RICE UNIVERSITY

A TRANSPORTATION CONCEPT FOR THE HOUSTON CENTRAL BUSINESS DISTRICT

by

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ABSTRACT

A TRANSPORTATION CONCEPT FOR THE HOUSTON CENTRAL BUSINESS DISTRICT

William Cook Burks

In our increasingly specialized society, accessibility has become the key to the location of activities, and consequently the key to land development.

The Houston Central Business District has continued to function and develop largely because of improved accessibility afforded by improvements in the regional automobile transportation network. There are physical limits, however, to the amount of traffic which can be delivered by this network or accommodated within the CBD, and studies indicate that these limits are now being approached. If the CBD is to continue to develop, and demographic forecasts indicate that it should, then such development must be matched by improvements in accessibility, and such improvements will have to come largely from modes other than the private automobile.

This thesis deals with the need for transportation improvements in the CBD, the technological means for making these improvements, and a strategy for undertaking them.

First, the CBD is analyzed, as it exists today, in terms of regional function, activity patterns, and available modes of travel.
Second, a range of potential transit systems are listed and compared according to performance, space and scale characteristics, and a basis for a planning approach to transportation systems and technology is defined.

Third, a series of sequentially staged transportation improvements are proposed and discussed in detail. These stages are presented to demonstrate the concept of an evolutionary transportation network which:

a) improves accessibility in incremental steps to match growth and development;

b) integrate modes of transportation to satisfy a variety of trip demands;

c) combines short range and long range planning objectives in order to use the earlier stages as full scale tests of service and response;

d) responds to technological and economic changes and developments by allowing for an opportunity to review and revise long range goals and objectives.
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Transportation, considered broadly, embraces all the systems and modes of conveying people, energy, or ideas from place to place. This thesis, however, will limit considerations to one aspect of transportation, the movement of people. While the movement of people is not the only transportation problem, it is the most serious; it has a direct impact upon the lives of almost everyone in this country. Not only do people make more and longer trips today, but the environmental side effects of transportation affect people when they are not traveling. Transportation has become an essential and ever increasing facet of life, a facet with a cost, in many households, second only to that of housing.

The other limitation of this thesis is the limitation of considerations to a specific place, the Houston Central Business District. This is an artificial limitation, necessary to limit the scope of this study in order to allow some concentration in detail, and it should be remembered that the CBD represents only one end of a trip, that it is only a part of the whole Houston metropolitan area whose transportation problems should be considered as one.

The CBD was chosen as a study area because it was a well defined area, and because considerable data was available from previous studies. Being the oldest developed area of the city, it has a history of over a century of changing
land use and transportation modes. And being the most densely developed area of the city in terms of floor space, with a high percentage of daytime commuters, it most dramatically demonstrates the environmental effects of transportation.

Considering the CBD as a sort of isolated, concentrated area of trip destination, surrounded by a grey, nebulous area of trip origin, may have eliminated many of the implications of the transportation problem. Specifically, it has eliminated consideration of the implications of connecting the CBD with other centers of activity in the Houston area, and instead concentrated primarily on the requirements of the trip to work and the internal trip. Emphasis has also been placed more on the nature of movement systems and on the problems of staging, constructing, and integrating new modes, rather than on the land development potentials.
Section A

The Central Business District Today
Up to 1850 or even later . . . much of the growth of metropolitan cities seems to have been occasioned by an increasing concentration of the goods-handling activities within the central areas. . . . after 1850 a rapid change came over the centers of the metropolitan cities: the traditional activities were joined, and then sometimes displaced, by new types of activity which were characteristically carried on in offices. This was no sudden once-for-all process; it has gone on happening ever since, and it threatens to be a major feature of the development of the great metropolitan centers in the immediate future.

At the very center of the structure of the central business district of each world city there is found a relatively small nucleus of highly skilled professionals. All these people, in one way or another, live by creating, processing, or exchanging ideas . . . .

The central business district therefore can be seen as a highly specialised machine for producing, processing, and trading specialised intelligence. And of all commodities, intelligence has the highest cost of transportation.

Peter Hall   THE WORLD CITIES
SECTION A: THE CENTRAL BUSINESS DISTRICT TODAY

DIMENSIONS OF THE CBD

Regional Function

The Central Business District is the major focal point of Houston. It contains the greatest collection of offices, financial institutions, retail establishments, hotels, and cultural and entertainment facilities.

There are reasons why the CBD has a strong attraction to specific functions. Major companies tend to locate their offices where they can best fulfill the need to communicate with related industries on a person-to-person basis. Once an area has become established as a major center of commerce, it functions as a magnet, drawing investment and development from related industries.

Houston is the center of the Gulf Coast oil industry, the biggest refining area in the nation. The Houston port, completed in 1914, is the nation's foremost oil port.\(^1\)

During the past decade, Houston's CBD has shown amazing growth and economic vitality. Most conspicuous in this growth have been office structures which serve as headquarters for the oil, gas, and petro-chemical industries. Oil companies and oil-allied offices utilize a very high percentage of downtown office space.\(^2\)
This growth is due in part to recent changes in office management practices in national or international corporations, as explained by John R. Meyer:

\[ \ldots \text{the strongest argument favoring increased growth of central cities seems to be an argument applicable to strengthening the position of certain very large cities at the expense of lesser cities, rather than to centralization within a given area. Specifically, recent advances in communication, the rapidity of air travel, and the growth of electronic data processing appear to make district offices less necessary relative to regional offices, and regional offices less necessary relative to central or national offices. In short, technological progress has made greater centralization both possible and desirable in office and managerial control functions.}\]

Physical Definition

The Houston City Planning Department has defined the Central Business District as consisting of two parts--the "Core" and the "Frame." The Core is the concentrated heart of the district, those blocks in the city with the most intense land use, the tallest buildings, the greatest concentration of daytime population and business activities. The Frame consists of surrounding areas contiguous to the Core that contain similar characteristics but in considerably less concentration.

The limits of the Frame may be physical boundaries, or they may be arbitrarily drawn at some point where land use characteristics show a sufficient deviation from those in the Core. In the case of the Houston CBD, the City Planning Department has defined the Frame area limits as the edges of the freeway inner loop on the north, east, and west sides, where a definite physical barrier exists, and at Elgin Street on the South.
Fig 3: Population and Employment Projections, Harris County

Fig 4: Employment Trends, Houston CBD

Fig 5: Daily Trip Ends, Houston CBD

Fig 6: Trends in Office Space, Houston CBD
Employment Projections

The number of people employed in the Central Business District in 1960 was approximately 78,000. Based on demographic forecasts, employment is expected to grow by $154\%$ by 1990, to approximately 198,000.

