ANALYSIS OF DUAL-MODE TRANSPORT

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Dual-mode transport envisions compact conveyances that could be driven on roads and that could also travel on exclusive automated guideways. Performance characteristics assumed for this exploratory study reflect the technology proposed in the "Urbmobile" version of this innovative concept. This paper attempts to estimate the expected patronage and economics of a hypothetical dual-mode installation in a real city. Patronage is "synthesized" by selecting the most likely users from actual trip-making reported in the same real metropolis. The synthesis approach seeks to make relatively explicit the unavoidable guessing about how people would respond to an unprecedented mode. Results suggest that the total dollar economics of the dual-mode system and of private automobiles might be comparable. The limited road range of the battery-electric Urbmobile would preclude its being adopted as an alternative vehicle by most of the households owning only one vehicle. For persons lacking access to the stations by private vehicle or walking, extending the range of station coverage by frequent jitney or bus service would greatly enhance system usefulness. The scale of Urbmobile facilities might be a major consideration in the design of the route network and in the acceptability of the system.

•BECAUSE of its broad responsibilities for planning balanced metropolitan transport, the New York State Department of Transportation is naturally interested in the long-range potential of emerging transport technologies. The Department is interested in finding answers to questions such as: Do these technologies offer relief from pollution? Would they provide better mobility for more people? How would they bear on highway investments? Such questions can, to some degree, be answered by monitoring the literature on advanced transport, but that carries the risk of dependence on the assumptions and possible biases of others. We believe that there is special value in the experience gained by the first-hand pursuit of studies that try to predict the impact and applicability of new systems. Therefore, an investigation of the dual-mode concept was undertaken that resulted in a different approach to the use of this innovation. That method, the initial findings from it, and some additional observations on dual-mode transport are reported in this paper.

DUAL-MODE TRANSPORT

The dual-mode idea has been described as a class of hybrid systems in which the conveyance operates both on conventional roads under control of the driver and on an exclusive guideway with control of the conveyance completely automatic and independent of the driver. Thus, the dual-mode conveyance could be driven on streets like an automobile or travel on high-speed off-street tracks like a miniature rapid transit car. Conveyance change-over from the transit to the road-vehicle mode would be accomplished only at ramps in stations adjoining the guideways.

It is expected that dual-mode facilities could also be utilized for personal rapid transit. Because individually owned conveyances would be ill suited to this kind of service, a supplementary fleet of what may be termed public conveyances would be needed.

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A public dual-mode conveyance would be available to anybody while it was standing empty in a station. (The right to exclusive occupancy for the person boarding an empty conveyance would probably be accorded by statute.) Further, provision might be made for renting public conveyances to use as road vehicles. They would, of course, have a private status when not on the dual-mode facilities.

Urbmobile

Originally intended to be a generic descriptor of the dual-mode concept, "Urbmobile" is a name coined in 1964 by Cornell Aeronautical Laboratory, Inc. (CAL). In the course of their work, the CAL staff developed a specific version distinct from those of other innovators. This nonproprietary system was taken as the subject of our analysis.

CAL's dual-mode Urbmobile proposal appeared to be well-developed, as described in its report (1). From among the system possibilities discussed by CAL we came to view the basic Urbmobile system in terms of the following set of attributes that are likely to be significant to prospective patrons:

1. Has automated exclusive facilities;
2. Can be ridden as express transit (60 mph);
3. Can be driven on roads at moderate speed;
4. Is of compact size—seats 4 (with parcels);
5. Has road range of 40 miles (on battery);
6. Can be rented or owned like an automobile;
7. May not require downtown parking; and
8. Does not contribute to air pollution (at street).

The CAL precept of basing its design solely on established engineering practice gives the Urbmobile system a quality of relatively immediate practicability, although at a price in road performance. Exotic (and unproved) battery developments were spurned by CAL in favor of conventional lead-acid storage batteries—amounting to over 800 pounds in the basic Urbmobile. Thus, the Urbmobile would not be a lively vehicle and nominally could travel only 40 miles without a lengthy battery recharge. In most instances that would effectively impose a 20-mile "tether" on Urbmobile travel beyond the electrified guideways.

Yet the modest capabilities of the Urbmobile are appropriate for the system as described by CAL (1). In the CAL study, the Urbmobiles seemingly were regarded as being possessed by multivehicle households and used to commute between outlying homes and downtown. Tolerance toward Urbmobile deficiencies could be expected of a clientele that could secure convenient and nearly effortless commuting and, at the same time, retain a regular automobile for other journeys. CAL also envisioned a relatively small fleet of public Urbmobiles in the metropolitan installations considered, but in general CAL's view of the system may be characterized as focused on the Urbmobile-owning downtown commuter. This outlook on dual-mode transport was recognized as deficient with regard to nondrivers and persons not possessing a conveyance, and CAL candidly stated (1, Vol. 1, p. 87): "At this time we are unable to cite a means of use by which the Urbmobile can be claimed to have an unmistakably significant advantage over any other public transportation system or automobile rental service."

