MINICAR
TRANSIT SYSTEM
Final Report on Phase - I
"Feasibility Study"
Book - I - Summary

by
UNIVERSITY OF PENNSYLVANIA

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to

URBAN MASS TRANSPORTATION ADMINISTRATION
U.S. Department of Transportation

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PREFACE

This report covers the first phase of a study on the feasibility and desirability of a MINICAR MASS TRANSIT SYSTEM.

Book 1 presents a concise summary and recommendations for future work.

Book 2 presents details of the work.

The second phase of this study is expected to be an "Implementation Plan."

This Project was conducted by University of Pennsylvania personnel and members of the General Motors Research Laboratory. The systems aspects were the responsibility of the University. Details of vehicles and power trains were supplied by General Motors Research under a subcontract to the University.

The original sponsor was the U.S. Department of Housing and Urban Development.

After completion of the initial work, the General Motors Corporation recommended that a new subcontractor be obtained to supply the University with automotive expertise. Minicars, Inc. was chosen to fill this role.

The Project Director extends his thanks to the University which gave this work its unstinting backing and encouragement, to General Motors for the excellence of their contributions, and to Minicars, Inc. for their fortitude in tackling this challenging problem.

This Project, which combines the efforts of Government, Private Industry, and a University, has shown the value of a multi-institutional approach to a massive technological and sociological problem.

Manfred Altman, Director
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### BOOK 1

**MINICAR MASS TRANSIT SYSTEM**

**SUMMARY AND CONCLUSIONS**

This study concludes that:

1. A good case can be made for developing a safe, low pollution, full-width-but-half-length "Minicar," optimized for fleet type urban-suburban driving.

2. Under appropriate Governmental stimulation and control, a fleet of about 26,000 Minicars served by 100 to 300 terminals can be introduced into Central Philadelphia, in the decade from 1972 to 1982, on a sound and practical business basis.

3. This Minicar system could:
   
   A) Increase the traffic capacity and flow in heavily congested areas by 25% to 75%.
   
   B) Decrease localized rush hour air-pollution levels by 40% - 60%.
   
   C) Release a potential investment of 90.4 - $0.7 billion in parking facilities for other important urban uses.
   
   D) Reduce the suburban auto commuter’s daily cost for transportation to his urban job by 40% - 50%.
   
   E) Enhance the suburban commuter’s usage of subway, train and bus transit systems by providing him with central city transportation convenient to the downtown terminals of those systems.
F) Provide the economically deprived, non-car-owning urban driver with the short door-to-door travel times of a taxi ride at a price only slightly above that for a bus or subway trip.

G) Largely eliminate the need felt by urban dwellers for privately owned automobiles.

H) Produce substantial returns for the investors and operators of the Minicar system.

I) Attract more customers to the central city area by virtue of its cleaner air, more quiet and less congested environment, and more efficient transportation facilities.

THE PROPOSED MINICAR MASS TRANSIT SYSTEM

THE PROBLEM

Day after day, year after year, millions of cars in America's big cities clog the roads in a regular, morning-evening cycle. Why must each commuter drive his own car? Cars with one hundred and fifty square feet of road-cluttering planform area mainly devoted to five empty seats, a huge engine, and a spacious but empty trunk.

Unfortunately, there is no easy answer to this question. Each city and neighborhood is different, and conditions change from time to time. Americans want—and have generally insisted on getting—the freedom to go and to stop wherever and whenever they may individually desire. Privately owned automobiles presently offer the most attractive single way of meeting this need for our city and suburban dwellers. Clearly, it will not be an easy matter to introduce an urban transportation system that will work better than the present one does under all the different factors and conditions, both obvious and hidden, which now shape (and will in the future characterize) our cities.

But one may ask: can't city drivers be induced gradually to shift toward smaller and less noxious automobiles in order to reduce the city's rush hour congestion and smog?

The answer is clearly: not easily—simply because today it is still true that per dollar invested by the private owner, a big car will give a smoother, faster, and more quiet ride, carry more passengers, and yield far more safety, than will a small car. Moreover, as indicated above, most owners want to feel free to decide at any time to take a lengthy impromptu trip with family or associates, and such a trip requires the large car of today.
Well, then, can't city drivers be somehow attracted out of their big cars into smaller and more suitable ones which can be made available to them in the urban area at reduced prices?

