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IN 1968, at the request of Congress, the Urban Transportation Administration of the U. S. Department of Housing and Urban Development completed a study of new systems of urban transportation.[1] This study found that a combination of new systems would be required to meet the projected needs for urban transportation while creating opportunities for improved urban development.

No single device was conceived that could satisfy the diverse origins and destinations of those who are dependent upon public transportation. While the private automobile was recognized as a close approximation to a universal transportation system, it has serious disadvantages that have been adequately documented elsewhere.

A comprehensively planned, integrated, combination of systems was considered a more effective means of meeting future needs than the conventional systems presently in use. This realization has led to the development of the following new urban transportation systems: **Dial-a-Ride** for low density suburban town travel; **Personal Rapid Transit** for higher density trips in extended urban areas, and **Fast Transit Links** for providing high-speed service between the remote concentrated centers of activity in metropolitan areas.

This paper discusses the urban transportation applications of a tracked air cushion vehicle (TACV). Of the various technologies investigated, a TACV system was considered as having the greatest potential for a fast transit link to: Connect two or more contiguous urban complexes; Provide access to remote regional airports; Connect large long-haul airports with several short-haul airports, and Provide commutation along corridors connecting urban centers and new communities.

The characteristics, advantages, costs and potential applications of a TACV system as well as the objectives and schedule of the development program are presented in the following sections.

SYSTEM CHARACTERISTICS

Specifications for an Urban TACV are outlined in Table 1. Performance specifications for this system were prepared by the Transportation Systems Center in Cambridge, Massachusetts, under the technical direction of the Federal Railroad Administration. They are based on progress in the development of a 300 mph tracked air cushion research vehicle. Performance is considered within the state-of-the-art and reflects current technology developed in the United States, England and France. A cutaway view of the vehicle is shown in Figure 1.[2] Significant features of the UTACV are discussed below:

TABLE 1
VEHICLE SPECIFICATIONS
(PROTOTYPE)

VEHICLE	
Passenger Capacity	60
DIMENSIONS	
Overall Length	94.0 ft.
Overall Height	10.8 ft.
Overall Width	10.7 ft.
Interior Cabin Height	6.8 ft.
Interior Cabin Width	9.5 ft.
WEIGHT	
Net Vehicle Weight	46,000 lb.
Passenger and Baggage	14,000 lb.
Gross Vehicle Weight	60,000 lb.
POWER	
LIM Propulsion at 150 mph	2,000 KW
Auxiliary Electrical Load	700 KW
Total Electrical Load (Cruise)	2,700 KW
NOISE	
External, 50 ft. at Cruise	73db(A)
Internal	65db(A)
PERFORMANCE	
Cruising Speed	150 mph
Maximum Speed	170 mph
Acceleration Distance to Cruising Speed	1.75 mi.
Normal Stopping Distance	1.5 mi.
Emergency Stopping Distance	0.5 mi.
Allowable Grade at Cruise Speed	5.5%
GUIDEWAY	
Aerial Guideway	142 in.
Reaction Rail Height (Overall)	33 in.
Surface Waviness	1/8" in. 25'
Minimum Vertical Turn Radius	10,000 ft.
Minimum Horizontal Turning Radius	1,500 ft.
ELECTRIFICATION (3-Phase AC Power Supplied from Wayside)	
Frequency	60 Hz
Voltage	4,160 volt
Substation Spacing	5.0 mi.

Guideway. The guideway consists of two elements: the supporting structure and reaction rail. The supporting structure design represents a trade-off between specified ride comfort criteria for the vehicle and economy of construction. By limiting surface waviness to one-eighth inch in 25 feet, the guideway slab can be constructed within the state-of-the-art for modern aircraft runways. Use of standard highway construction practice is also acceptable, if the slab is overlaid with a lift of asphalt to provide the final specified surface smoothness. The asphalt lift offers the additional advantages of simplifying restoration of guideway

Urban Transportation Applications of a TACV System

by

*H. W. Merritt**

smoothness disturbed by supporting structure settlement.

Supporting structures for elevated spans can be designed with conventional precast concrete sections. These designs can take advantage of the vehicle loads distributed through the air cushions. The most severe design restraint is that imposed by passenger comfort requirements.

The reaction rail performs two functions: it serves as the secondary of the linear induction motor to give thrust to the vehicle, and it provides lateral guidance for the vehicle. The reaction rail is an aluminum extrusion 33 inches high and tapered from 1.8 inches at the base to 0.68 inches at the top. A seven-inch wide flange at the bottom of the rail permits fastening to the guideway slab. The rail extrusions will be 60 feet long of 6061-T6 aluminum alloy with a maximum conductivity of 37 percent. The rail sections will be welded together upon installation with only a few expansion joints needed.

Air Cushions. The vehicle is both supported and guided by air cushions. The cushion designs are based on developments of the Societe Bertin & Cie under the direction of the Societe de l'Aerotrain.

Air is supplied by two electrically driven 350 HP compressors through plenum chambers separately serving the guidance and lift cushions. The lift cushions cover approximately 80 percent of the area under the vehicle. This area and the specified guideway smoothness permit the cushions to operate with an air gap of about one-eighth inch and a nominal air pressure of 0.68 psig. Under these conditions, 200 HP is required to levitate the vehicle. The remaining air supply is required for the guidance cushions and for cooling the linear induction motor.