Availability

It was our view that dual-mode transport should serve as many people as possible, with the aim of winning a large constituency for the support of its development and implementation. Moreover, a transport innovation blending rapid-transit ease with doorstep convenience for many persons ought to be under some obligation to help with the comparative immobility of other persons. Thus, we were concerned with making the dual-mode system broadly useful.

What seemed a promising idea was the inclusion of a short-term rental capability based on public dual-mode conveyances being available and returnable at all stations. This rental capability would enable a suitable licensed subscriber to use a public con-

veyance as his own until it was returned. System operations would benefit because empty public conveyances could be recirculated and stored indiscriminately (unlike private ones that must be retrievable by a specific person at a specific place). Yet this on-and-off kind of Urbmobile possession, despite its convenience for some subscribers, does not appreciably enhance mobility or gain efficient use of the public fleet.

The home is the key to the limited impact of the short-term rental concept. On the average, only two out of ten urban person trips are not made to or from home. For the large majority of trips, then, what is the situation at the home end? For rented public Urbmobiles to be available in the morning, they must (with few exceptions) have been driven home the previous evening and kept there overnight—just like a family automobile. CAL in its own investigation, however, indicated that possession of an Urbmobile would be financially comparable with owning an automobile (1, Vol. 1, pp. 81, 82, and 113; Vol. 2, p. 275). Therefore, the overnight "family style" possession of Urbmobiles would merely be a substitute for private automobiles, one for one. It is difficult to see how this practice would create a mobility gain for nondrivers and persons not having a vehicle in Urbmobile households. Vehicle availability could be improved greatly if off-line rental depots for public Urbmobiles were nearly as widespread as mail boxes, as in the PAS concept (2); however, that idea quite transcends the intent of dual-mode transport as generally conceived.

If we must reject the widespread use of rental depots, what about access to and from Urbmobile stations via nondriving modes? Walking is naturally the basic station access mode for those few trip-makers within range. The schedules of bus transit in middle-sized cities (our context here) have a way of seldom seeming convenient, and that experience would tend to affect the entire dual-mode trip. CAL proposed to combine access with line haul via the dual-mode Urbmobus. It is supposed to collect passengers along a street route and then take them along the guideway without any transferring—except by the driver, who would get off to board and operate an incoming Urbmobus. (On the guideway no one aboard would have authority to cope with an unruly rider. Also, the efficient scheduling of the drivers could become woefully complex.) Demand-jitneys appeared attractive for station access, but the feasibility of the basic concept had not been established.

An appealing means for extending station coverage would be by so-called "minibus loops." Each would be a short one-way route, traversed by a single small bus on a dependable 10-min headway from early morning until late evening. Figure 1 shows

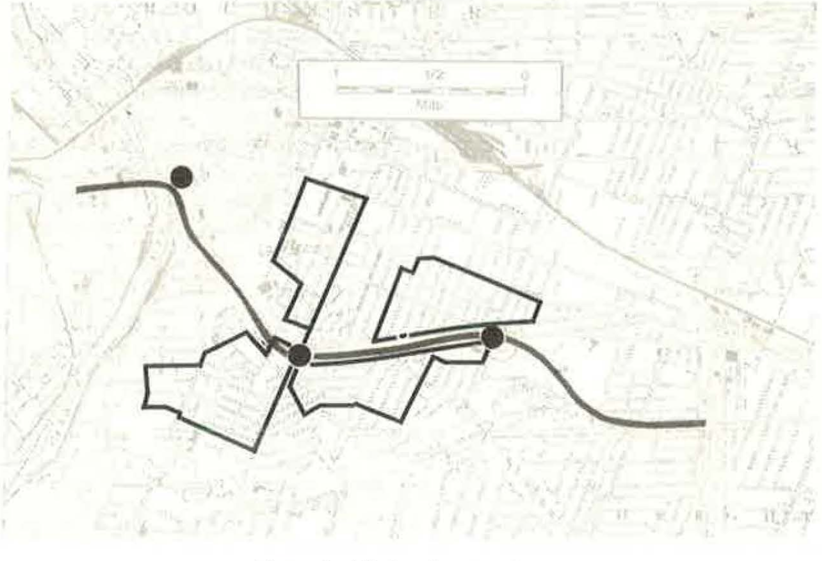

Figure 1. Minibus loop routes.

several loops warped to fit an existing street pattern. The service would be better than is usually available on typical bus routes in middle-sized cities. The simplicity of the operation facilitates estimating its expense, which is believed to be roughly in balance with the revenue likely to be generated.

Extent and Scale

The kind of Urbmobile installation primarily studied by CAL consisted of a few radial routes converging in downtown. Figure 2 shows how this kind of "basic" network might appear in a real metropolis. Obviously for many residents the facilities would be inaccessible or seldom useful. Enlarging the scope of a dual-mode installation seemed to require a more comprehensive network, augmented by minibus loops providing service to many of its stations. Figure 3 is an example of a so-called "metro" network, which encompasses most of the populous part of an actual metropolis. Urbmobile routes were laid out with an eye to effective coverage by minibus loops (which implies a route spacing of somewhat under 2 miles).