Within the CBD there will be a trend towards a higher percentage of office jobs, reflecting the changing role of the CBD as well as a shift in the economic base structure in the Houston area. This shift entails a decline in agricultural jobs and an increase in manufacturing, finance, insurance, and real estate.

Future Physical Requirements

The continued growth of jobs within the CBD is dependent on many economic, physical, and psychological factors. Assuming the economic predictions are accurate, the physical requirements which must be met are:

Office space
If 75% of the 86,000 new jobs predicted for the CBD during the next twenty years are office jobs, this will require over 15,000,000 square feet of new office space in addition to the 16,000,000 square feet available in 1969.

Accessibility
An increase in daily trip ends in the CBD of 345,000 is
predicted by 1990, over the 415,000 of 1970. The situation will only prove tolerable if workers, shoppers, and visitors can reach the CBD without undue congestion, strain, and delay.

Internal circulation
Once having reached the CBD, people need to be able to move about freely and comfortably and with as much efficiency as possible. The need to reach and communicate with other users and the need to share common facilities is essential to the life of the CBD.

MOVEMENT GENERATORS

OFFICES (Figure 9) are the most conspicuous building type in the CBD. Occupying 51% of the total floor space in 1969, the generator of most of the daytime population, and the building type which will show the most increase in the future. There is a strong clustering pattern seen by plotting the locations of the largest office buildings, with the centroid lying somewhere about McKinney Street, one or two blocks west of Main Street. The Texas Eastern project which has been announced for the east side of the CBD may draw the centroid back toward Main Street.

BANKS (Figure 10) do not show as strong a tendency to cluster as offices, but there is a noticeable linear pattern for which Main Street serves as a spine. Banks relate to office buildings, in many cases the bank occupies the lower floors
of the building. There is a functional relationship between business and finance which is expressed in this physical relationship.

RETAILING (Figures 7, 8) shows the strongest pattern of all in the CBD. A plotting of all department stores, clothing stores, jewelers, and shoe stores, shows that Main Street serves as the spine of the downtown shopping district, with 100% of the department stores, 77% of the clothing stores, and 63% of the shoe stores having a Main Street address.

This shopping district stretches for 12 blocks or almost 4000 feet along Main Street, exceeding pedestrian walking distances. There is a tendency for sorting according to price of goods, however, with a cluster of discount stores and credit clothiers located north of Texas Street in the 300 and 400 blocks. The primary retail block is the 1100 block with the two largest department stores occupying either side of the street, and the more exclusive small stores located in this vicinity. Medium price stores usually locate somewhere between the two poles. Several men's clothing stores have been drawn to the west of Main Street toward the centroid of office buildings.

There is no strong pattern for other types of retailing in the CBD, such as furniture stores, office supply dealers, etc. Generally, these uses occupy older or fringe areas.

Retail trade is no longer the principal activity within the
CBD. In 1969, retail activities accounted for only 13.2% of the total floor space. CBD retail sales dropped from 50.5% of total city sales in 1948 to 22.5% in 1963. The number of firms decreased from 1590 to 1060 during that same period.

GOVERNMENT SERVICES (Figure 11) are clustered in two general areas: the Harris County Court buildings are grouped in the northeast quadrant of the CBD, and the Houston Municipal buildings are located in the Civic Center area on the western edge. There are related Federal buildings in each group.

CULTURAL AND ENTERTAINMENT (Figure 12) facilities are scattered throughout the CBD. Cultural (public) facilities, which include a symphony hall, theater, convention center, coliseum, library, and museum buildings, are located in the Civic Center. Private entertainment facilities are relatively scattered with seldom more than one facility per block. Most of these are located in the older part of town.

HOTELS (Figure 13) in the CBD account for approximately one-half the total number of hotel and motel rooms in the city. There is no strong pattern of groupings among the hotels. Functional relationships exist between hotels and transportation facilities, offices, and cultural facilities.

Other land uses in the CBD, including residential and industrial, but excluding parking, accounts for 6.3% of the total floor space. Both residential and industrial use is on a decline.
24 Hour Traffic Volumes

Fig. 14

Freeway Access

Fig. 15
THE EXISTING MOVEMENT SYSTEMS

The Automobile System

A discussion of movement systems must begin with the automobile system, which is the major form of transport of persons in U.S. cities today. In the Houston area, 96% of all trips are made by private automobile. The comfort, speed, and convenience of door-to-door transportation by automobile is well-known.

The Freeways

Houston has a classic Freeway System of radials and circumferentials. The hub of the system is the Inner Loop which, as mentioned previously, has been largely adopted as the limits of the CBD Frame.

Automobile access to the Houston CBD is presently very good compared to other cities of comparable size. During the 1960's travel time to the CBD improved along all major freeway corridors except one (Gulf Freeway) due to improvements and additions to the Freeway network.

The relatively easy automobile access accounts for the high percent of trips to the CBD by private automobile—approximately 80%.

The One-Way Street Grid

Another important factor contributing to good automobile access to the CBD is the one-way street grid. The street
right-of-ways are wide (80' typically) and uniformly spaced (330' on center) in each direction, accounting for 44.5% of the surface area of the CBD. All major streets with the exception of Main and Franklin are one-way traffic streets, with up to five traffic lanes. Intersections are controlled by a pretimed signal system coordinated through a master controller.

One important quality of the grid street system in the CBD is its comprehensibility to the motorist. Being a uniform grid with alternating streets moving in opposite directions and having a uniform and highly visible system of controls, the CBD street system can be comprehended almost at once. Having no difficult maneuvers, it creates confidence in the driver, who knows that if he is misdirected he must only go one or two blocks to reach a street traveling in his direction.

However, the multipurpose nature of the CBD streets creates serious functional conflicts. For example, the same street which has a local function—giving access to individual buildings and lots—carries traffic volumes equal to a major arterial. This street may have access drives to parking lots and structures, parallel parking space with meters along the curb (usually restricted to non-peak hours) local bus traffic with its start-stop movement pattern, and high volumes of pedestrian traffic.

The 24-hour traffic volumes of individual streets recorded
in 1960-70 range from 4282 vehicles on Leeland to 26,856 on Smith Street.

A grid street system has a high number of intersections and consequently a high potential for accidents. During 1969, there were approximately 2000 accidents in the CBD; approximately 42% of all accidents occurred at intersections. The two two-way streets--Main and Franklin--had a large percentage of the intersection accidents.