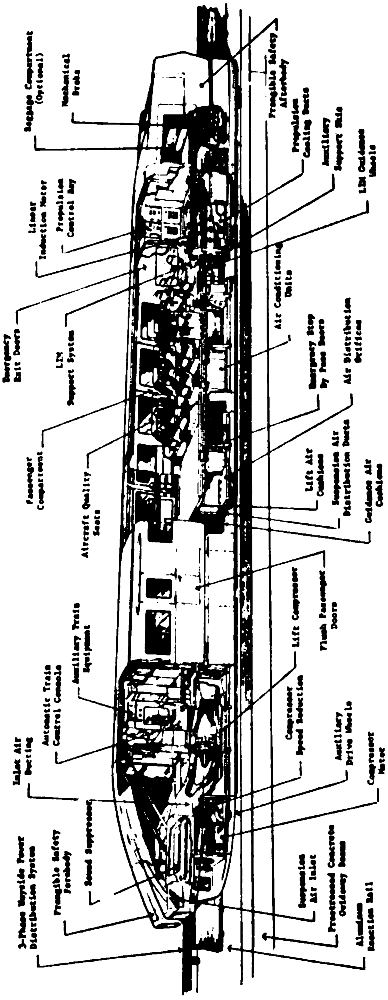

Figure 1. Cutaway view of the 60-passenger prototype UTACV

The guidance cushions have been modified to accommodate a 1500-foot radius curve. They have also been designed to meet lateral acceleration limits with steady winds up to 30 mph and wind gusts up to 60 mph from any direction. The guidance cushions must also be able to laterally support the ve-

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hicle on curves with up to ten degrees of superelevation.

The cushion lips are fabricated of flexible material to reduce wear and to enable the vehicle to surmount small obstacles without damage.

Power and Propulsion.[3] Four elements comprise the power and propulsion subsystem.

Primary power to the UTACV system is supplied from an urban power grid at available subtransmission voltages. Distribution along the guideway at primary voltage will be generally underground in urban areas. Substations located at intervals along the guideway will provide control, protection and transformation of primary power to the specified wayside power rail voltage. For the prototype system, a three-phase, 4160 volt, alternating current wayside power system has been selected.

Power collection is from three equally spaced power rails, arranged in delta form, installed along the edge of the guideway. A three-phase pick-up plug, attached to the vehicle by a pantograph, rides captive between the rails. Up to five megawatts of power is transmitted through brushes on the plug to the power conditioning unit in the vehicle.

Power conditioning regulates delivered power to provide both smooth, jerk-limited acceleration, and braking when the power supply is reversed. The prototype power conditioning unit is a solid-state thyristor controller which does not vary the frequency. Fixed frequency LIMs do not have a high thrust at zero speed. A small hydraulic motor with two auxiliary drive wheels will accelerate the vehicle to about seven mph, at which point the LIM provides enough thrust to continue accelerating the vehicle without danger of overheating the reaction rail. Development of a variable frequency, variable voltage, power conditioning unit is expected to improve the efficiency and performance of the LIM propulsion subsystem.

The **Linear Induction Motor** (LIM) provides a starting thrust of approximately 5000 pounds, a maximum thrust of about 10,000 pounds, and 7,000 pounds of thrust at 150 mph cruise speeds. The LIM is double-sided with a cobalt-iron core. Windings are delta connected, concentric wound, with four poles. The motor develops about 2,500 H.P. with 4,160 volts, 60Hz, and is cooled by forced air circulation. The motor mount permits some lateral movement. Eight guide wheels, four forward, and four aft, allow the motor to closely follow the reaction rail rather than the motion of the vehicle.

Braking. Three independent braking subsystems provide deceleration from 150 mph to standstill.

Normal braking is accomplished by reversing the phases of the power supply to the LIM (plugging). The reversed thrust will slow the vehicle to approximately 20 mph. Hydraulically actuated mechanical caliper brakes are blended in to bring the vehicle to a complete stop within 1.50 miles from the start of braking action. Back-up for the hydraulic system is provided by a one-time pneumatic actuator. The specified maximum deceleration is 0.15g and average deceleration is 0.0815g.

Emergency braking simultaneously combines LIM plugging and mechanical braking. During an emergency stop, a maximum of 0.4g deceleration is permitted. A complete stop from 150 mph full speed is required within one-half mile.

Redundant braking is effected when an accelerometer fails to sense a 0.25g minimum deceleration rate with all braking systems actuated during emergency braking. The suspension system air plenum is vented, the vehicle is dropped onto five pairs of longitudinal skids and is stopped by guideway friction.

Automatic Control and Communication. This subsystem consists of elements in the vehicle and on the wayside. Automatic Train Operation (ATO) and Automatic Train Protection (ATP) comprise the on-board elements. Wayside elements provide line supervision for a single or multiple vehicle system.

Automatic train operation enables the vehicle to be operated with minimum human intervention. Greater predictability of response and faster response times required for high-speed vehicle operation can be achieved than with manual operation. ATO performs the following sequential functions: Complete the start sequence upon receipt of a dispatch signal from the station attendant; Close doors; Accelerate to line speed; Adjust speed for civil speed changes and schedule deviations; Sense station approach; Perform stopping profile, and Stop at station, open doors and start dwell.

Automatic train protection is primarily concerned with enforcing civil speed limits and headway control. ATP performs the following functions: Vehicle speed enforcement; Right-of-way hazard detection; Attendant initiated emergency stops; Monitoring vital vehicle functions; Vehicle separation control, and Interlocking (doors closed before vehicle moves).