These contrasting types of Urbmobile networks could involve significant differences in the location and general bulk of their facilities. Much of the mileage of a basic network might advantageously follow existing railroads and freeways, thus facilitating economical construction of guideways alongside or above. Guideways could be sized to accommodate Urbmobuses while also allowing for the emergency service trucks that CAL tentatively proposed for removing disabled Urbmobiles (Fig. 4).

The comparatively fine mesh of the metro network would restrict locational options for many of its routes and would confine guideway alignments to narrow corridors, which would

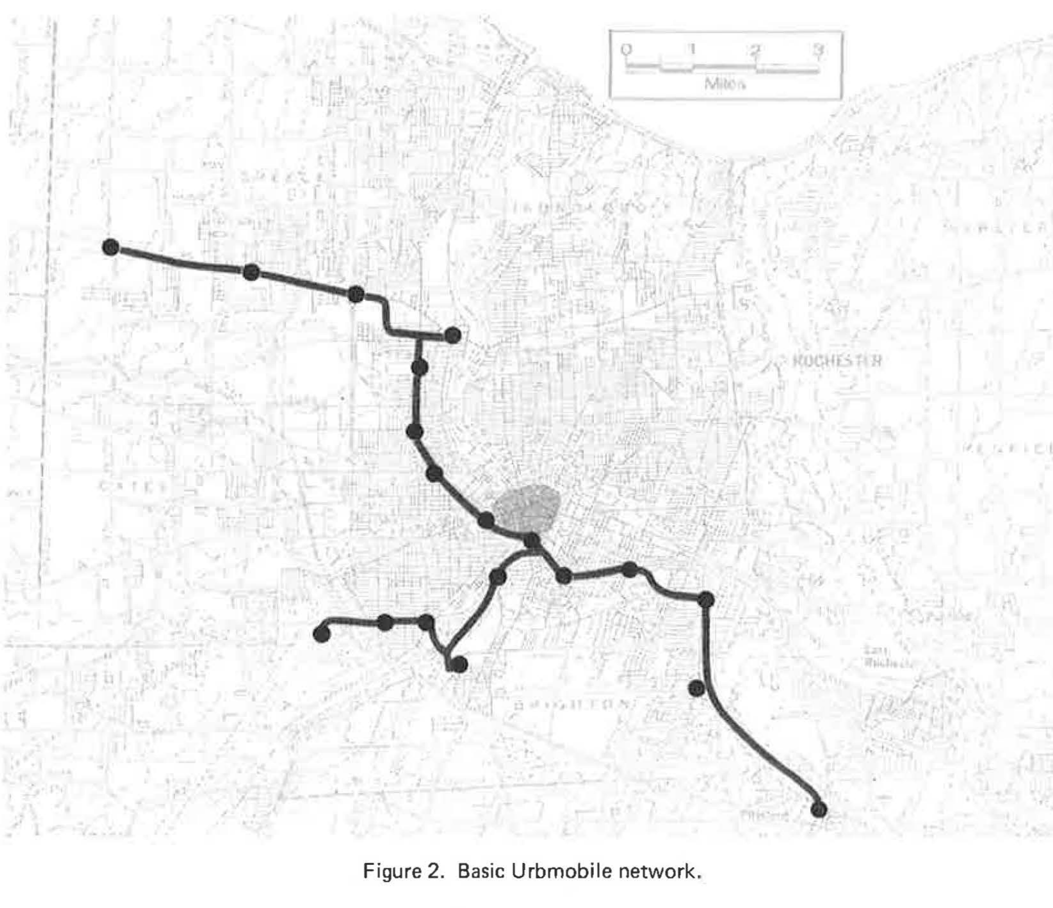

Figure 2. Basic Urbmobile network.

virtually compel fitting the facilities into all manner of urban settings. Hence a scaling down of Urbmobile facilities could become critical. Rejection of Urbmobuses and of the precautionary service trucks seems justified. Their omission (Fig. 5) might make possible a subway for Urbmobiles only, which would be shallow enough to avoid costly sewer relocation. Conceivably, too, the smaller elevated guideways (open or enclosed) would be tolerated where larger ones would not be. A metro network contains so many stations and junctions that their massive size, as conceived by CAL, would have to be curtailed sharply to prevent serious displacements (1, Vol. 1, p. 63).

It appears that dual-mode transport might be furthered by expanding the route network and contracting the scale of the fixed facilities. That would entail some modifications in Urbmobile technology, of course, but that might be the price to be paid for gaining a larger constituency.

UTILIZATION

Assumptions and Background

Any serious appraisal of a proposed innovative mode, and of the role it is apt to attain among other modes, depends heavily on how much it is expected to be used. Because Urbmobile would be so unlike existing modes, we were skeptical of applying current prediction techniques. We decided to place a hypothetical Urbmobile installation into a real-world trip-making environment and then to judge which trips might have found use of the facilities to be worthwhile.