Many of the streets connect directly to the freeways or parkways, particularly along the western edge. Of the twenty east-west streets within the inner loop, thirteen are connected on the west to a parkway or freeway ramp. The interconnection between street grid and freeway is, unfortunately, considerably more difficult to comprehend than the grid street system. Too often an uninitiated motorist will venture too close to the western edge of the CBD, perhaps looking for a parking place, only to realize that he is committed to an approach ramp for the freeway. Having no choice but to continue, he finds that his search for a parking place is soon carrying him at great speed up to the highway towards Dallas, and he must travel a considerable distance before he has an option to redeem his situation.

This very direct and quick access to the freeway system has undoubtedly affected land use in the CBD, however. The correspondence between the development of access and the shift of office centers to the south and west can be easily seen.
Fig 16
Off Street Parking Structures

Fig 17
Off Street Parking, CTD
Parking Facilities

Presently there are some 50,000 parking spaces within the CBD. Most of these, approximately 30,500 off-street spaces and 3,500 curb parking spaces, are concentrated in the Central Traffic District (CTD), an area encompassing the Core of the CBD and extending fourteen blocks along Main Street, from Leeland to Franklin, and including mostly six blocks on either side. Of the buildable land area within the CTD, 45% is occupied by parking lots and garages.

Of the 30,500 off-street parking spaces in the CTD, 14,000, or 46% are in parking structures. The remaining spaces are in parking lots. In many cases the parking lot may be an interim land use and the land will in the future be developed for a higher use. Thus future building development will increase the demand for parking space but may, in fact reduce the supply.

One solution commonly advocated to meet the demand for parking space is for each private developer to provide the parking space for his own building. To examine how this solution works, let us assume an office building to be built housing 1,000 office workers. The present transportation modal split in the CBD is 80% private/20% public. Thus we can deduce that 800 workers will commute to their jobs by private automobile. Cordon counts in the CBD have established that the average automobile occupancy is less than 1.5 persons per vehicle. Thus these 800 workers will bring 533 cars to be stored.
Accumulation of Vehicles & Persons, CTD 1965

Trip Ends per Day, CTD by Mode
The 1000 office workers will require an office building with an area of 250,000 square feet (250 s.f./person). The automobile will require parking space of 213,200 square feet (400 s.f./car). Thus the office building will require parking space of almost equal area.

The practice of providing office space with its own parking facilities has several disadvantages. If the office is in a prime location, then it requires the use of very high cost land for parking. If it is decided to stack offices above parking, or to create the popular "parking sandwich" with retail or service space at ground level, parking on the floors immediately above, and offices at the top, the result is usually a very inefficient parking structure with considerable space given up to the vertical circulation needs of the offices above, and corresponding compromises in the office structure. The parking facilities gained are very high cost space resulting in expensive parking fees. The results are also distressing at street level, where sidewalks are interrupted at mid-block by driveways and the gaping entrances of parking structures.

If we acknowledge that the purpose of the CBD is to bring people and facilities together, then we are defeating our purpose by giving up nearly one-half the total floor space for the storage of automobiles, thereby forcing people apart, causing loss of proximity which is vital for the success of the district.

Future Traffic Problems
The success of the automobile system and network improvements
made in the past decade have resulted in great increases in automobile usage. Continued increases in traffic as projected by the Houston-Galveston Area Council Study, ROAD AND TRANSIT, will result in substantial overloads on the network by 1990, even allowing for continued improvements to the system. This study also concluded that

The motor vehicle circulation network in the central Houston area, including its grade streets, parking facilities, and the freeway elements of the test networks, will be substantially deficient by 1975 and completely inadequate before 1990. Other solutions to these problems of downtown traffic access, circulation, delivery, and storage must be examined.

Public Transportation Systems

Public transportation systems operating within the CBD consists of

the local bus system
the intercity bus lines
the railroad passenger service
the airport transit service

The Local Bus System

The local bus system operated by Rapid Transit Lines, Inc., is the primary form of mass transit available in the CBD today. The company operates twenty-one routes to serve the CBD out of a total of thirty-three routes in the city. Most of the routes operate on collector or arterial streets to reach the CBD. There are also a few express lines which use the freeways to reach the CBD from outlying areas. Two lines are used
 existing public transit
specifically for internal circulation within the CBD; these are the North-South Shoppers' Special and the East-West Shuttle. All lines operate entirely in mixed traffic on the automobile street system.

The equipment used throughout the system consists of air-conditioned, diesel-powered coaches seating approximately fifty passengers. Fare is deposited under the driver's supervision upon boarding the coach. The standard adult fare is 45¢, with 5¢ added for each zone line crossed. Maximum fare is 65¢.

Routing within the CBD is diffuse. Of twenty east-west streets within the inner loop, eighteen have a bus line on them at some point. While this diffusion of bus traffic gives broad coverage, it complicates the bus system to a point beyond comprehension. Even the east-west shuttle travels on four different east-west streets. It is mentally impossible to associate that line with any one street—a fact which must discourage many potential transit users because of their own uncertainty as to whether the bus will take them to a destination they have in mind.

Loading and unloading of passengers at transit stops usually takes place on the street. Streets with relatively concentrated bus service have the stops marked with a small sign giving the names of the bus lines which serve the stop. Elsewhere the stop is signified only by a small metal pole. On many streets within the CBD the transit stops do not even have curb space. That is, curb parking is allowed and the transit
rider must walk out between parked cars to reach the stopped bus.

Waiting for a bus is seldom a pleasant experience. The person waiting is afforded no shelter from the elements and is generally required to stand at curbside because the bus may not stop unless hailed. When one waits for a bus on a busy street at peak hours, both sidewalk and street are usually crowded with traffic and there is little comfort in trying to stand between the two streams.

Another serious deficiency of the bus system, as compared to other modes of travel, is comfort afforded to the riders. Because they operate in the stream of automobile traffic, buses tend to use acceleration and deceleration rates in excess of comfortable standards for transit and which virtually preclude standing. Another cause of discomfort is the routing within the street grid which creates a large number of turns. Turns create uncomfortable centrifugal forces; also, the crowning of the street surface for drainage can create unpleasant roll effects within a bus when it maneuvers from one side of the street to the other.

A bus system has the advantage of almost unlimited flexibility. The system operates as a response to demand, and service can be extended, withdrawn, or changed as the demand requires. However, the lack of commitment to future service is perhaps one of the major factors in the dwindling of bus patronage, because the system does not furnish the image to which
developers and patrons can respond.