Manual controls are provided to override the automatic operation in the event an emergency arises which is not within the normal automatic mode of operation. Manual operation is also necessary if the automatic controls fail. A train attendant's console displays status information on speed, acceleration, the status of critical subsystems, and includes a start and an emergency stop button. Foot pedals control thrust and braking. The attendant will be able to operate the vehicle in either a forward or reverse direction with speeds up to 30 mph in reverse. The attendant will also be able to operate the vehicle at creep speeds in stations, on a turntable, or in a maintenance area.

The wayside control system consists of passive position indicators (PPI's) mounted on the guideway and a two-channel radio link. The wayside line supervision functions include: Central and local line supervision; Vehicle dispatching; Operating status; Corrective strategies; Performance level adjustment; Dwell adjustment; Schedule revision, and Emergency shut-down of the system.

The PPIs are Alnico-5 bar magnets, 1 by 4 inches, fastened to the concrete subsurface and encapsulated in the asphaltic concrete overlayment. Combinations of PPIs at predetermined locations along the guideway impart pulses to sensors in the vehicle from which speed and location data are derived. The PPIs function as speed zone markers, station stop profile indicators and berthing index markers.

A speedometer/odometer mounted on the LIM guidance wheel provides back-up information on the vehicle speed and distance traveled.

A two-channel 450-470 mHz radio link provides door and emergency controls from the wayside. One channel carries the paired tone burst codes of the commands and acknowledgements required. The other channel is used for voice communication between the station and vehicle attendants.

In summary, vehicle performance has been specified at levels that will insure the system is as comfortable and quiet as the best available public transportation. The linear induction motor and air cushion suspension provide frictionless acceleration and deceleration. Noise and pollution levels are below those of other public transportation systems. The cruise speed of 150 mph can achieve significant savings in line haul travel time with station spacings of 5 to 10 miles and for trip distances out to 50 miles. Completely automatic controls have been specified as being safest at these speeds, though provisions have been made for manual monitoring of operations and overriding the controls.

Systems based on the same technology have been developed and demonstrated in France and England. The system under development in the United States is an advancement over the others in the following aspects:

It is the first passenger-carrying prototype to combine all-electric power for both the linear induction motor and air fans.

It is the first to use fully automatic controls.

These are characteristics which should make a UTACV system attractive for urban transportation applications.

SYSTEM ADVANTAGES

For point-to-point line haul travel where patronage levels, system length and station spacings can take advantage of high speeds, a TACV system offers the following potential advantages over a conventional steel wheel on steel rail system:

Higher Speed. The maximum operational speed for conventional rail rapid transit cars is 80 mph. The top speed for sustained safe operation of steel wheels on steel rails is about 160 mph. A TACV system can operate at cruise speeds of 150 mph and has the potential for speeds up to 250-300 mph.

More Consistent Comfort. Steel rail alignment and wheel roundness are increasingly difficult to maintain as speeds increase. The resulting vibration makes riding less comfortable. TACV air cushions virtually eliminate contact with the guideway. More consistent passenger comfort results from the lack of high frequency vibrations which would otherwise be transmitted from guideway irregularities.

Greater Derailment Safety. The TACV is held captive on the guideway by a 33-inch high rail. This rail provides both vehicle guidance and reactive thrust for the linear electric motor. The risk of derailment is far less than that for a conventional rail system traveling at the same high speeds.

Quieter Operations. TACV system specifications require that the external noise level shall not exceed the following at 50 feet from the nearest noise source on the vehicle:

Cruise speed (150 mph)	73 dB(A)
Braking, idling, in terminals	63 dB(A)

Special attention to the design of fan, fan motors, air ducts, cushion lips and other possible sources of noise will make this vehicle quieter than a conventional transit bus pulling away from a stop.

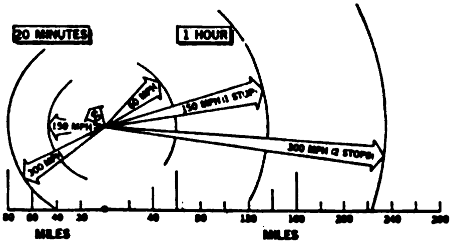
Lower Guideway Costs. The absence of concentrated wheel loads and the distribution of lighter loads through the air cushions offer the potential of less expensive guideway construction. Innovations in materials and construction techniques suited to an air cushion suspension system offer the further possibilities of lower guideway costs. Analyses by the Massachusetts Institute of Technology suggest that significant reductions in guideway construction materials can result from a combination of air cushion suspension and a three-span semi-continuous guideway of advanced design. Maintenance costs should be minimal, since there is virtually no wear on the guideway surface. (No maintenance costs have been incurred in three years for the 11.5-mile guideway for testing the 155 mph Aerotrain TACV near Orleans, France).[2]

Advantages of Higher Speeds. Speeds up to 150 mph for urban travel can be advantageous only if the line haul system is served with an adequate feeder and distributor system. With efficient intermodal integration, speeds up to 150 mph offer several advantages. These advantages are principally in economy of time for the traveler and improved productivity for a given investment in right-of-way and vehicles.[3] These points are discussed in the following sections.

Economy of Time. Total travel time is as much a function of collection and distribution as it is of the line-haul segment of a trip. Travel times associated with feeder services are quite variable and dependent upon local site-specific conditions. Where these services can be adequately integrated into the total transportation system, the implications of line-haul trip times become significant.

Typical urban commutation trips may range from 20 minutes to an hour. The relationship between these times and the distances traversed are shown in Figure 2.