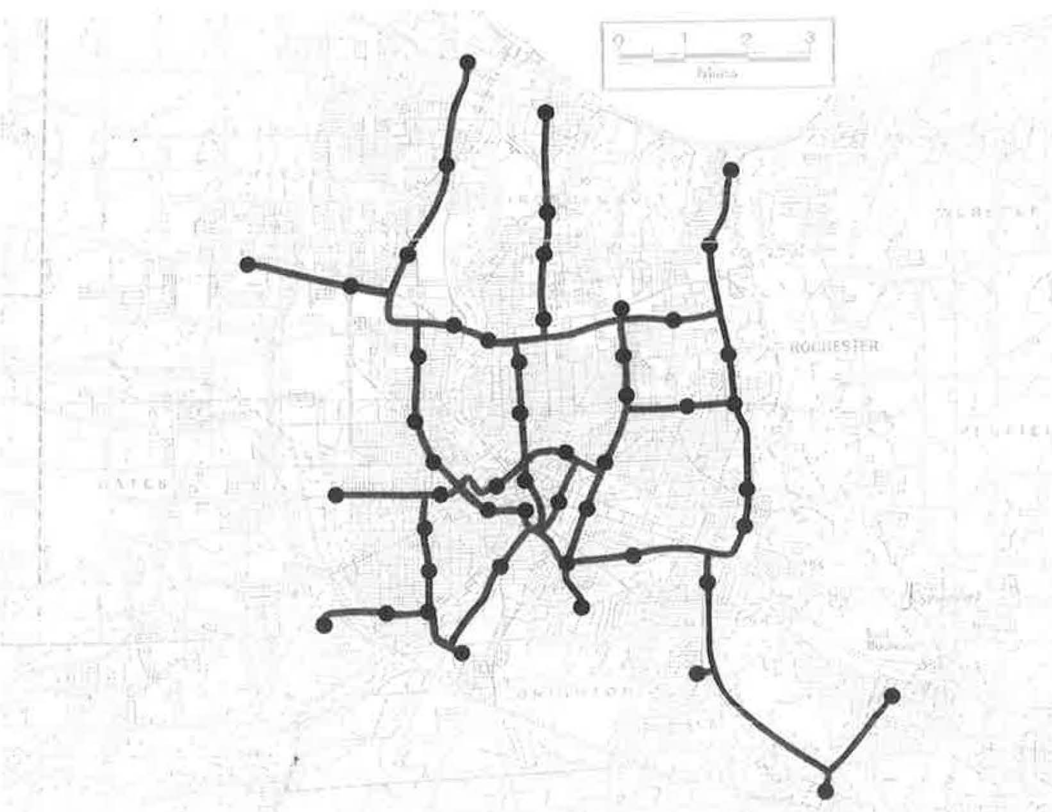

Figure 3. Metro Urbmobile network.

The trip-making environment was supplied by a large sample of person trips, as reported in the 1963 home interview survey of the Rochester Metropolitan Transportation Study (RMTS). Because the vast majority of such trips were by private automobile, the most productive initial course was to forecast Urbmobile patronage only from the actual trips of automobile drivers and their passengers. In relation to total vehicular activity in the survey area, the forecast patronage gives an indication of the local impact of the installation.

We refer to this type of forecasting as "synthesis." It is essentially just a reasoned selection of trips from the travel survey file. By computer, the trips were screened individually through a sequence of criteria. The criteria are supposed to reflect the forces on the trip-maker (and household) that would shape his response to the new system on each one of the survey trips. It is the resulting trip-maker responses—considered together, for one vehicle at a time—that finally determine which households might advantageously have possessed an Urbmobile.

The hypothetical Urbmobile installation to be tested was the basic network shown in Figure 2, less its spur to the southwest. As shown in Figure 6, the test facility is a single 17-mile suburbs-to-CBD route having 14 stations. To save computer processing, we excluded from consideration whole households and all their trip-making if they lived where an Urbmobile probably would not be useful. Only residents of the arbitrary "domain" (414,000 persons out of an RMTS total population of 610,000) were, by definition, even eligible to possess an Urbmobile.

Only the reported trips of private automobiles, and their "conversion" into Urbmobile trip-making, are dealt with in the synthesis. When considering its output, one should bear in mind the rudimentary nature of the procedure. Here are some assumptions and other factors in the synthesis:

1. Because the possession of an Urbmobile would be financially comparable to owning an automobile, households could only rent, lease, or own an Urbmobile to replace an automobile—not to supplement it.

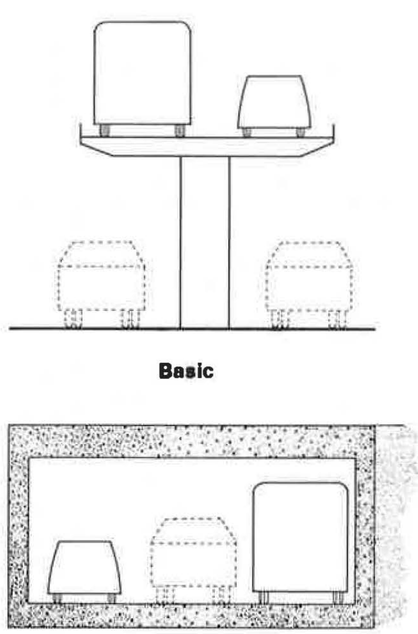

Figure 4. View of basic type of Urbmobile facility.