The Intercity Bus Lines
Intercity buses arrive at two terminals within the CBD—the Continental Trailways Bus System terminal on McKinney and the Greyhound Bus Lines terminal on Texas. Together these terminals handle an estimated 3000 passenger arrivals daily. Many of these arrivals undoubtedly have destinations outside the CBD and will transfer to other modes of transportation.

The Railroad Passenger Service
Rail passenger service to Houston has dwindled to an almost insignificant consideration. However, the upgrading of future passenger service on a nationwide basis is expected when the National Railroad Passenger Corporation takes over the operation of passenger service lines. This will undoubtedly stimulate the use of the passenger facilities located in Union Station on Texas Street.

The Airport Transit Service
Airport Ground Transportation, Inc. operates a bus line between the Houston Intercontinental Airport and several distribution points within the city. A downtown terminal is located in the Thomas Convention Center and stops are also made at four hotels in the CBD. Buses operate on twenty minute intervals on weekdays. A shuttle car is also operated to pick up passengers from other hotels on request.
Pedestrian Circulation

Pedestrian circulation is an often neglected area within the modern city. The increasing demands of the automobile have generally been met in city centers at the expense of the pedestrian on the street, by encroachments into the sidewalk space, by sacrificing such amenities as trees and planting space, and by the constant interruption of pedestrian movement by automobile traffic.

Within the Houston CBD we find that the generous street right-of-ways afford wider sidewalks and more generous pedestrian spaces than in many comparable cities. The typical 80-foot street right-of-way has a width of 50 feet devoted to automobiles, leaving a 15-foot pedestrian space on each side.

In most cases the quantity of pedestrian space on the street is adequate, but in terms of quality it falls far below expectations of comfort and convenience for a modern city. In this day of air conditioned cars, buses, and buildings, the sidewalk offers not even the most elementary of climate control devices. The pedestrian on the street is subject to the glare and heat of the Texas sun, rain, winds which are intensified around large buildings, and to the noise and threat of physical danger from automobile traffic. To cross a street usually means waiting at the corner for the traffic light to change, then dodging the turning cars which are still in conflict with the pedestrian movement.
Fig 21  Existing Pedestrian Tunnels
With the advent of larger building complexes within the CBD, especially highrise office towers, the building entrances are more often near the center of the block, rather than at the corner. To move from one such building to another directly across the street requires a circuitous route by sidewalk: Walking down to the corner, crossing with the light, then walking back up the sidewalk on the other side of the street. In this day of sixty mile-per-hour freeways, and 250 foot-per-minute elevators, such circulation seems to be an anachronism.

The pedestrian tunnels that have developed in the CBD during the past decade are a result of the need for a more comfortable and convenient pedestrian connection between buildings. Presently thirty blocks are connected with one or more other blocks by pedestrian tunnels; the largest continuous system connects five blocks. However, with the completion of all presently proposed tunnels, at least sixteen blocks will be connected, and the potential exists for expanding the tunnels into a comprehensive pedestrian network below grade.

The tunnel system, for the most part, has been developed privately and in piecemeal fashion with no master plan. It has some serious deficiencies which may become even more critical as the system is expanded. For traveling several blocks, the tunnels may be even more circuitous than the sidewalks, as construction has always followed the line of least resistance. Tunnels zig and zag and hump up and down to avoid existing utilities, foundations, and other underground conditions.
Comprehensibility is very low; in fact, probably very few people understand more than a few sections of the tunnel systems. After traveling a short distance, one becomes confused and disoriented. Worst of all, however, is that the tunnels offer a dull and monotonous environment from which the excitement and scale of the city are completely excluded.
FOOTNOTES, SECTION A


2. Wilson et al, Ibid.


4. Houston City Planning Department, CBD TODAY, pp. 2-6.


8. Houston City Planning Department, CBD Floor Space Projections, unpublished report, 1970.

9. Houston City Planning Department, Ibid.

10. Wilson et al, Ibid.

11. Houston City Planning Department, CBD TODAY, p. 21.

12. Houston City Planning Department, Ibid.


14. Houston-Harris County Transportation Study, HOUSTON CBD REPORT, p. 4.

15. Wilson et al, Ibid.


Footnotes, Section A

20. Ibid, p. 11.
24. Houston-Harris County Transportation Study, p. 6.
25. Houston-Harris County Transportation Study, Ibid.
28. Based on information from interview with Rapid Transit Lines, Inc.
29. Ibid, Interview with Rapid Transit Lines, Inc.
Many advanced forms of human accomplishment are complex in the sense that they require close interrelations among large numbers of people in order to be achieved. Since long-distance communication is not a satisfactory form presently for many of these interrelations, people resort to locations of dense habitation in order to facilitate them. In the city an individual has access from his bases of operation to the maximum number of participants in other activities, thus maximizing potential interaction.

The primary function of urban transportation, then, is to provide the characteristic of accessibility to locations in the city... This accessibility is unevenly spread because some locations are necessarily closer to the rest than others... we can define transportation planning as the selective distribution of access in urban space.

Ralph A. Gakenheimer Urban Transportation Planning: An Overview TAMING MEGALOPOLIS
SECTION B: FORMULATING A TRANSPORTATION CONCEPT

POTENTIAL TRANSIT SYSTEMS

Transportation systems can be broadly divided into two categories:

- INTENSIVE systems
- EXTENSIVE systems

An INTENSIVE system is one in which carrying capacity is high, but the range of operation may be limited. Furthermore, access to and from the system may be limited to specific and widely spaced points, creating nodal patterns of access. The intensive system is exemplified by a high capacity Rail Rapid Transit system, such as that soon to be in operation in the San Francisco area for the Bay Area Rapid Transit District (BARTD). Because of its high cost, the BARTD system will have only 75 miles of route in its first stage, but it has a capacity for moving 30,000 people per hour per line of track.