A 20-minute trip using 60 mph conventional transit technology would cover about 19.4 miles, or 17.9 miles with one intermediate one-minute stop. The same 20-minute trip with a 150 mph UTACV would extend to 46.5 miles, or 28.5 miles with one-minute stop at eight-mile intervals. A one-hour commuter trip served by a 60 mph system would reach about 50 miles with one-minute stops about every 8 miles. The same 50-mile trip could be made in about 33.4 minutes with a 150 mph UTACV system. A one-hour trip served by a 150 mph system could extend the commutation range to 140 miles with one intermediate stop and to 87 miles with stops about every 8 miles. Similar relationships are shown in Figure 2 for a 300 mph advanced tracked levitated vehicle system.



Relationships between speed and trip distance for given travel times.

FIGURE 2

The economy of time offered by a 150 mph TACV system makes possible several urban planning alternatives.

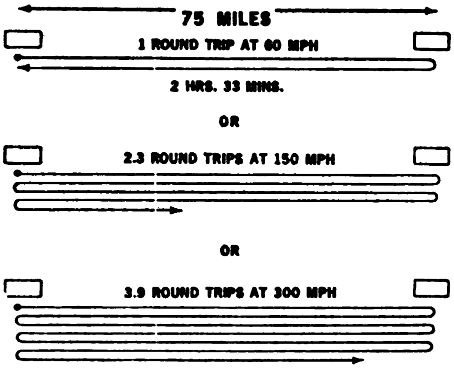
For a given investment in travel time, a UTACV system can widen the sphere of commercial and social interaction. Additional housing and job opportunities could be made available within the time people are willing to spend commuting between home and work. Large regional airports, with their environmental problems, could be located at greater distances from urban centers, yet would be accessible within reasonable travel times.[4]

The availability of a high-speed ground transportation system could change the development patterns of metropolitan areas. Several short-haul airports could be interconnected with a high-speed access system to serve a single, large, long-haul, regional airport[5] The spatial organization of metropolitan areas could be changed through the development of multi-centered cities (new communities, new towns in town), with preserved open spaces between.[6]

For a given line-haul distance, a 150 mph UTACV system can reduce travel times to half those of conventional systems. While trips on stage lengths shorter than eight miles can make use of the 150 mph speed capability, actual time savings with a UTACV system do not become significant until system lengths exceed 30 miles. For systems less than 30 miles long there are other compensating advantages which are discussed below.

Increased Productivity. Higher speeds improve system productivity for a given stage length by: Increasing the level and frequency of service for a given inventory of vehicles, or Reducing the number of vehicles required to provide a given level and frequency of service.

These principles are illustrated in the following two figures. Figure 3 shows that more seat miles and more frequent service can be provided in a fixed period

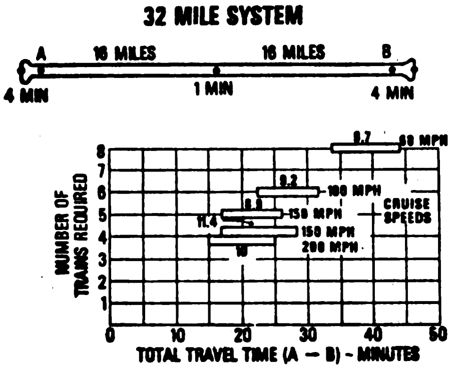


Relationship between round trips and increased vehicle speeds.

FIGURE 3

of time as vehicle speeds are increased from 60 mph to 150 mph and 300 mph.

Figure 4 roughly approximates the Dallas-Fort Worth airport access system presently under study. For a 60 mph system, eight trains operating at 9.7-minute headways can provide travel times at a minimum of 34 minutes and a maximum of 43.7 minutes. At speeds up to 100 mph, six trains at 9.2-minute headways can reduce travel times to a range of 22.6 to 31.8 minutes. Increasing the speed another 50 mph to 150 mph can save another five minutes. While this saving may not be significant, five 150 mph trains could service the system at 8.9-minute headways and four trains, or half the number of 60 mph trains, could service the system at 11.4-minute headways. A 150 mph speed appears optimum for this stage length, since increasing the speed to 200 mph at ten-minute headways requires the same number of trains (four) with no appreciable reduction in travel times.[3]



Relationship between number of trains and total travel time for a given operational profile.

FIGURE 4

In summary, a UTACV system offers many performance characteristics that are potentially advantageous for urban transportation applications. The system can provide more consistent comfort, quieter operations, greater derailment safety over less costly guideways at higher speeds than conventional rail systems. The higher speeds offer the opportunity to reduce travel times and increase productivity for a given investment in facilities. These advantages, if used creatively, can influence commutation patterns and urban development in growing metropolitan areas.

COMPARATIVE COST ANALYSIS

The ability of a transportation system to defray total annualized costs through fare-box revenues is a measure of the system's financial viability. This ability is also a useful basis for comparing different systems providing comparable service.

The Transportation Systems Center, Cambridge, Massachusetts, has conducted an analysis of UTACV system costs in comparison with costs of other line-haul systems, including rail rapid transit and express bus systems.[7] The total annualized costs of the systems include all costs for operations, maintenance and debt financing of capital facilities. The primary parameters considered in this analysis included the method of system financing, the system length and the volume of system patronage.

To facilitate this comparison a baseline transportation system for line-haul service was established. Each case assumed a route over an exclusive guideway with one-third of the route elevated and two-thirds at grade. A range of patronage from 2.3 to 10.6-million passenger trips per year was analyzed for route lengths of 10, 20 and 35 miles. The baseline vehicle characteristics for the three systems are summarized in Table 2 below.