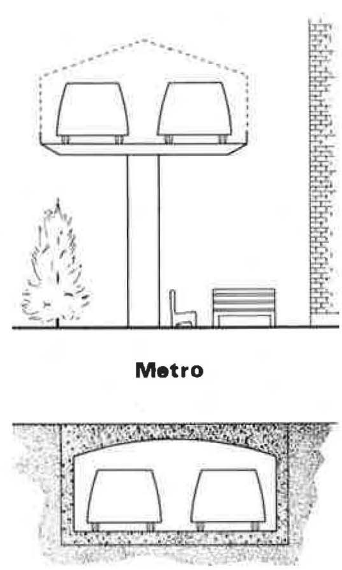

Figure 5. View of metro type of Urbmobile facility.

2. The patronage on the hypothetical high-speed route is drawn from traffic that occurred in the absence of such a facility, and it thus had no real-world opportunity to rearrange traffic patterns to its advantage.

3. Processing was expedited by using simple differences and aggregations of travel time, which was chosen as a major factor in determining Urbmobile possession.

4. Our survey data are a window on the trip-making activity of any particular household for a single workday—how the weekend performance of the new mode would affect its overall attractiveness is not known.

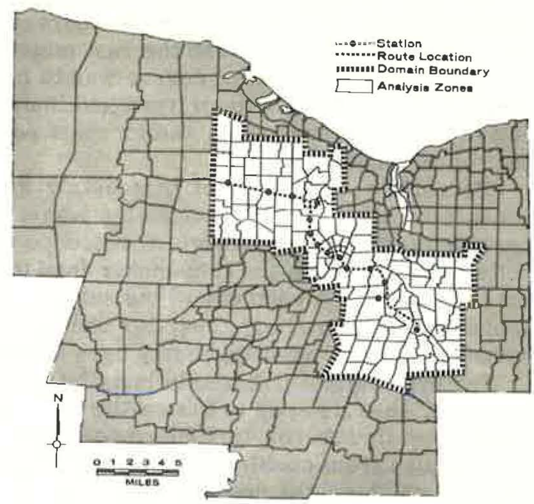

Figure 6. Urbmobile domain and hypothetical route.

Synthesis of Patronage From Automobile Trips

1. Screen out unsuitable trip records—The trip file, which includes thousands of detailed records, is first trimmed to facilitate later processing. The computer confronts each trip record with a battery of questions. Those records that do not deserve further consideration are ignored while the surviving records are duplicated on magnetic tape. As this abbreviated file progresses through later steps, any record that passes a major test is so marked, which allows analysis by category at the conclusion of the synthesis.

For the initial screening, households located outside of the domain are screened out as most unlikely candidates for possessing an Urbmobile. All trips made by persons not driving a private automobile and trips made by all households not having automobiles are also discarded. Urbmobile capacity and range limitations are taken into account in two ways. Any one-automobile household is excluded if it had more than four members, or if its automobile carried more than four occupants. Also, the computer is programmed to test whether the successive trips reportedly made by an automobile would have outrun the battery "tether" of an Urbmobile; if so, all travel by that automobile is disregarded.

2. Identify trips that might have utilized the guideways—Each record that was copied on the duplicate tape then faces the next challenge: Would the Urbmobile system have sufficiently improved the journey for the driver such that it might "qualify" as a possible dual-mode trip? Travel time can be conveniently used as the basis for deciding whether avoidance of city driving outweighs the delays in changing-over the Urbmobile between street and guideway travel.

(Existing tree-building programs permit calculation of average-speed travel time between every pair of traffic analysis zones. One set of zone-to-zone average-speed path values is calculated for automobile travel on the actual arterial network. A second set of path values is calculated for possible dual-mode travel on the same arterial network, to which the hypothetical high-speed guideways are added in the form of infinite-capacity freeways connecting directly with the arterials at each Urbmobile station.)

A look-up table is used by the computer to find the two-path values for whatever trip is being screened. If the paths are equal, the guideways were not useful; in that case the trip is of no more interest. If the paths are unequal, the guideways seemingly provided a faster route than did arterial streets. The apparent saving in time could not fully be realized in practice, however, because of Urbmobile mode-changing delays. Therefore a realistic penalty is charged—about 1 min to enter the facilities and 1 min to leave—and a "net time saved" is calculated for the trip. (Should this turn out to have a negative value, the dual-mode trip would have taken longer than driving the whole way on the streets.)

Metropolitan travel is probably perceived by the traveler in terms of both time and effort. We assume that drivers in Urbmobiles would prefer the ease of traveling on the automated guideways even if that slightly lengthened the trip duration. Therefore each trip is subjected to the tentative (and arbitrary) criterion shown in Figure 7 in order to decide whether there is enough net time saved relative to automobile driving time. For example, a ½-hour automobile drive could take as much as 3 min longer when made partly via guideway and yet still qualify.