Here, now, is a significant and promising question. The present study was undertaken to determine the feasibility of an approach which:

(a) Uses a very short car as the basic component

(b) Can be implemented without major capital expenditures other than for the vehicles

(c) Is as readily available as a taxicab

(d) Costs the user less than a privately owned "standard" automobile

(e) Costs the user more than mass transit

This study, then, was concerned with the design of a viable mass transportation system for intra-city and commuter movement.

The work so far has shown that such a system may well be feasible and desirable, and that the possibility exists to serve fleet and other special users, i.e., such as post offices, parcel delivery services and others.

THE PROPOSED MINICAR MASS TRANSIT SYSTEM

THE SYSTEM

The Minicar Mass Transit System (MNTS) concept consists of a special vehicle, which is described later, and which is used in the following two ways. Commuters would subscribe to a "Flat Rate" service, and city travelers would subscribe to the system, and obtain cars on a "Trip Rate" basis. Minicar facilities would be distributed throughout the central city area so that any one of them can be reached by walking no more than about two minutes.

The Minicars brought into the city by the commuters are to be used for the "Trip Rate" service, or by fleet users during the working day. The commuter returning home obtains a Minicar, but not the one he dropped off in the morning.

This shared use of a vehicle is expected to result in reasonable costs to the users, and in benefits to the city in terms of decreased parking needs, among others.

The "system" is to be automated. Check-in and check-out as well as billing is to be computer controlled. A dual computer system with high reliability is envisioned.
THE PROPOSED MINICAR MASS TRANSIT SYSTEM

THE VEHICLE

A detailed examination of the characteristics that must be possessed by a small, fleet-type automobile optimized for the contemplated system, shows that it should have:

1. A length of about nine feet or less (whence the name "Minicar") yet of standard six-foot width able, comfortably, to accommodate three passengers abreast.

2. A "high-quality" appearance and performance (e.g., good styling, excellent paint and trim, well-fitted doors tailored for easy access, good agility, no clutching or gear shifting, etc.).

3. Air-conditioning and heating.

4. A novel power train with low exhaust emissions during normal operation and no gaseous outputs wherever for travel over short distances in tunnels, garages, and other special spaces.

5. Subassemblies which use currently available parts wherever possible so as to reduce costs in limited production.

6. A first cost not exceeding that of a modern "compact car."


8. High inherent reliability.


10. High level of safety in mixed traffic.

Detailed justification of these requirements is set forth in Chapter VII of Book II.
THE PROPOSED MINICAR MASS TRANSIT SYSTEM

TERMINAL FACILITIES

Parking facilities for Minicars are to be located within a few blocks of any location in the CBD.

A typical facility will be a portion of an existing lot or garage.

THE PROPOSED MINICAR MASS TRANSIT SYSTEM

COMPUTER SYSTEM

The Minicar Mass Transit System would utilize electronic equipment to check cars in and out of terminals. A method has been conceived (using coded cards for each patron and vehicle plus a patron identification number) for achieving security against theft and malicious mischief.

Such an installation would be attractive, simple and convenient. The computer system is envisioned to perform the following functions:

1. Check validity of card being used.
2. Release car to user.
3. Identify driver and car.
4. Record time and odometer reading.
5. Compute appropriate charge.
6. Prepare monthly billing.
7. Maintain record of vehicle usage.
THE PROPOSED MINICAR MASS TRANSIT SYSTEM

MAINTENANCE FACILITIES

The relatively high initial cost of individual Minicars is caused by the rugged construction, the special power plant and the relatively small volume of car production. However, in conjunction with using standard production parts whenever possible, the rugged construction and special power train will substantially reduce maintenance and repair costs, resulting in lower total system costs.

A maintenance system is envisioned which would house a mobile service facility as its primary element. Such a facility could be a service truck with an articulated boom. This boom would make available at each Minicar within 40 feet the necessary lines for fueling, washing, vacuuming, and diagnosing for incipient problems.