Table 3 lists the base unit operating and maintenance costs for the various baseline systems. Table 4 provides the unit capital costs used for comparative purposes.

Analysis of Primary Parameters. The results of the analysis of the primary parameters contained in reference (7)

TABLE 2

BASELINE VEHICLE CHARACTERISTICS

	UTACV	RAIL RAPID	EXP. BUS
Vehicle Cruise Speed, mph	150	75	50
Vehicle Capacity, passengers	80	75	50

TABLE 3

BASE UNIT OPERATING AND MAINTENANCE COSTS FOR VARIOUS BASELINE SYSTEMS

PARAMETER	UTACV	RAPID RAIL	EXPRESS BUS
ENERGY, ¢/SEAT MILE	.20	.11	.08
OPERATIONS & LABOR ¢/SEAT MILE	.61	.70	1.16
VEHICLE MAINTENANCE, ¢/SEAT MI	.28	.31	.44
ELECTRICAL MAINTENANCE, ¢/SEAT MILE	.11	.13	0
OVERHEAD; ¢/SEAT MILE	.23	.27	.60
GUIDEWAY MAINTENANCE, $/LN. MI./YR.	2000	2000	4000

are summarized in the following discussion.

Method of Financing. The method of financing determines how system revenues are allocated to cover total annualized costs. The Urban Mass Transportation Act of 1964 recognized the need to assist local transit agencies in the construction, acquisition or improvement of facilities and rolling stock where revenues were not likely to cover total annualized costs. The Act authorizes capital assistance up to two-thirds of the cost of that part of the project which cannot be reasonably financed from revenues (net project cost). The remaining one-third of the net project cost must be provided by the local community from cash surpluses, replacement or depreciation funds, or reserves available in cash or new capital. The local one-third share cannot be provided from sources such as bonds financed by fare-box revenues.

Where a project qualifies for Federal financial assistance, the break-even fare level need cover only the system operating and maintnance costs. Under this method of financing, there are several advantages in lower operating and maintenance costs which warrant consideration in planning a new urban transportation system.

Comparatively lower fare levels should obtain for a highly automated system that is less labor intensive, has fewer items of rotating machinery and has less guideway wear than conventional systems. Fare levels less sensitive to inflationary escalation should become comparatively more favorable as time progresses. The higher capital cost of a more sophisticated system may be partially offset by the reduced numbers of vehicles required for a given level of service at high speeds. The reduced number of vehicles should also contribute to overall lower operating and maintenance costs.

System Length. The TSC analyses (7) found that for a given volume of pa-

TABLE 4

UNIT CAPITAL COSTS USED FOR COMPARATIVE PURPOSES

Cost Parameter	UTACV	Rapid Rail	Express Bus
1. GUIDEWAY (1/3 ELEVATED 2/3 ON-GRADE), ALL COSTS $MILLION/MILE			
A. Base Cost	1.86	1.86	1.86
B. Electrification	0.344	0.344	0
C. Control & Instrumentation	0.411	0.411	0.035
D. Safety Guards	0.042	0.042	0.042
E. Substructure	0.172	0.172	0.172
F. Site Preparation	0.155	0.155	0.155
G. Reaction Rail	0.165	0	0
H. Electrical Sub-station	0.02	0.02	0
I. Engineering (% of total cost)	4.5%	4.5%	4.5%
Total Cost, $Million/Mile	3.2	3.0	2.3
2. VEHICLES, $MILLION			
A. First Vehicle	2.6	0.75	0.09
B. Over Ten	1.85	0.50	0.06
3. TERMINALS, AIR, $MILLION			
A. Base Cost	7.5	7.5	7.5
B. Vol. Dep. Cost, f (PHR), f =	0.006	0.006	0.006
4. TERMINALS, COMMUTER, $MILLION			
A. Base Cost	0.86	0.86	0.86
B. Vol. Dep. cost, f (PHR), f =	0.004	0.004	0.004
5. PARKING LOTS, $MILLION	0.275	0.275	0.275
6. MAINTENANCE FACILITIES, $MILLION			
A. Base Cost	5.0	5.0	5.0
B. Vol. Dep. Cost, f (No. Veh.), f =	0.025	0.025	0.025

tronage, the break-even fare level required to defray the total annualized costs is affected by the system length. The method of financing determines the degree to which fare levels are affected by system length. Where there is no debt financing and revenues are applied only to operating and maintenance costs, fare levels are relatively insensitive to system length. With full debt financing, break-even fare levels are significantly affected by the length of the system.

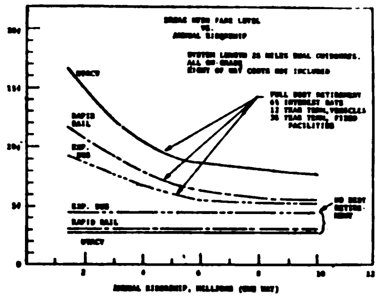
The primary factor affecting this relationship is the ratio of vehicle costs to guideway costs. As trip distances decrease, the average speed of the vehicles decrease, their productivity is reduced and the ratio of vehicle costs to guideway costs increases. This ratio causes fare levels for a UTACV system to begin to increase for system lengths less than 40 miles. A sharp increase occurs at lengths less than ten miles which suggests that a UTACV system shorter than ten miles is financially undesirable, unless it can be incorporated into extensions more than 40 miles long.