An EXTENSIVE system is one which has very broad coverage, but has a lower carrying capacity on any one of its links. The extreme example of an extensive system is the Private Automobile system, which can provide door to door access from virtually any one point to any other point in the city, and can likewise function between cities, states, and even countries via the extensive and complex network of streets, highways, and freeways that has been built in this country over a period of many years. The standard capacity of an
### Comparison of Transit System Vehicles

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>VEHICLE CAPACITY</th>
<th>MAX SPEED</th>
<th>TRAIN LENGTH</th>
<th>MIN HEADWAY</th>
<th>LINE CAPACITY (PPM/HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARTD</td>
<td>72</td>
<td>80 mph</td>
<td>2-10 cars</td>
<td>90 sec.</td>
<td>50,000</td>
</tr>
<tr>
<td>TRANSIT EXPRESSWAY</td>
<td>28</td>
<td>70</td>
<td>1-10 cars</td>
<td>75 sec.</td>
<td>16,000</td>
</tr>
<tr>
<td>EXPRESS BUS</td>
<td>53</td>
<td>55</td>
<td>1</td>
<td>60 sec.</td>
<td>20,000 *</td>
</tr>
<tr>
<td>MINI BUS</td>
<td>24</td>
<td>30</td>
<td>1</td>
<td>60 sec.</td>
<td>15,500 *</td>
</tr>
<tr>
<td>MINI RAIL</td>
<td>12</td>
<td>15</td>
<td>1-4 cars</td>
<td>50 sec.</td>
<td>8,400</td>
</tr>
<tr>
<td>CARVEYOR</td>
<td>4-10</td>
<td>15</td>
<td>continuous</td>
<td>-</td>
<td>9,000/11,000</td>
</tr>
<tr>
<td>MOVING SIDEWALK</td>
<td>1 per 4 sq. ft.</td>
<td>2.5</td>
<td>continuous</td>
<td>-</td>
<td>8,000</td>
</tr>
</tbody>
</table>

* X on exclusive right-of-ways
expressway lane, for comparison, is 1500 vehicles, or 2250 to 3000 persons per hour.

The relationship between transportation system and land use is very clear. An INTENSIVE system not only encourages, but, for successful economic operation, requires high density land usage at points of access along the entire length of its operation. An EXTENSIVE system, on the other hand, encourages spreading out, or low density land usage.

In addition to these two extremes are a whole range of transportation systems, both existing and proposed, which have potential for use in the Houston area. The following section will enumerate and compare those systems which have implications for the Central Business District.

High Capacity Rail Rapid Transit - the BARTD System

The BARTD system is the first totally new mass transit system to be built in this country in more than fifty years. It is also the first to openly challenge the automobile in terms of speed and comfort. The system uses lightweight aluminum vehicles which will run on steel wheels on steel rails, each car being self-powered by electric motors with power pick-up from a third rail. Automatic Train Control will be employed, allowing trains to run at ninety second intervals during peak hours. Stations are spaced an average of two miles apart, and the system is designed to maintain an average speed of fifty miles per hour.
The majority of the route is to be on elevated structures, or at grade. About one-fourth of the route is underground, this mostly in the three major urban areas, San Francisco, Oakland, and Berkeley. In San Francisco the trains will run approximately seventy feet below grade. The BARTD system, as compared to conventional urban transit, is more nearly a high-speed, luxurious interurban and commuter service.

The Transit Expressway

The Transit Expressway, a new concept developed by Westinghouse in collaboration with the Port Authority of Allegheny County and others, is conceived to fit the needs of a medium density metropolitan areas for urban service, and is not intended for intercity use. It is a system based on the use of a lightweight, electrically powered, rubber tired, driverless vehicle, operating singly or in trains. The roadway has two tracks, which are twenty-two inch wide ribbons of concrete, with a steel guide beam mounted in the center. Other running gear arrangements, including overhead suspension, are feasible. The concept calls for computer controlled, constant service around the clock, with trains passing a given point at two-minute intervals. Capacity would be varied by adding or subtracting vehicles from the trains.

The basic technology of the Transit Expressway has been demonstrated in a full scale test system near Pittsburg. The test system uses vehicles with twenty-eight seats; however, the system is capable of being scaled up or down to meet varying
needs. For example, a seventy-two mile rapid transit system has been proposed for Baltimore using the Transit Expressway, as has a small (4800 ft.) loop system to provide internal circulation in the Post Oak Center in Houston.

While offering slightly less speed and capacity than conventional rail transit, the Transit Expressway promises lower capital costs, lower operating costs, greater flexibility, quieter operation, and lighter structural requirements.

Upgraded Motor Bus Transit

Motor bus transit in Houston still has much undeveloped potential. With only about 350 vehicles serving almost as many miles of route, the bus system can be considered extensive, but certainly not intensive, in its present form. From the point of view of capital investment and time required to enact improvements, upgrading the bus system appears extremely attractive.

The public has not been attracted to use bus transit, even by improved, air conditioned equipment, because it does not offer the convenience or speed of the private automobile. Since bus transit operates over the same streets and expressways as the automobile, it is subject to the same rush hour congestion and delays, and in addition has delays caused by the necessary stops along route. Other user disadvantages of the system, as it now exists, are enumerated in Section A.
Reserved Bus Lanes

One solution which gives bus transit an advantage is to reserve lanes of the existing roadway system exclusively for buses, especially in the areas subject to rush hour congestion. Buses would then be able to move freely in their own lanes, although they would still be subject to traffic control measures such as traffic signal lights. Although the private automobile would lose some lane capacity, it would have the advantage that buses would no longer operate on ordinary streets in the core area, and buses stopping for loading and unloading passengers would no longer hinder movement of automobile traffic. For bus patrons this has the advantage of making bus service more intensive (if less extensive) by concentrating bus traffic on certain streets and making the pattern of bus movements more conspicuous, hence more comprehensible. As a part of the upgrading policy, patron amenities should be incorporated, such as:

- Bus shelters and benches,
- Currency changers or fare vending machines,
- Top level graphics and visual design criteria aimed at increasing the comprehensibility of the system.

Express Bus Service

The concept of an express bus service connecting the CBD with suburban zones, if combined with reserved bus lanes in the congested area, has many of the advantages of a rapid transit system. An express bus would have few delays from stops on route and if it were able to circulate within the CBD core on reserved lanes, it should be able to offer average speeds
comparable to the automobile. To add bus lanes to the existing freeways, however, especially around the inner loop with its very complicated interchanges, would appear to be very costly, if not impossible.

The upgraded bus system could be an immediate measure, with the reserved bus lanes expanded in a gradual manner in order to minimize disruption of automobile traffic. It does not involve a large capital investment whose future utility is doubtful. According to PROJECT METRAN, the concept is "essentially a redistribution of present capital (i.e., roadways) to a different mode, mass rather than private, in order to gain an overall savings in congestion . . . . The system is evolutionary in that it can grow or contract with changing demand, and in that it can change its form through planned obsolescence of vehicles to meet new types of demand or new technological improvements at minimum cost."

The bus system uses a great deal of labor for its operation, a fact which will surely mean higher costs of operation as time goes on. At best it cannot offer the riding comfort or market appeal of a good rapid transit system. Therefore, the real potential of bus transit is to serve as the main public transit for an interim period before a more technologically advanced system can be constructed, and then to compliment and balance that system.