OPERATION AND BENEFITS OF THE MINICAR SYSTEM

SERVICES OFFERED

Four basic types of customers will gain particular advantages by using the Minicar Mass Transit System (MMIS).

1. Suburban residents who customarily drive their cars to work and park them all day in the central city.

2. Persons who have one or several errands to perform during the day in the urban center.

3. CBD residents who presently own cars.

4. Urban residents who presently do not own cars.

The first type of customer will be offered a flat rate* and the second a trip rate** fare structure. In the first of these arrangements, the subscriber purchases a low-cost monthly lease, not for the use of some particular Minicar but rather for the use of any convenient Minicar. Thus, the subscriber would be free to check out a Minicar each evening, weekend, or other time, and use it like his privately owned automobile until he checks it back in again. In usual practice he would check it in each week day morning at any of the system's 150 or more convenient terminals. During the day, then, the car would form a part of the trip-rate pool of Minicars. That evening when the subscriber wants to leave his office he would again check out a (different) Minicar, and the cycle would repeat.

*Independent of mileage up to some maximum except during the work day.

**Based on mileage and time.
The trip-rate fare, on the other hand, would make Minicars available to customers on a single-trip basis at a higher, though still attractive, price. A rapid, computerized check-out and check-in system to facilitate this service has been conceived. Needed terminals have been specified and expected demand estimated. The majority of these cars will be the same units that are employed during the night hours by the flat-rate customer, but an additional number of vehicles will be provided to compensate for imperfect distribution and demand fluctuation. Monthly billing to subscribers will be automated.

In addition to the foregoing two kinds of customers, it is expected that many urban dwellers will find the flat-rate fare highly attractive as compared to the expense and bother of owning their own vehicles. Likewise, many center city residents including those with low incomes should find the trip rate more economical than any type of privately owned automobile, as well as being far more rapid and convenient than the available bus or subway service.

OPERATION AND BENEFITS OF THE MINICAR SYSTEM

USER BENEFITS

Of the many possible, and even likely, uses of Minicars, the study so far has examined only two. These are first, the use of the Minicars for trips which originate within the city center, and two, the use of Minicars for commuting purposes.

A modal split analysis has been made (see Chapter II of Book II). This analysis resulted in an estimated 114,000 trips per day for Minicars on a "Trip-Rate" basis. It was also estimated that roughly 8,000 Minicars would be needed to supply this demand.

The price for "Trip-Rate" service which was assumed in the modal split analysis was such as to generate a very high profit. Since one objective for the NMTS is to substitute Minicars for big cars it was then decided to use this profit to support the "Flat-Rate" subscription system in order to make it attractive to commuters.

The demand for "Flat-Rate" service obviously depends on the cost to the user. A comprehensive optimization study is needed before a price for this service can be set. Such a study has not yet been made. A reasonable assumption was made, however, namely that the cost to the user should be less than the cost of operating a VW for commuting purposes. This average monthly cost is about $100. For that reason an assumed
cost of $75 per month was chosen for the "Flat-Rate" service. This monthly cost, when coupled with the total cash flow generated by the "Trip-Rate" service, results in an estimated total number of vehicles of about 26,000. An examination of the financial data (see Chapter IV of Book II) shows that the introduction of this number of vehicles still produces a reasonable profit for the operator.

The implications of the above are as follows. A commuter who maintains an automobile specifically for the purpose of commuting to work will find it attractive to subscribe to Minicar service because:

1. It is less expensive than using an automobile he owns - even in the extreme case of a low-cost VW.
2. It relieves him of the chore of maintenance.
3. No lost time due to repairs.
4. The Minicar is planned to be very much safer than any currently available small car.
5. Parking is planned to be available in many locations.
6. He is producing a social benefit from which he himself is going to benefit.

These advantages are expected to outweigh such obvious disadvantages as:

1. Inability to leave packages in the car.
2. Unrestricted weekend use (a maximum of 150 miles is planned for).
3. Pride of ownership.

The question which must now be answered is whether 26,000 of these commuters can be converted to MMTS users by 1982.

