Dual-Mode System Development Program of the Urban Mass Transportation Administration

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This paper reviews an early study that compared dual-mode and conventional bus rapid transit and that served as background to a three-phase development program of the Urban Mass Transportation Administration. Phase 1 includes system concepts and design; phase 2 includes detailed design and system performance on a test facility; and phase 3 includes prototype development and tests and a demonstration in an urban area.

Dual-mode transit system (DMTS) vehicles can be operated manually on streets and highways and automatically on exclusive guideways. When driven manually, these vehicles are typically operated on routes in suburban residential areas or shopping areas and in either a scheduled or a demand-responsive mode. When the driver completes the collection and distribution route, he or she guides the vehicle through a mode interchange at a guideway station and continues, operating automatically, on an assigned route through the exclusive guideway network. These guideways are along the heavily traveled corridors and through the central business district. At the completion of its guideway route, the vehicle is met by a new driver who places the vehicle into manual operation and drives it along its next collection and distribution route.

The DMTS under development is being designed for regionwide service in urban areas that have populations of more than 750,000. Such a regional system might have 6 major corridors, 225 lane-km (140 lane-miles) of guideway, 75 stations, 1000 to 2000 vehicles with a capacity of 15 to 30 passengers, and the capability to transport 10 000 passengers/h/lane and 30 000 passengers at one time.

A typical passenger trip for DMTS is as follows: At a preassigned time each day, Mr. Jones, a regular commuter, meets the vehicle in front of his home where he joins neighbors who are scheduled for the same general destination. If Mr. Jones needs to arrive earlier or later on a particular day, he calls the central control center for a trip reassignment for that day and is assigned to the best available vehicle that can complete his trip. If his new departure time cannot be readily matched with a vehicle headed to his general destination, he may have to transfer somewhere along his route. If so, he will experience a minimum of inconvenience, for his transfer is made at an enclosed guideway station where his next vehicle will arrive within 3 min.

Numerous studies have investigated dual mode as a transportation alternative. The conclusions indicate that dual mode is a feasible form of transportation. In 1971, a study on the application of DMTS in Milwaukee County was performed by the Allis Chalmers Corporation for the Urban Mass Transportation Administration. The study investigated the merits of dual-mode alternatives and chose a bimode transit minibus because the technology was currently available; because the transit operator would have better control of the vehicles and, hence, better maintenance and greater safety; and because greater user benefits would occur in a shorter time. The study then compared, for a time period to 1990, a conventional bus rapid transit system and DTMS.

Conventional Bus	Dual Mode
53-passenger, gas turbine bus	19-passenger, electric drive bus
12.9 km (8 miles) of exclusive busway with manual operation	117 km (110 miles) of guideway with automobile operation
Operation on primary streets and highways	Collection and distribution in neighborhoods

The findings indicated that DMTS provides a higher level of service, produces higher labor productivity, operates at competitive fares, has a higher flexibility and growth potential, obtains benefits that exceed costs, and results in greater attainment of regional development goals. For the guideway network, the study indicated that the right-of-way could be obtained as follows:

Area	Percent
Existing freeway or street	51
Residential	19
Railroad or utility	18
Vacant	7
Industrial	5

The findings of the study indicated that the high level of service of DMTS resulted from its convenient passenger access on manually operated collection and distribution routes, its short vehicle headways (during peak periods, headways are typically 5 to 10 min on the collection and distribution routes and 5 to 10 s on the guideways), the pervasiveness of its regionwide network of guideways, and shorter passenger trip times because of the high vehicle speeds on the exclusive guideways and the coordination of passenger-vehicle-driver movements provided by its central management system. Hence,

there was ample indication that DMTS more nearly matches the capability of the automobile for point-to-point service. Further, the total cost of DMTS was 25¢/vehicle-km (36¢/vehicle-mile) or 3¢/passenger-km (4.5¢/passenger-mile) when the average load is 8 passengers/vehicle. DMTS uses less than half the energy per passenger-kilometer that an automobile does.

PROGRAM OBJECTIVES

The objective of the Urban Mass Transportation Administration DMTS development program is to improve the quality of urban transportation by developing a system that has a high level of service that is competitive with that of the automobile. In addition, the system design must have a safe operation; short vehicle headways; aesthetically pleasing structures and vehicles; a favorable environmental impact; a high level of service for the youth, elderly, and mobile handicapped; the potential for orderly expansion without significant obsolescense; minimum capital and operating costs; and maximum use of existing rights-of-way. We have a program goal to increase the capacity of 10 000 passengers/h/single lane to 25 000 passengers/h/single lane. This can be accomplished by training vehicles, using larger vehicles, or decreasing headways from a 5 to 10-s range to a 2 to 4-s range. In addition, a goal of the development program is to incorporate into DMTS other transit vehicles and privately owned passenger vehicles.