Circulation/Distribution Systems
**Fig. 23** Average Speed of Bus

**Fig. 24** Bus Loading Time
Efficient internal circulation is essential within the CBD, and the area has reached a scale such that walking, however healthful, is not practical as the only means of internal circulation, even if the pedestrian had an idea system of walkways. The following mechanized internal circulation/distribution might serve the needs of:

a) Persons who daily drive an automobile and park in the CBD, who wish to move about without moving the automobile.
b) Persons who commute by automobile but might park at a less expensive, peripheral location, if they had access to a circulation system.
c) Persons who commute by public transit but need to move from the primary transit terminals to other points in the CBD.
d) Persons who might live in the CBD without an automobile, if their transportation needs could be met by public systems.
e) Visitors to the city who do not bring automobiles.

Mini Bus

The Mini bus concept has proven to be extremely popular in the cities of Detroit and Washington, where a smaller bus with a seating capacity of about twenty-five is operated on routes in the CBD to serve downtown shoppers and office workers. The mini buses operate on close time intervals and charge a nominal fare of five or ten cents. Such service on reserved bus lanes
FOR INTERNAL CBD CIRCULATION, DISTRIBUTION AND COLLECTION OF EXPRESS BUS OR RAPID TRANSIT PASSENGERS, AND SHUTTLE SERVICE BETWEEN CBD CORE AND PERIMETER PARKING FACILITIES, DESIGNED FOR EASY ACCESS/EGRESS, TO MINIMIZE LOADING TIME.

Fig. 25 Mini Bus Design
in the CBD core could offer convenient internal circulation, as well as distribution for the express bus, and eventually, the rapid transit.

With a bus stop at every second block, the mini bus would have at least eight stops per mile. Average speed then becomes largely a function of the time required for loading and unloading passengers (Figures 23, 24). PROJECT METRAN proposes a bus vehicle design which uses multiple doors to minimize loading time (Figure 25). Such a vehicle necessarily dispenses with fare collection by the driver, another time-consuming procedure. Fares would either be collected remotely, or dispensed with altogether. In the latter case, revenues for operating the system would be derived from other sources, such as assessments on property within certain proximities to the bus stops, revenues from the express bus or rapid transit service, etc. The obvious analogy is with elevator service in a high rise building, the cost of which is not paid by the immediate user, but shared by all those who benefit from the service, i.e., the occupants, through their rent.

Minirail

The Minirail system, developed in Switzerland, has been successfully demonstrated at several expositions, including Montreal's Expo 67. It uses a series of small, twelve-seat cabins joined into trains, making tight radii possible. It runs on a central steel track using automatic, driverless control. The Minirail's chief advantage is the minimum space
requirements and visual obstruction of the infrastructure, being suited to routing over existing sidewalks and streets and even through buildings. The U.S. Pavilion at Expo 67 was designed with the minirail penetrating the main space of the building, but not stopping. The result was a tremendous, dynamic visual experience for riders and spectators alike, and demonstrates the kind of excitement which new transit systems could add to the urban environment.

Carveyor
Designed by Goodyear, the Carveyor system is a continuous running system, using cabins with from four to ten seats, propelled by conveyor belts at fifteen mph. At boarding intervals of 1200 feet, the cabins slow to one and a half mph. The boarding platforms are pedestrian conveyors moving parallel to the track at the same speed. After passing the boarding platforms, the cabins accelerate again to fifteen mph while simultaneously spreading out to a wider spacing.

The first permanent installation of the Carveyor system will be in San Jose, California, where a six mile system will link perimeter parking areas with downtown areas.

Moving Sidewalks
Moving sidewalks, at least in simplified form, offer no speed advantage over walking. However, they do offer an effortless, restful way to move short distances. Because it is a no-wait system, almost effortless to board, and adaptable to almost any interchange spacing, especially short spacing, the moving
sidewalk has some definite advantages for use in major activity centers with high pedestrian traffic volume.

A BASIS FOR LONG RANGE PLANNING STRATEGY

In order to establish a basis for a planning strategy, let us first look at some general social or economic trends which have implications for transportation planning. These will be stated as three general assumptions:

First, that transportation will be a continuing and increasing facet of urban life. PROJECT METRAN explains the omnipresence of transportation: "people are now forced to move, to execute trips, in order that the basic needs and the pleasures of their lives are to be satisfied. As specialization of functions increases in our society, the need for high-volume, high-speed transfer of information, goods, and people will greatly increase. In a very real sense, transportation is 'everywhere, everything, everyone, all the time'.'\)

Second, that relative costs of various inputs to our economy are changing. Labor is becoming more expensive in relation to capital per unit of output; land is becoming scarcer and more valuable in urban areas. A movement towards automation seems reasonable, as does the need for more efficient use of urban space.

Third, that cities exist is a state of continuous and accelerating change, and that firm, long-range predictions are generally inaccurate due to the inability to anticipate future
technological, economic, or political developments. There are many future unknowns and we must therefore design for uncertainty.

Specifically, we know that the Houston CBD is fast approaching the limits of the automobile system which is its primary mode of transportation. We also know that for the next five years the CBD will continue its growth and development at a very high rate by virtue of sheer momentum. We have the advantages of comparative statistical data from other cities and other points in time, to see if there are consistent patterns, relationships, etc. We also have a short range view of Federal government policies concerning cities and transportation.

For the long range, however, we have few fast and hard facts on which to base decisions. We find that many of the long range predictions for Houston are straight-line projections of figures which may have been estimates to begin with. If these projections are realistic, then it is obvious that new solutions will be required to handle the future transportation requirements of the CBD.

The time-lag factor involved in implementation of major new transportation systems is great, requiring that plans be made years in advance. The static approach to transportation planning, i.e., designing an optimum system for a certain target date, say, of twenty or thirty years in the future, might create problems of under-use of facilities before that date.
continuous cycle of analysis, action, and response.

The following quotation from Kenneth C. Orski represents current thinking about planning strategy:

In considering a comprehensive long-range transportation development plan for a metropolitan region, we can expect that even by the end of the first 5 years things will have changed . . . . The conditions would no longer correspond to the planner's initial set of assumptions and, therefore, would call for a modified plan of action. If changes have been relatively minor, the actions to be implemented in the subsequent stages of the planning strategy may stay the same; more likely, however, the later stages of the plan will likewise have to be revised because of further changes in critical conditions.