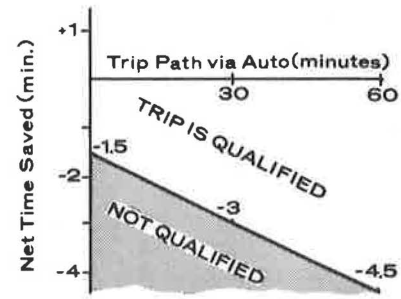

Figure 7. A criterion for deciding whether an automobile trip would save enough time to qualify for further synthesis processing.

3. Select households warranting an Urbmobile—The trip records of each household are processed individually, and the computer identifies those trips qualified to become dual-mode trips. These trips are the input for answering the question, If the advantages of the dual-mode system for this household today are considered, would an Urbmobile have been warranted in view of system disadvantages? The warrants shown in Figure 8 offer explicit criteria for deciding whether a household automobile should be converted to an Urbmobile. These arbitrary warrants are readily altered. They match the total net time an Urbmobile would save against the total amount of time for driving an automobile over the same 1-day aggregation of trips. For any household these two totals define a point on Figure 8. If the point lies on the convex side of the criterion line, an Urbmobile is not warranted.

Because of the assumed role for the Urbmobile as an automobile replacement, one-automobile households would be most sensitive to system deficiencies. Therefore, a relatively stringent warrant (Fig. 8, left) is appropriate for such households. As an example of the present criterion, if a one-automobile household would not save time by using an Urbmobile, none would be warranted unless the single automobile had been driven for at least 45 min on "qualified" trips. In the case of multivehicle households, the more lenient warrant is applied to each driver individually, as a subhousehold, though no more than one Urbmobile is ever assigned to an entire household.

When an Urbmobile is found to be warranted by a household (or by a driver or subhousehold), all of its trip records are so marked on the duplicated magnetic tape. This amounts to conversion of the automobile and its trips into an Urbmobile that made Urb-

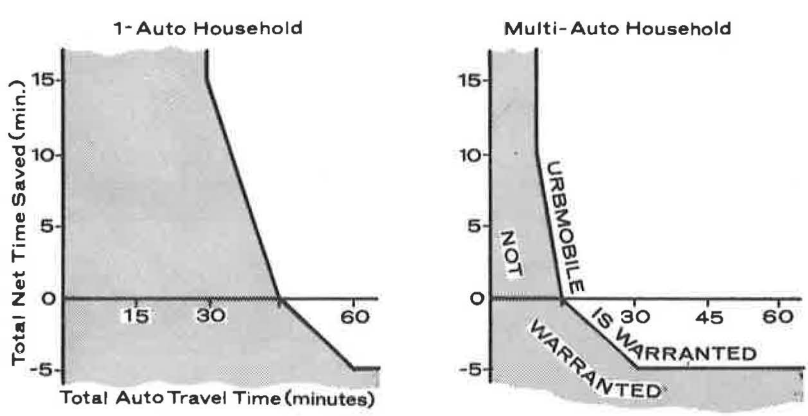

Figure 8. Tentative criteria for deciding whether an automobile would warrant being converted to an Urbmobile.

mobile trips. Trips that traversed only the streets are Urbmobile "street" trips; the so-called qualified trips finally become dual-mode Urbmobile trips, which implies some use of the guideways.

Synthesis Results

Preliminary results from the synthesis procedure are given in Table 1. These results are shown in Figure 9 in relation to the domain. Perhaps the most striking feature is the seemingly minor share of vehicle possession and use attributable to household Urbmobiles. In fairness, though, the arbitrarily defined domain may be disproportionately large as the basis for judging the single Urbmobile facility.

More significant is the evidence of the important contribution that converted one-automobile households would make to system utilization. Although under present criteria fewer than 10 percent of the one-automobile households switched to possessing an Urbmobile, these households would produce over 40 percent of the revenue from