System Patronage. For a given system installation, the break-even fare level is dependent upon system patronage. An acceptable fare level requires a minimum volume of patronage. To be economically viable, a typical ten-mile UTACV system would require a minimum of 4-million passengers per year to totally annualize the costs at a fare level of 25 cents per passenger mile. Without the need for debt financing, either the patronage or fare level could be considerably reduced while maintaining a viable system.

The relationships discussed above are shown in Figure 5. The break-even fare level versus annual ridership for three comparable systems is presented. For full debt retirement, fare levels for a UTACV exceed the least expensive express bus by about six cents per passenger mile at 2-million passengers per year. This difference is reduced to three cents per passenger mile or less at patronage volume of 4-million or more passengers per year. Where no debt service is required, three cents per passenger mile makes a UTACV system an attractive alternative to a rail rapid or express bus line-haul system.

Even with full debt financing, the fare levels for a UTACV system are likely to be less than those presently being charged for access to major airports, as shown in Figure 6.

UTACV guideway and system costs need not be out of line with other transit system installations. Table 5 presents data collected in October 1972 on the capital costs for guideways and total systems for current installations. Estimates for the UTACV were based on the study for a 16-mile installation between the Los Angeles International Airport and San Fernando Valley, and on firm fixed-price bids for a 13-mile installation at Dulles International Airport. These estimates have been confirmed recently by the bids received for constructing the UTACV test track at Pueblo, Colorado.

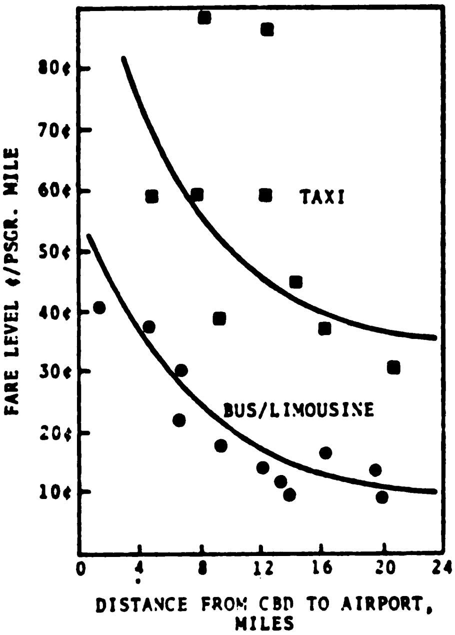


Break-even fare level vs. annual ridership.

FIGURE 5

Based on the assumption that a new guideway would be required for all the compared systems operating under the defined baseline situations, the TSC comparative cost study concluded that:

— The O&M costs for a UTACV sys-



Existing Fare Structures for Access to Major Airports.

FIGURE 6

TABLE 5

COMPARISON OF GUIDEWAY AND SYSTEM CAPITAL COSTS

GUIDEWAY CAPITAL COSTS

	Transit System	Guideway Cost ($M/Mile)
Rail Rapid Transit	BART	3.4
	CTA	4.0
	MBTA	4.6
Transit Expressway	TERL	5.7
UTACV	—	3-5

TOTAL SYSTEM CAPITAL COSTS

	Transit System	Total Cost ($M/Mile)
Rail Rapid Transit	BART	16
	CTA	7.5*
	MBTA	11.7
	D. C. Metro	30
Transit Expressway	TERL	20
UTACV	—	10-15*

*Right-of-way available.

tem are less than for the other systems compared and will become increasingly favorable as time progresses. — The capital costs for the UTACV are somewhat greater than for the other systems compared, but this disadvantage can be effectively offset, as seen through the fare levels, by means of non-revenue financing. — The method of system financing has a large impact on required fare levels. Adoption of methods currently in practice with existing ground transportation systems and encouraged by the 1964 Urban Mass Transportation Act tends to favor those systems such as the UTACV which are capital intensive and low in O&M costs. — The UTACV system is financially more suitable for applications involving long hauls or widely spaced station stops while the slower systems such as the express bus are more suitable for short haul applications. — It is estimated that, for the Nation's 20 largest airports, there exist potential applications where a high speed ground access system can generate ridership sufficient to financially support the UTACV system.

UTACV PROGRAM PLAN

The goal of the Urban Tracked Air Cushion Vehicle Program is to establish a TACV system as a viable urban transportation alternative for funding under the UMTA Capital Grant Program. The specific limited objectives of the program are to: — Verify system performance on such features as ride quality, noise and safe high-speed operations. — Provide public officials with measured data on system performance, reliability, safety and environmental impact.

The UTACV Program has been planned and is being accomplished in four phases:

Phase I—Engineering Design

This phase covered the engineering design of a state-of-the-art, 60-passenger prototype vehicle propelled by a linear electric motor, design of site independent aspects of facilities for a complete system including guideway, wayside power distribution, wayside control system, passenger and baggage handling facilities, and a vehicle maintenance facility.

On May 12, 1971 proposals were requested for the design and fabrication of a TACV in conformance with a scope of work and performance specifications prepared by the Transportation Systems Center and the Federal Railroad Administration. On June 30, 1971 cost plus fixed fee contracts were awarded to Rohr Industries, Inc., and to the Vought Aeronautics Company. Designs were completed and proposals submitted in December 1971 for fabrication of the prototype vehicle. Following review of these designs a cost plus incentive fee contract was awarded to Rohr on 18 February 1972, for fabrication of the prototype vehicle, representing the state-of-the-art in TACV technology.