It has been estimated that about 50,000 automobiles will enter the city center during rush hours by 1975 (when 5,000 Minicars would be available). Of these, the great majority can be expected to be daily commuters. It becomes apparent, then, that the MMTS could not supply all of these commuters with cars since only about 26,000 Minicars can be supported on the previously discussed basis. Only experience can determine how many of these commuters will be willing to switch to Minicars, but based on the advantages enumerated above it is not unreasonable to suppose that there will be a demand exceeding the supply in 1975 and leading to about one half of those eligible in 1982 - which makes the assumption of 26,000 Minicars a reasonable one.

It should be pointed out that the profitability of the system does not depend on a large number of "Flat-Rate" users. As a matter of fact, fewer "Flat-Rate" users allow lower "Trip-Rate" fares; thus the system is self-adjusting since lower rates will attract more "Trip-Rate" users.
It should also be noted that many other possible users of minicars have been ignored in this analysis, but should be examined in future work. Two such potential individual users deserve special mention. First, the city resident who finds it increasingly expensive and inconvenient to own an automobile. A combination of Minicar service and Rent-a-Car service, i.e., the ability to obtain a big car when needed, may be preferable to car ownership. Second, the underprivileged surrounding the city center may find new mobility with the shared, low cost of Minicars. Both of these will be examined in future work.

The following table summarizes the average yearly costs of operating privately owned cars specifically for commuting purposes from the suburbs, also for city residents, and compares them to the projected costs of using Minicars.

<table>
<thead>
<tr>
<th>Type of User</th>
<th>Private &quot;Standard&quot; Car</th>
<th>VW</th>
<th>Minicar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban Commuter</td>
<td>1,966</td>
<td>1,140</td>
<td>900</td>
</tr>
<tr>
<td>(12,000 mi./yr.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City Resident</td>
<td>1,918</td>
<td>990</td>
<td>1,075*</td>
</tr>
</tbody>
</table>

Note that a city resident can subscribe to Minicar "Trip-Rate" service, obtain a "standard" car for weekend trips, and still save money and convenience over owning a "standard" car. The cost was based on ten 200-mile weekend trips and one 1,000 mile trip.

*3,000 mi./yr. Minicar
3,000 mi./yr. Rent a Car

OPERATION AND BENEFITS OF THE MINICAR SYSTEM

SOCIAL BENEFITS

Benefits to the city come mainly in three areas of (a) improved land use (reduced vehicular parking area requirements), (b) increased traffic capacity and flow, (c) reduced air and noise pollution, and (d) increased general mobility.

Land Use

The chart below shows the number of parking spaces saved if some 2500 additional Mass Transit System Minicars are introduced each year beginning in 1972 to a total of about 26,000 vehicles by the end of 1982. (This means that 5,000 Minicars will be introduced after 1978 to compensate for the vehicles taken out of service.)

Since each conventional parking space and its access area covers an area of about 280 square feet, the 1982 saving of more than 16,000 parking spaces amounts to over 4,500,000 square feet. This land is worth in Central Philadelphia) approximately $0.4 - $0.7 billion.
The sketch below shows 12 Minicars (which do not have to be retrieved individually) parked in the same space that will accommodate only four standard vehicles of the privately owned type (which do have to be retrieved individually), or 6 if attendant retrieval and parking is possible.

4 Standard Vehicles (Needing Individual Retrieval).

12 Minicars (Not Needing Individual Retrieval).

In the case of densely parked cars which must be retrieved individually, it must be remembered that retrieval is time consuming, requires manpower, leads to annoyance, and increases the chance for damage.

Further, it is highly desirable to effect major economies in curb parking. Three Minicars can be accommodated by head-in parking in the standard parking space on a city street, whereas only one VW, for example, can be parked in such a space.
OPERATION AND BENEFITS OF THE MMTS

SOCIAL BENEFITS

Traffic Capacity and Flow

The following graphs show what a given number of Minicars would do to increase traffic velocity, particularly if, as we expect, the number of cars queued at each traffic light is reduced. Research has indicated that, at intersections controlled by traffic lights, the flow of vehicles per hour of green will increase by 25% to 75% in times of heavy congestion (2-4 mph traffic) when the usage of Minicars is predicted to range from 50 percent to 70 percent of all cars on the city streets.