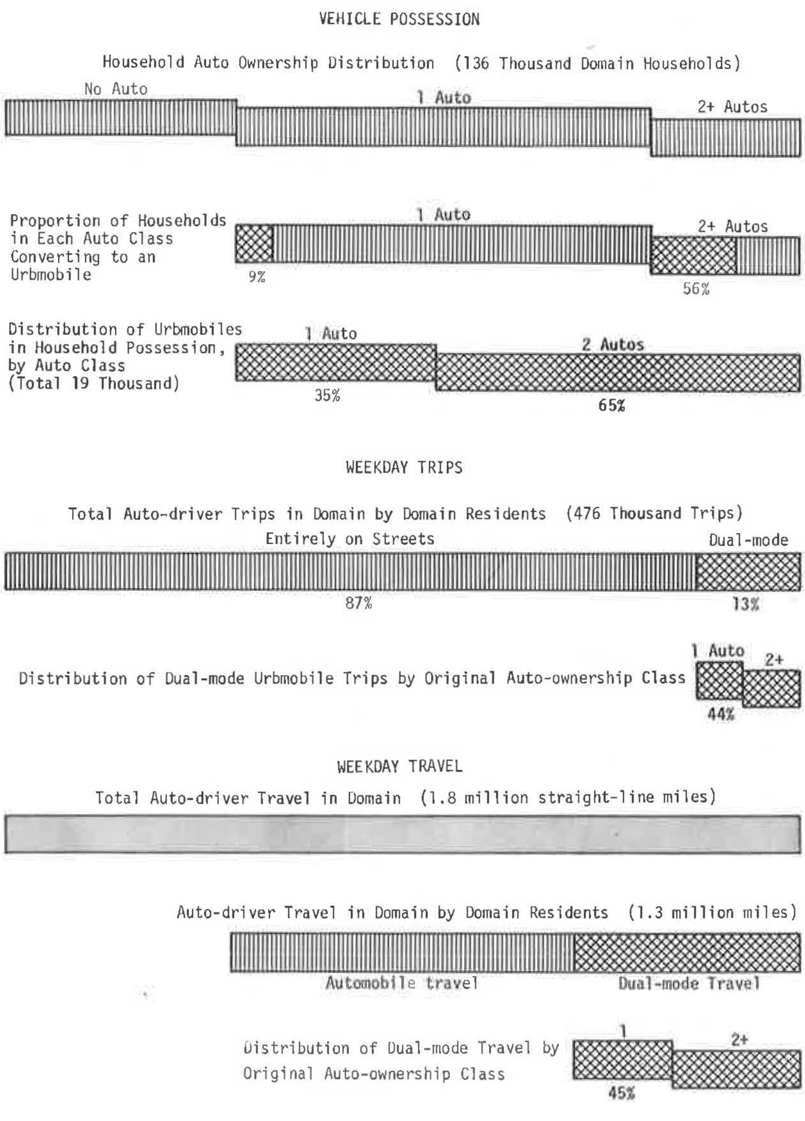

Figure 9. Results of a trial synthesis: role of Urbmobiles in relation to domain.

TABLE 1

RESULTS FROM AN INITIAL SYNTHESIS

Household Use and Possession of Urbmobiles	Household Automobile Ownership			
	1 Car	2 Cars	3 Cars	Total
Urbmobiles (one per household)	6,773	10,967	1,588	19,328
Urbmobile trips				
Dual-mode	26,177	29,208	4,478	59,863
Street only	20,159	26,624	4,482	51,265
Person trips via urbmobile				
Dual-mode	39,680	40,264	6,172	86,116
Street only	30,775	39,558	7,309	77,642
Urbmobile travel (straight-line miles)				
Dual-mode	135,473	143,944	24,415	303,932
Street only	37,361	50,799	9,567	97,727

converted automobile travel. The obvious inference is that an Urbmobile installation—needing all the utilization it can gainfully obtain—must be designed as a complete system that serves the needs of present-day one-automobile households. A valuable auxiliary might be an automobile rental service that could dispel any inconvenience caused by not keeping an automobile all of the time.

It must be emphasized that present criteria represent an initial venture. Further work is expected to give insights on the sensitivity and, perhaps, reasonableness of the criteria governing patronage. In any case, sensitivity analysis can in principle be carried out simply by altering criteria in the computer program in an easily understood and explicit fashion.

This first test indicates that Urbmobiles possessed by households in the domain would, on a typical weekday, generate about 300,000 (straight-line) miles of dual-mode travel plus about 100,000 additional miles of travel on street-only trips. Although the net environmental gain in electrifying that much travel has not been established, it is estimated to represent the avoidance of street fumes from the incomplete combustion of perhaps 100 tons of gasoline a day. Another environmental benefit would be the shifting of travel from road facilities to the high-speed guideways. For the average dual-mode trip a net reduction of about 2.75 road-miles could be expected. (This is based on having "driven" eight so-called qualified trips over a map of the Urbmobile route and city streets. Each trip was made as an automobile would travel and repeated as an Urbmobile taking advantage of the high-speed facility for part of the way.) The Urbmobile guideway is thus estimated to lift roughly 165,000 vehicle-miles of travel daily from domain streets. That is about one-eighth of the automobile travel made within the domain by its residents.

The synthesis indicated that Urbmobiles would replace only 1 out of every 6 automobiles among the 125,000 owned by domain residents. Still, a requirement for some 20,000 Urbmobiles is implied. A production lot of that size, even in the absence of a wider national market, should be large enough to benefit significantly from economies of scale.

Preliminary Urbmobile Economics

A rough economic check can hint at the financial realities of the kind of Urbmobile installation tested here. First, consider the fixed facilities. The investment in them is reduced to an annual expense and then combined with an assumed total operating expense (Table 2). (The capital recovery factors given in Tables 2 and 3 approximate a 5 percent interest rate on a quarter-century term for fixed facilities and a one-decade term for the fleet. Considered historically, the designated interest rate is not unreasonable. The service life assigned the facilities is comparable with that often given highways, and the Urbmobiles, necessarily kept in excellent repair, presumably outlast the average automobile but not the average transit bus.)