Vought has continued the study of several innovations not included in the original UTACV designs. These new concepts are potentially advantageous for certain revenue applications and include the following features: Single-sided linear induction motor; Variable frequency power conditioner; Magnetic guidance, and High pressure levitation cushions on moveable trucks.

Phase II—Vehicle Fabrication

The second phase provides for fabrication of a prototype vehicle in accordance with documentation prepared under Phase I. Components and sub-systems will be tested prior to and during assembly in the vehicle. The complete vehicle will be checked out both statically and through operational tests on a short. 500-foot, section of guideway, at the Rohr plant.

Final documentation is to include engineering drawings and design specifications in sufficient detail for competitive procurement of a vehicle and related facilities by a local public agency. This phase will also require the delivery of in-plant vehicle test results, system-engineering design studies. costs analyses, and a system test plan. Phase II will extend for 16 months after the contract award.

Phase III—Test Operations

This phase includes the acquisition of test facilities at the Department's High-Speed Ground Test Center at Pueblo, Colorado, as well as the acceptance and system tests to be conducted with the prototype vehicle.

Test facilities are planned to include: 10.5 miles of test track with concrete guideway slab, three-phase, 4160 volt, wayside power rails, aluminum reaction and guide rail, an elevated, eight-span, section of track, and a guideway switch; Access and service road with drainage and erosion control; Maintenance building and control center; Primary power supply and substation provided by the Federal Railroad Administration.

Designs of the facilities are complete. Bid packages were released on 23 February 1973; proposals were submitted on 20 March 1973. Contract awards were made on 4 May 1973 and construction is expected to start before the end of the month. The UTACV test facilities are shown in Figure 7 on the map of the High Speed Ground Test Center.

Depending upon the availability of completed facilities, test operations are planned in accordance with the following schedule: July 1973-October 1973, Low-speed tests on an initial 500 to 1500 feet of guideway; November 1973-June 1974, High-speed tests on 3 to 5 miles of guideway; July 1974 to December 1974, Operational tests on the completed 10.5-mile loop.

Experience gained from construction of these test facilities and results of the test operations are expected to provide local officials with valid data for planning a revenue system.

Phase IV—Revenue System

Installation of a revenue system is expected to be accomplished with financial assistance from UMTA's technical studies and capital grants programs. No demonstration of a UTACV system in an urban area is contemplated with RD&D funds.

On 20 March 1972 the City Council of Dallas, Texas, and on 27 March 1972 the City Council of Fort Worth, Texas, passed similar resolutions to support an Addendum to the Regional Public Transportation Study to perform a UTACV technical study. These resolutions provided: Funds or contributed services in the amount of $83,000 each as the matching share of a $332,000 technical study grant from UMTA. Agreed to actively seek to obtain the necessary funds to construct a TACV system within the travel corridor, if the study indicates that the construction of a TACV system is not only feasible, but in the best interest of the citizens from a financial, environmental, and travel demand standpoint.

On 6 June 1972, the Administrator, UMTA, approved the technical study, with the provision that certain tasks of the Regional Public Transportation Study be completed before proceeding with all the tasks on the TACV study. The evaluation of alternative transportation systems in the travel corridor has been completed sufficiently to substantiate the possible application of a TACV system in revenue service. Results of the regional transportation study warrant a detailed analysis of the proposed TACV installation.

On January 23, 1973 the North Central Texas Council of Governments was authorized to proceed with the remaining tasks in the TACV technical study. This study encompasses the following three main elements: Preliminary engineering of the route, including aerial surveys, soil analysis and the need for right-of-way acquisition; Economic analysis of the system, including patronage, revenue return, operating costs, capital costs and methods of financing; Environmental impact analysis, including noise, visual impacts, intrusion, disruption and other social and economic effects of the installation.

This study will be completed in about one year. Results of the study will provide the basis for local decisions on whether to proceed with the project, to hold public hearings and to develop an application for capital assistance under the Urban Mass Transportation Act. Results from testing the state-of-the-art prototype and from the analysis of advanced system designs will play major roles in the local and Federal decisions to proceed with a revenue system.

A more detailed program schedule is presented in Table 6.

Program Management

The Director, Special Projects, in UMTA, is responsible for overall management of the UTACV Program. Project engineering is provided by the Advanced Systems Division of the Federal Railroad Administration. Technical support for the project is provided by the UTACV program team of the Transportation Systems Center. Responsibilities for TSC include: Preparation of system technical and performance specifications; Monitoring vehicle fabrication contracts to insure compliance with technical and performance specifications as well as with quality assurance standards; Supervising test operations, including the inspection of test facilities, the planning of test programs and the evaluation of test results; Conducting