Air and Noise Pollution

The introduction of 26,000 contemplated Minicars could materially reduce the local vehicular pollution generation in those locations and at those times when it is most needed. This is illustrated in the graph below, which shows that on congested streets, tunnels, bridges, or intersections, pollution generation will decrease to between 40% and 60% of levels which would exist without Minicars. This benefit is caused by the fact that the usage of Minicars will be greatest during congested periods.

Similar arguments can be made with reference to the local generation of noise.
OPERATION AND BENEFITS OF THE MMTS

SOCIAL BENEFITS

General Mobility

The MMTS may make it possible to provide transportation to areas which are not conveniently reached by using existing mass transportation at reasonable cost and time.

OPERATION AND BENEFITS OF THE MMTS

OTHER FACTORS

The vision of the Department of Transportation includes transit systems whose existence depends upon a great deal of technical research and development. The Minicar Mass Transit System (MMTS) can be designed for compatibility with all six other mass transit systems recommended in Tomorrow's Transportation. The MMTS can serve in conjunction with rail and bus systems. It can be designed for eventual operation on automated, exclusive use, or dual-mode guideways. It can also be compatible with pallet, ferry, and network cab conveyances.
The early introduction of the MMTS will provide an opportunity to evaluate many of the developments necessary to the future of urban transportation. Operation of the MMTS will enable testing of: advanced identification and fare collection systems, efficient maintenance and analysis of vehicle safety and performance programs, and mass transit application of electric power trains. The use of computers will allow evaluation of their ability to oversee the status of the system, routing, distribution and maintenance schedules. Computerized records will also quickly indicate user demand and trip patterns by origin, destination and time in transit.

The MMTS program permits testing of the public's attitudes toward sharing vehicles, their feelings about the safety, comfort, convenience and reliability of small cars, and their preferred mode of transportation. Success of the MMTS depends upon demonstrating to the public the acceptability of small cars in a mass transit mode that provides individual travel freedom and privacy. Minicars will facilitate maintaining and improving urban areas as centers of commerce, and they will prove the advantages of providing transportation for the economically deprived.

An MMTS can be operated in a variety of ways. It could be a public utility, a private, regulated utility, or a private unregulated business. A way must be found to set up a system which takes maximum advantage of private enterprise but which is provided with incentives to profferate Minicars to the maximum feasible extent.

WHY GOVERNMENT INVOLVEMENT

The problem which is bound to arise is illustrated by the graph below. The private operator would naturally tend to maximize the return on his investment and the total profits such that primary emphasis would be placed, among other factors, on obtaining the greatest number of trips per car per day. This would mean operating only 3 - 5 thousand cars, and this would fail to achieve most of the social benefits available when 26,000 Minicars are in operation. In order to achieve significant social benefits, then, the operator must somehow be provided with incentives to optimize the system in such a manner that the greatest feasible number of Minicars is introduced, i.e., he must be given the incentive to plow the great profits available when operating in the 3 to 5 thousand car range back into the support of the additional 21 to 23 thousand cars for which a demand will exist at the optimum cost to the subscriber found in this study.
An unregulated enterprise would tend to establish subscriber rates and qualifications typical of rent-a-car operators, thereby denying use of Minicars to the economically deprived (many of whom are licensed drivers but not car owners). In 1960 there were 25,000 non-car-owning but licensed drivers in the three poorest districts of downtown Philadelphia.

In consequence, it is important for the government to become involved in stimulating and controlling this system. The need in Philadelphia is for an MMTS of 26,000 specially designed vehicles served by 250 or more terminals and serving 500,000 people. This kind of system would offer all people (including the economically deprived) convenient, low-cost, high quality transportation having the privacy and flexibility of the automobile.

Below is shown a comparison between an MMTS which is publicly owned or regulated and a privately operated, unregulated Minicar system.