TABLE 2

ESTIMATE OF FIXED EXPENSE FOR HYPOTHETICAL URBMOBILE FACILITY

Item	Cost (millions of dollars)	Annual Expense (millions of dollars)
Line		
New subway, 4.1 mi at $8 million/mi	33	
Elevated and surface, 13.3 mi at $2 million/mi	27	
Stations		
Outer, 13 at $2 million	26	
Central, 1 at $4 million	4	
Subtotal	90[a]	6.3
Operations (assumed)		
100 station attendants and 200 other employees		3.0
Power, supplies, upkeep, and revenue handling		3.7
Total		13.0

[a]$90 million at 0.07 capital recovery factor = $6.3 million.

TABLE 3

ESTIMATE OF EXPENSES RELATING TO AVERAGE HOUSEHOLD URBMOBILE

Item	Annual (dollars)	Daily (dollars)	Per Mile (cents)
Depreciation, $3,000 at 0.13 capital recovery factor	390	1.07	4.6
Insurance	50	0.14	0.6
Maintenance		0.12	0.5
Road-use tax[a]		0.12	0.5
Total		1.45	6.2

[a]50 percent of travel is estimated to be on roads.

The final $13 million annually (Table 2) is essentially a fixed expense, notwithstanding some variable components. This sum translates to an average $40,000 expense per weekday, assuming 325 equivalent weekdays per year. To illustrate its scale, this burden may be charged entirely to the dual-mode travel of the 19,300 Urbmobiles. Their synthesized 300,000 straight-line miles are equivalent (at a 1.25 network/straight-line ratio) to 375,000 miles of travel on roads and guideway. Thus, the expense of the installation—exclusive of the fleet and of patronage from sources other than household Urbmobiles—could be covered by a rate of fare approaching 8 cents per dual-mode Urbmobile mile.

Next, the economic component relating more directly to the fleet may be estimated. The average household Urbmobile travels a total of about 21 (straight-line) miles per weekday, or some 23 miles of guideway and road travel every day (allowing for equivalent weekdays and network/straight-line conversion). Because it is less exposed to street traffic than most automobiles, such an Urbmobile might incur an insurance premium of about $50 annually. The average expense for possessing and using one of these conveyances (estimated by CAL to cost $3,000) is given in Table 3.

The total economics of the typical "family" Urbmobile, assembled from these components, are summarized as about 15 cents a mile, or roughly $1,200 per year. Because these estimates are derived from crude inputs, for a specific installation, they should be considered merely as tending to confirm that a family Urbmobile would be as expensive a possession as a family automobile. The highly conjectural nature of nearly all cost items in this brief economic check cannot be overemphasized.

CONCLUSION

The synthesis technique described here appears to be a reasonably straightforward approach to estimating the expected use of an entirely novel transport system. In the context of the middle-sized metropolis, the results suggest that dual-mode transport may border on financial feasibility, in spite of the heavy capital expense of the automated guideways and related facilities.

Underlying that tentative conclusion are the merits and flaws of a particular dual-mode system, Urbmobile, proposed and described by Cornell Aeronautical Laboratory, Inc. Although Urbmobile technology should achieve commendably simple automation of the guideways and stations, there are some deficiencies in the Urbmobile system as a whole. These deficiencies primarily stem from the inadequate performance of the Urbmobile when driven on streets; the typical household that owned only one automobile would be disinclined to give it up for an Urbmobile limited in road range and speed. If the Urbmobile could be modified in this regard to perform as well as an ordinary automobile, numerous one-vehicle households might be induced to convert, thus increasing

guideway travel and system revenue. Alternatively, instead of the automotive refinement of Urbmobiles, a convenient and favorably priced automobile rental service for regular Urbmobile possessors might be incorporated into the system.

It is evident that the existence of a metropolitan dual-mode guideway network would not, by itself, overcome limitations on personal mobility caused by the lack of a vehicle or the inability to drive. If a costly dual-mode installation is to be used fully and make its maximum social contribution, access to the facilities by everyone cannot be ignored. Thus, adequate transit service to and from the dual-mode stations should be considered an important system element.

There may be a significant environmental role for the Urbmobile system. Although its clean-air superiority has been diminished with the advent of legislation on vehicular emissions, the small size of the guideways could prove to be highly advantageous. Potentially, these channels might move travelers rapidly and individually with little disruption to the urban environment. If Urbmobile technology and operations could be adjusted to minimize the scale of all the automated facilities, the system might be feasible to install in urban corridors where the construction of conventional high-capacity facilities is becoming unacceptable.

It appears that dual-mode transport may be furthered in a variety of ways, some technological and others commercial or institutional. The parties interested in this innovative transport concept ought to consider seriously the purposes for which the dual-mode capability is desired and how it most effectively may be employed.

REFERENCES

1. Bi-Modal Urban Transportation System Study. Cornell Aeronautical Laboratory, Inc., Vols. 1, 2, and 3, March 1968.
2. Henderson, C., et al. Future Urban Transportation Systems: Descriptions, Evaluations, and Programs. Stanford Research Institute, Final Rept. 1, March 1968.