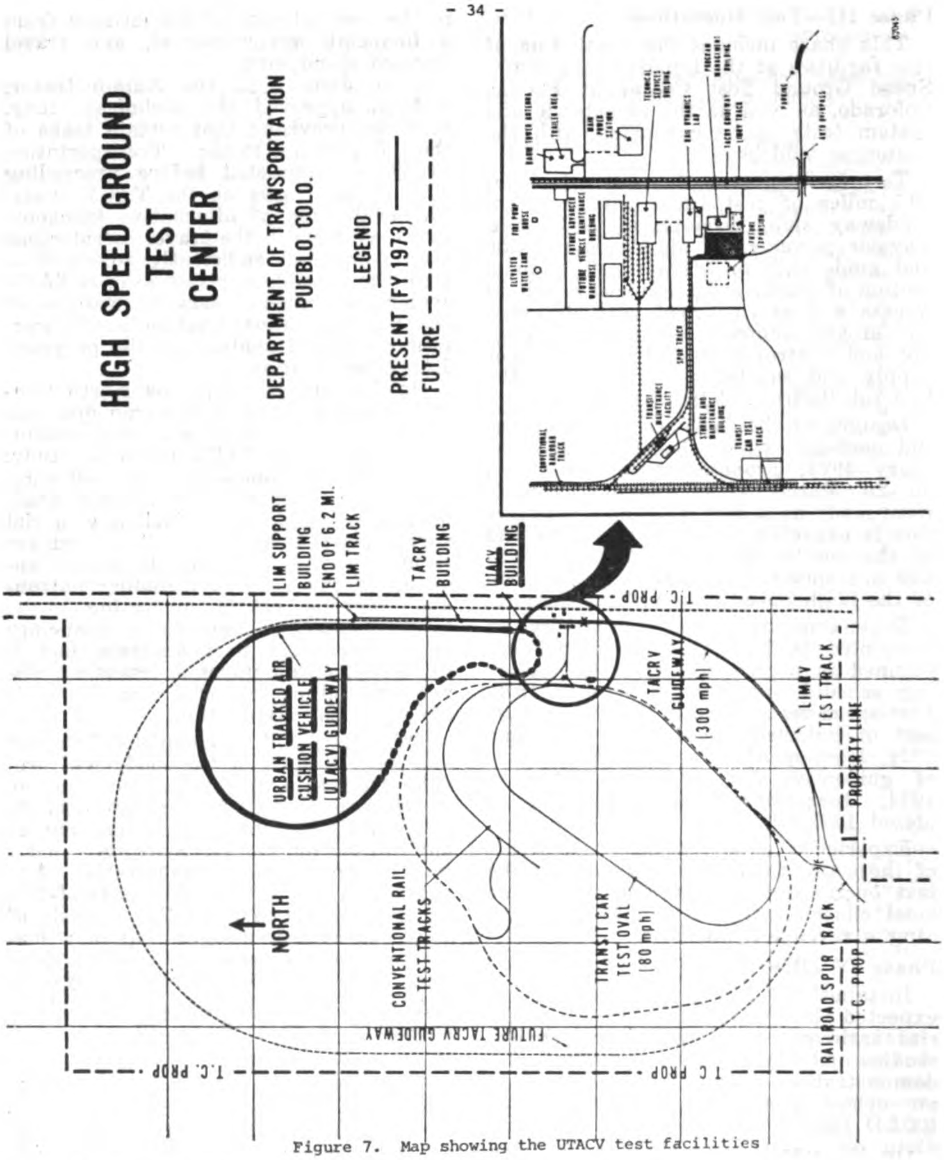


Figure 7. Map showing the UTACV test facilities

technology and systems analyses to investigate the worth of advanced alternate concepts, to verify the engineering on critical components, and to establish the costs and environmental impacts of system applications.

Though the UTACV is being developed as a Department-wide program, it is being managed by UMTA for three reasons:

Such a system, whether inter or intra-urban, must begin, end and/or pass through an urban area. The routes, stations, service levels, and transportation feeder systems must evolve as part of the local comprehensively planned metropolitan area transportation system. Adequate consideration must be given to the disruption, socio-economic effects and environmental impacts this system would have on the local communities it would traverse.

Close coordination of research and development with technical planning studies will help insure that the tested system can satisfy an operational requirement in an urban setting. This coordination can also help local trans-

TABLE 6
UTACV PROGRAM SCHEDULE

— Phase I — Engineering Design	
• Prototype Vehicle Design Contracts Awarded	28 June 1971
• Designs Completed, Phase II Proposals Submitted	15 December 1971
• Advanced TLV Design Contract Award	15 May 1973
• Advanced TLV Design Complete	15 February 1974
— Phase II — Vehicle Fabrication	
• Contract Awarded	18 February 1972
• Vehicle Complete	30 June 1973
• Acceptance Tests Completed	15 August 1973
• Vehicle Received at Pueblo	1 September 1973
— Phase III — Test Operations	
• Facility Design Contract Awarded	30 June 1972
• Facility Designs Complete	1 November 1973
• Construction Contract Awarded	4 May 1973
• Construction Complete	1 July 1974
• Test Operations Begin	1 September 1973
• Test Operations Complete	15 July 1975
— Phase IV — Revenue System	
• Proceed with Technical Study	23 January 1973
• Complete Technical Study	15 January 1974
• Complete Capital Grant Application	1 June 1974
• Commence Final Design	30 June 1974
• Complete Final Design	1 April 1975
• Commence Construction	1 July 1975

portation planners take full advantage of the capabilities this new system offers.

UMTA's technical study and capital grant programs can make Federal financial assistance available to qualified local agencies for the implementation of a revenue system in an urban area.

With continued strong support from other offices and administrations in the Department, the likelihood is good that the program's goals and objectives will be achieved.

APPENDIX A
REFERENCES

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FOOTNOTES

1 Director, Special Projects, Urban Mass Transportation Administration, U.S. Department of Transportation.

2 The prototype UTACV is being fabricated by Rohr Industries, Inc., Chula Vista, California, for the Urban Mass Transportation Administration under the U.S. Department of Transportation Contract DOT-UT-10031.

3 The linear induction motor and power collector for the prototype vehicle have been supplied by LeMoteur Lineaire, Grenoble, France. The power conditioning unit has been assembled by General Electric Control Rectifiers, Ltd., Stafford, England.