The planning process described involves an iterative or sequential approach. The transportation plan is conceived as a sequence of staged actions; at the conclusion of each stage, the planning strategy is revised and possibly modified in the light of fresh data acquired through observation and appropriate demonstrations.

PROJECT METRAN offers the following Dynamic Staging Strategy:

Let us now delineate the general guidelines for the staging of the transportation system over time. First, it is desirable to examine steps which could be implemented soon at little cost and offer improvements in service over the next ten years. These steps must consider the costs of adapting to future programs . . . . Second, it is desirable to use experimental demonstrations desired to test the marketability and feasibility of new systems. Demonstrations could either be in certain areas or spread over the whole area, depending on the cost of the demonstration and what we wanted to test. Third, when we are looking further into the future, we have insufficient data, so it may be desirable to hedge on the decision, or if there are two possibilities for development, see if we can find a reasonable cost way to keep both possibilities open. Fourth, we wish to make larger investments when we fee our success is insured.
Fig. 27. Decision Tree
Our procedure in making long term predictions is to allow for alternatives which we cannot predict or control, and suggest that we will apply the same sorts of constraints and guidelines then as we did now in order to plan the staging of our system. Paradoxically, only if we allow for our planning to be evolutionary will our system be evolutionary, and not just a bad or a good guess . . .

A useful conceptual framework for integrating some of the various policies discussed above . . . is the decision tree. In this structural framework, decisions, possible outcomes, possible future decisions, and their range of outcomes are shown . . . (Statistical analysis and market surveys) can be used to narrow the range of possibilities and to allow the design of experiments in which the consumer can experience the alternatives. These experiments can be monitored and evaluated by our combined real-time analysis and simulation. Once the decision is made, its implementation will also be monitored and evaluated so that it too will serve as an experiment to aid future decisions.17

Our planning strategy, therefore, should be based on the concept of an ongoing and dynamic process of continuous assessment of future conditions and search, evaluation, and refinement of alternative solutions.
FOOTNOTES, SECTION B

2. Ibid.
3. Ibid.
6. MPC Corporation, Ibid.
7. Massachusetts Institute of Technology, PROJECT METRAN, p. 194.
11. Brian Richards, NEW MOVEMENT IN CITIES.
12. Massachusetts Institute of Technology, p. 3.
15. Robert B. Mitchell and Chester Rapkin, URBAN TRAFFIC, A FUNCTION OF LAND USE; and Roger L. Creighton, URBAN TRANSPORTATION PLANNING.
17. Massachusetts Institute of Technology, PROJECT METRAN, p. 192.
Section C

An Evolutionary Transportation Concept
MATCHING ACCESS TO GROWTH BY STAGING

In this section, a series of staged transportation improvements are proposed and discussed in detail. These are illustrated as concepts rather than as firm plans, and specific locations of system right-of-ways are chosen primarily to demonstrate the concept.

The first stage begins by reorganizing existing public transit equipment and existing street right-of-ways to create a more ordered, intensive service. It would have low fixed costs and could be implemented within one year from completion of planning.

The following stages would be longer range and higher cost improvements. They would be planned not only to integrate with first stage improvements, but would be planned upon information gained through these early improvements.

STAGE ONE: UPGRADE BUS SYSTEM

Goals:  
Increase Transportation Capacities Immediately  
Increase Public Transit Usage  
Increase Development Potential  
Test Public Response to Transit Improvements  
Test Development Response to Positive Transit Commitments
Fig. 28  STAGE ONE  Reserved Bus Lanes
Limitations: Existing Infrastructure
   Existing Transit Organization
   Low Capital Investment
   Immediate Implementation
   Minimum Constraint on Future Programs

Program: Establish Reserved Bus Lanes in CBD Core
   Expand Express Bus Service
   Establish Mini Bus Service
   Add Patron Amenities

Figure 28 shows a possible first stage configuration of
Reserved Bus Lanes established within the one-way street grid.
Main Street would be converted to a two-way Bus Only Street.
The other lanes would occupy a portion of a one-way street.
Incoming buses would make a loop on certain of the Bus Lane
Streets.

All bus lines would either cross or pass down Main Street,
reinforcing the already established role of Main Street as
the central transit street in the CBD.

Incoming Express Buses would operate most efficiently if turn
around time in the CBD is minimized. This means that express
buses would not want to make a lengthy distribution loop
around the CBD. Part of the distribution might well be
handled by Mini Buses if patrons were not subjected to long
delays and inconveniences while making the necessary transfers.
This question could only be answered by actual implementation
STAGE ONE  RBL partial plan
of test programs; however, patron acceptance would be more likely if transfer conditions could be optimized. Reserved bus lanes with buses operating on close headways, free transfers, and sheltered loading and unloading would greatly enhance transfer conditions.

Figure 29 shows in detail a portion of the bus lane system and illustrates a significant ramification of this transportation decision. Buses would occupy the lane on the right hand side of the street in order that loading and unloading could be carried on in the conventional manner. Automobile lanes would be on the left. Automobiles sharing the street with buses would then be free to move ahead or turn left at the proper intersections. If they turned right, however, they would be crossing the bus lanes, an unworkable conflict. Right turns for the automobiles would always be prohibited on bus lane streets.

Thus bus lanes can become an effective planning tool. The horizontal zoning of two functions on the same street has certain inherent conflicts; specifically, it can act to inhibit or prevent certain movements. By placing these lanes in a strategic pattern, one can create a kind of subtle automobile filter, without the necessity of closing streets to all automobile traffic.

There are several ramifications to the bus lane policy which should be carefully considered. One side effect, illustrated
Fig. 30

STAGE ONE RBL detail area A
in Figure 30, is that pedestrian movement on sidewalks parallel to the bus lanes would be greatly improved, because pedestrians would no longer have to contend with turning cars when they cross an intersection. Major building entrances and entrances to the tunnel systems could be oriented towards or integrated with the sheltered bus stops, to create a convenient network of pedestrian circulation.

Another consideration is that small business establishments fronting a bus lane will lose direct automobile access, especially if in a mid-block location. As these establishments may depend on the street front for servicing, loading space must be provided. One solution is to allow trucks or other service vehicles to use the bus lanes in off-peak hours. This would require that the lane be wide enough for one vehicle to pass another at curbside—probably a wise measure in any case.

Still another ramification is that it may be necessary to cut off access to certain parking facilities. In the long run, this will have a desired effect, because one purpose of the bus lanes is to define areas of intense pedestrian and transit usage, and, as much as possible, parking and cars should be restricted from these areas.