<table>
<thead>
<tr>
<th></th>
<th>Number of Vehicles</th>
<th>Number of Terminals</th>
<th>Number of People Served</th>
<th>Parking Spaces Saved</th>
<th>Effect on Street Capacity and Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBLIC</td>
<td>26,000</td>
<td>150</td>
<td>17,000</td>
<td>Favorable</td>
<td></td>
</tr>
<tr>
<td>MINICAR SYSTEM</td>
<td>300</td>
<td>500,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNREGULATED</td>
<td>3,000</td>
<td>30</td>
<td>30,000</td>
<td>Almost</td>
<td></td>
</tr>
<tr>
<td>PRIVATE</td>
<td>to</td>
<td>to</td>
<td>to</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>MINICAR SYSTEM</td>
<td>8,000</td>
<td>75</td>
<td>80,000</td>
<td></td>
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</tr>
</tbody>
</table>

The column "Number of People Served" needs to be explained. In the case of the "public" system all licensed drivers will be eligible for subscribing to the "Trip-Rate" service, but the private entrepreneur tends to be quite selective. (Note, for instance, that credit cards such as Hertz, Avis, or Diners Club are reserved for people with annual incomes in excess of $7,500). The 500,000 people served by the "public system" represents one half of the licensed drivers in the area under consideration.

It is not likely that Minicars will be developed and tested without governmental stimulus, simply because:

A. No established market exists for such vehicles.

B. The primary incentive for making such special vehicles is social gain rather than private benefit.

C. Only the government is in a position to establish incentives adequate for the production of such special-purpose vehicles.

On the other hand, it would be desirable for the government to persuade automotive manufacturers to enter this market. However, it is pertinent here to point out that special vehicles to fill special needs, such as Minibuses and jitneys, are built by specialized companies rather than by GM, Ford, Chrysler, and American Motors. The fact is that the big automotive manufacturers mainly produce vehicles which can be sold (to individuals) by the millions, and for which, therefore, initial cost, styling, and comparative performance are of paramount importance. When one examines urban requirements relative to parking space, noise, air pollution, and mobility, then it is not surprising that the specifications of a "socially desirable" vehicle for the central city differ from those pertaining to a "privately desirable" automobile.

Therefore, government action is required to insure that this system will most efficiently serve the public needs.*

*The MMTS can be operated either as a utility or controlled by any other appropriate legislative or administrative means.
RECOMMENDED PROGRAM PLAN AND BUDGET REQUIREMENT

There is much interrelated research and development that must be done to insure that the Minicar Mass Transit System (MMTS) is established with minimum waste and maximum benefit. We propose that the government can act in the public interest by subsidizing the necessary studies and to initiate an empirical experiment, on a limited scale, of operating an MMTS using developmental hardware. Governmental assistance would also be required in production engineering and computer system development for the full-scale Philadelphia experiment. Thereafter, only a loan guarantee would be necessary to insure the proliferation of the system.

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<td>Feasibility Studies Implementation Plan</td>
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Public Preference - A detailed survey of several hundred people in various walks of life should be conducted and the results analyzed to determine the general characteristics which would make short vehicles desirable in the urban environment. Full-scale prototype vehicles should be built. This would help to evaluate the Minicar System as compared to currently available alternatives. By the method of paired comparisons, the subjects' true preference for particular features can then be established and its value analyzed. Specifications can be prepared as a result of the above for the purpose of defining the system to be used for the experiments.

It would also be very desirable to obtain suggestions and critiques from representatives of groups who have an interest in the expected effects of Minicars. Such groups include operators of parking lots, garages, other mass transit systems, public officials, automotive manufacturers, etc. This type of information would be very useful in insuring a comprehensive design of the experiments, and the acceptability of the system when it is initiated.

RECOMMENDED PROGRAM PLAN AND BUDGET REQUIREMENT - Phase II

System Optimization - In order to be successful, the experiment (demonstration) must provide needed and desired service to users. Goals for user services will be established and outlined so that maximum utilization can be gained from about 150 vehicles.

Goals must also be established for the amount and type of data the experiment would produce. This combination of objectives will be oriented toward the eventual large-scale system since the underlying theme is to establish the optimal format for it.

Planning for the experiment requires use of available data and/or gathering new data to design administrative operations that will serve users efficiently and economically. This involves the choice of terminal sites, hardware, policies, rates and administrative and billing operations that will fill user needs and provide data essential to upgrading or modifying the system as the experiment progresses.

