway grids throughout the CBD (Figure 8). Station space may be rented in existing commercial office buildings.

The key advantage of the Rohr dual-mode concept is that it can be developed in phases during many years with a low-cost entry coinciding with the growth of a specific urban area. A city can start with vehicles and a management system of passengers, vehicles, and drivers. It can then expand to dedicated freeway lanes at negligible cost. When traffic warrants and the system management has been proved, guideways can be installed to permit fully automatic operation in line haul. At this time, vehicle retrofit can also be made by incorporating the automatic control module and steering.

This ability of the system to grow with the needs of the community and its flexibility distinguish the Rohr dual-mode system from more traditional fixed-guideway systems.