The present DMTS program of the Urban Mass Transportation Administration has three phases. The objective of phase 1, which began in September 1973, is the development of three alternative design concepts. In parallel with this system development, UMTA is funding two DMTS planning case studies to determine sketch planning methodology and implementation strategies. Phase 1 system development contractors were given specific performance guidelines and requirements to meet in developing their system concepts, but were permitted a broad choice of design detail. The technical requirements given were related to safety; availability; environmental considerations; system capacity; command, control, and communications; vehicle, station, and guideway; degraded operations; and capability to expand with urban growth.

CONCEPT DESCRIPTIONS

The three system concepts of phase 1 are being developed by General Motors Corporation, Rohr Industries, and Transportation Technology, Inc. A brief introduction to their proposed concepts follows.

The General Motors design uses a 17-passenger bimodal bus that is propelled by an internal combustion engine both on and off the guideway. This bus design is similar to the GM motor home vehicle. The bus incorporates a peripheral seating arrangement with provisions for a wheelchair and an elevator-door mechanism to accommodate wheelchair entrance. On the guideway, the bus uses an electronic lateral guidance system.

The Rohr design uses a 21-passenger bimodal bus that is propelled by a diesel engine both on and off the guideway. On the guideway, the bus uses side wheels, for its mechanical lateral guidance. The bus has a conventional seating arrangement with provisions for a wheelchair and a ramp to accommodate wheelchair entrance.

The TTI design uses a transporter chassis that can accommodate a pallet that will support a conventional minibus or automobile. The transporter chassis also accommodates a personal rapid transit body or a freight container. The transporter chassis uses an air-cushion suspension system and an electric linear induction motor propulsion system. A typical suburban station might have a station bypass lane and berths where vehicles can be mounted onto pallets for automatic operation. TTI has an option in its system concept that permits a bimodal electric bus to operate directly on the guideway without the need for a transporter. Off guideway, the bus is operated from batteries.

PHASE 1 REQUIREMENTS

Phase 1 contractors were required to deliver documentation that included system specification, phase 2 performance and test specification, safety and operation plans, cost analyses, design study reports, phase 2 proposals, and scale models of the vehicle, station, and mode interchange.

Design studies performed in phase 1 include

1. Cost analyses;
2. System capacity growth, including headway-reduction techniques;
3. Station and guideway design;
4. Vehicle speed and range;
5. Vehicle communications;
6. Vital safety functions including identification of hazards and analyses of preliminary failure mode and effects;
7. Degraded operational modes; and
8. System availability and the effects of delays due to equipment failure.

PHASE 2 REQUIREMENTS

It is planned that one of the phase 1 system development contractors will be selected to complete the concept design. In phase 2, that contractor will

1. Produce a detailed design with the objective of demonstrating system feasibility;
2. Construct a test facility at the high-speed ground test center in Pueblo, Colorado;
3. Perform tests to evaluate the system performance in parallel with the hardware development;
4. Perform computer simulations to determine and demonstrate the system performance of a regional DMTS;
5. Perform studies and analyses to determine the methodology required to expand the results of phase 2 to meet the requirements of a regional DMTS;
6. Study the methodology and the design requirements for incorporating small passenger vehicles into a DMTS with a mixed vehicle fleet; and
7. Demonstrate the compatibility of the design for mixed-fleet operation by suitably modifying an automobile and performing operational tests of mixed-fleet operation at the test facility.

The planned phase 2 test facility will contain five vehicles, line-haul loop and a CBD loop with a total of approximately 5 km (3 miles) of single-lane guideway, multiberth station, mode interchange facility, control center, maintenance facility, portion of the guideway that is elevated, and portion of the guideway that is at 6 percent grade.

In phase 2 the contractor will deliver the following documentation: test implementation plan, safety plan, quality assurance and configuration management plan, fabrication and product specifications, operations and maintenance manual, tests and management simulation reports, and updates of the major phase 1 documentation.

PHASE 3 REQUIREMENTS

Phase 3 depends on the success of the results of phase 2. The objectives of phase 3 may involve prototype development and tests or urban demonstration or urban deployment.

DOMESTIC MARKET POTENTIAL OF DMTS

In my opinion, a useful criterion of market potential for DMTS is any area with a population of more than 750 000 and a population density in the central city of more than 2300 persons/km^2 (6000 persons/mile^2). With this criterion, the following 20 urban areas would be applicable (this list does not include those cities that have or are building rail rapid transit systems): Anaheim and Orange County, California, Buffalo, Cincinnati, Columbus, Dayton, Denver, Detroit, Indianapolis, Los Angeles, Louisville, Miami, Milwaukee, Minneapolis and St. Paul, Newark, Paterson and Passaic, Pittsburgh, Rochester, St. Louis, San Jose, and Seattle and Everett.

If the criteria of market potential are broadened to include areas with a growth rate greater than 30 percent between 1960 and 1970, then the following seven areas would be applicable: Dallas, Fort Worth, Houston, Phoenix, San Bernardino, San Diego, and Tampa.

The implementation of DMTS in these urban areas might follow a logical technology evolution from conventional bus to dial-a-ride bus, bus priority traffic signal control, freeway-access ramp metering, freeway-dedicated bus lanes, central vehicle-driver-passenger management, guideway automatic vehicle control, and DMTS.