The experiment would need to be surveyed continuously in terms of its goals so that solutions for potential obstacles to large-scale public system could be effected, and potential trip demand and user attitudes may be forecast.

Part of the system optimization would be recognition of the need for the MMTS to be compatible with other proposed systems. Planning and design will be directed toward achieving this compatibility.

Vehicle Development and Testing - The vehicle used in the experiment (demonstration) would be designed to approximate as closely as possible the ultimate Minicar. Its design would comply with all safety regulations. In fact a great deal of emphasis should be placed on providing a high degree of safety in mixed traffic.
The styling, appointments, and interior configuration are to reflect the attitudes indicated about the prototype vehicles during preference studies.

The power train would be selected from the available market, in terms of adaptability to the design of chassis, body style, and utility with respect to intended service.

All other materials and components must be selected carefully in terms of safety, comfort and economy of production and operation.

The experimental vehicles should be tested for safety, adequacy of performance and dependability.

Servicing Equipment Development - Because maintenance of a large fleet of unique vehicles is extremely important, a special vehicle needs to be designed to provide these services. This will have far-reaching implications on the eventual large-scale system.

Equipment capable of fueling, servicing and cleaning would be designed to fit an existing truck chassis.

A study of the proposed functions of the servicing vehicle and the feasibility of providing them would be made.

Build About 150 Cars - During the development phase consideration will have been given to the construction techniques most appropriate and least costly to build 150 vehicles. fiberglass, steel, and ABS plastic-molded bodies must be considered. At present the cost trade-offs indicate preference for hand laid-up or sprayed fiberglass in quantities of under 4500 units, and plastic molding for quantities to about 50,000. The tooling costs for steel cannot be adequately amortized except in much larger quantities.

The tooling chosen is to be adequate to produce one vehicle a day until the required number of units are built. A special line will be set up so as to allow incorporation of last minute modifications of the design.

Operation and Analysis - Personnel would need to be provided for operation of the experimental system. The administrative staff would be responsible for billing and accounting, terminal, and maintenance personnel.

There would be a separate group responsible for data gathering and related observations.

The experiment could begin in October, 1969, and continue for 18 to 24 months, during which time all aspects of the program could be evaluated. We suggest that the experimental system use about 150 specially designed vehicles which approximate as closely as possible the ultimate Minicar. The cars would be available for "Flat-Rate" service from at least three carefully selected terminals. The experimental system would be designed in detail from the results of operations studies, and analysis of demand potential which should be started by November, 1968.

Power Train Development - Concurrent with the pre-experiment studies, it seems advisable to initiate the assembly and testing of an internal combustion engine-electric power train. This would assure the availability of an advanced power plant for the vehicles used in the large-scale system.
RECOMMENDED PROGRAM PLAN AND BUDGET REQUIREMENT - Phase III

The studies, hardware development and the experiments will facilitate implementation of the large-scale MMTS. Through advance study of user attitudes, potential demands for service, operations in terms of necessary services and facilities, and the legal requirements of the local, state and federal governments, potential obstacles can be avoided.

If the proposed program of study and experiment is initiated promptly by the government, installation of a full-scale MMTS can begin by December, 1971.

The production of a large quantity of vehicles would involve the setting up of a completely tooled production line. In order to reduce costs as much as possible the total production run and the production rate must be estimated from the studies of applying the MMTS to other cities and fleets. If the total quantity is large enough (say greater than 50,000) it is expected that the manufacturer would tool and equip a production facility without cost to the Government.

Computer Development - It would be necessary to set up a duplex computer system, terminal hardware, and software programming to store all information, establish costs and identification procedures, and provide system status reports.

Subscriber Sign-Up - Prior to operational status, efforts should be made to qualify subscribers. This should be done in advance, since different rate structures may apply to applicants with poor driving records (high insurance risks), the economically deprived, the "Flat-Rate" customers, etc.

Terminal Installation - Leases must be arranged to make available parking spaces in most of the city's parking lots and garages. Those facilities considered in areas of highest demand must be modified promptly to accept the terminals prior to system operation.

MMTS Operation - The operation of the MMTS is best described by an estimate of the financial status as a function of time. This information was summarized on page 14.