However, it is the intention to increase the overall accessibility of the CBD, and any elimination of parking facilities should be considered as losses of accessibility and entered on the minus side of the ledger. It would seem desirable to
recoup these facilities in another location; therefore, as a corollary to the bus lanes, parking facilities should be constructed outside the core, possibly as a buffer between the core and the freeway, or possibly on the less expensive land just outside the freeway. These could be constructed either by private or municipal action, and linked to the core by an extension of the reserved bus lanes to accommodate a mini bus shuttle, as shown in Figure 31.

By monitoring the response to the reserved bus lane program from both private developers and public transit users, important data can be gained to aid in decisions about future staged improvements.

STAGE TWO: RAPID TRANSIT SYSTEM, FIRST LINE

Goals:  
- Greatly Increase Transportation Capacities
- Greatly Increase Transportation Quality
- Decrease Noise and Pollution
- Increase Civic Qualities of the CBD

Limitations:  
- Creation of a New Transit District to Operate at a Regional Level
- Large Capital Investment Requiring Public Support
- Federal Aid for Large Capital Investment
- Very High Land Acquisition Costs Within CBD Core
- Transit Technology Which Has Been Proven

Program:  
- Construct a North-South Rapid Transit Line
The most serious problems with implementing rapid transit systems are the high cost and lengthy time period required to plan, promote, and build a new system. For example, the BARTD System in the San Francisco area has required a total of twenty-one years from inception to operation and a cost in excess of $1.2 billion. Washington has moved only slightly more rapidly with their METRO. Atlanta and Seattle have spent years planning and promoting but have not received the necessary public support for the bond issues for construction.

Among the twenty major U.S. or Canadian cities, Houston has the lowest population density and the lowest public transit patronage. If Houston had to go through the same process as the San Francisco Bay Area, i.e., convincing the public to support a billion dollar bond issue to build a transit system, then rapid transit might be a very long way off indeed.

One bright note in the future of rapid transit is the trend towards increasing Federal aid for capital expenditures on public transit. If this trend continues, and there is every indication that it will, then the local voters will only have to shoulder a fraction of the cost of a new system.

Another hopeful development has been the creation of systems
such as the Transit Expressway specifically for medium density cities. This has the potential of lowering initial costs, as well as the density requirements for successful financial operations of the transit line.

Right-of-way costs and construction costs are still serious factors, however, as construction costs for urban subways have frequently run fifteen to twenty million dollars per mile. To reduce these costs would have significant benefits. Within the CBD, where land values are at a maximum, existing public right-of-ways should be utilized wherever possible. This would avoid acquisition costs of very high cost real estate and would also avoid removing property from the tax roles.

Means of reducing construction costs should also be explored. The decision to go with overhead or underground routing is a critical consideration, as pointed out in URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY: "The development of elevated structures which are aesthetically acceptable in densely built-up downtown areas is the one improvement to the supporting way that seems of major potential significance. Using elevated, rather than subway construction could conceivably reduce capital costs by $10 million per mile and thus cut total money costs per passenger-mile in half."

Another consideration in determining construction through a dense area such as the CBD would be the degree of disruption of business and transportation services during the period of
STAGE TWO  Rapid Transit
construction. The process of building a cut and cover subway is both long and highly disruptive, involving the noisy operation of driving sheet piling, underpinning adjacent foundations, then excavating through existing utilities, removing high quantities of earth, pouring concrete for the tunnel structuring, then restoring the street surface. If the more expensive process of boring subway tunnels is used, the cut and cover process would still be necessary at the stations.

On the other hand, an overhead system could conceivably be designed for prefabrication and rapid erection of the roadway structural elements, bulk excavations could be eliminated, and drilled foundations might be used instead of driven piles.

Climate is still another factor in the choice of routing. Houston does not have the snow, ice, and freezing weather which hampers transit movement in northern cities, so another reason for subway construction does not exist here.

Figure 32 shows a possible alignment for a Rapid Transit line moving in a north-south direction through the CBD. Unlike the loops of the bus system, the rapid transit alignment would respect the straight line nature of a tracked system. The Main Street alignment seems obvious at this point in time: it would reinforce the traditional role of Main Street as the spine of the CBD, and it would recognize that the greatest intensity of development now lies in the blocks to the west of Main Street, but that the blocks to the east have the greatest potential for future development.
Fig. 33 STAGE TWO

Fig. 34 STAGE TWO  Rapid Transit
Three transit stations are shown within the inner loop. The central station is located near what is now the centroid of the office development; the ones to the north and south would stimulate redevelopment of these areas. A fourth CBD station might be located to the south of the freeway loop.

The stations are located at the intersections of the bus lanes and the rapid transit line, such that distribution to farther points within the CBD could be accomplished via the mini bus.

An overhead alignment has been investigated because of the economic reasons mentioned above. To reach the CBD core, an overhead line would have to cross the elevated Inner Loop Freeway at an elevation of forty to forty-five feet above grade. Rising to this height would give the passengers a good vantage point for viewing the city and a sense of entering a special area. The line would then descend to an elevation of about thirty-five feet which would be maintained within the core.

As shown in Figures 33 and 34, the 35-foot elevation of the overhead transit line would allow an intermediate level for pedestrian circulation above the street. At this level, pedestrians would enter the station where they would purchase a ticket from a vending machine or use a credit card to enter through turnstiles to the escalators leading to the loading platform above.
Fig. 35  STAGE TWO R/T Loading Platform
The loading platform, Figure 35, would be like a long elevator lobby, with sets of doors alternating with glass panels giving a view of the surrounding city. Lighted signs above the doors would direct passengers to the proper doorways for loading, thus avoiding much of the confusion and hassle when the train arrives. The entire station would be clean, well-lighted, air conditioned space—a far cry from the dismal subway stations in older systems such as that in New York, and a great improvement in the quality of transit facilities previously available in Houston.

A rapid transit system with one line moving in each direction, using the Transit Expressway vehicles similar to those proposed for Pittsburg, would have a capacity for delivering 32,000 people per hour. Divided equally between the three CBD stations, this is still over 10,000 people per hour arriving at one location. Added to this would be people arriving by bus.

With a relatively great concentration of transit users around the rapid transit stations, transit related commercial activities would tend to cluster around the stations and along the routes between the stations and the offices where most of these people work. Multi-level pedestrian circulation would allow these activities to cluster tightly around the stations.

The final question remains: What about civic qualities in the CBD? Would an elevated scheme create another Chicago "El," sacrificing everything for a cheap solution? Figure 36 shows
Fig. 36  STAGE TWO  Overhead Transit Station and Mall
that this is not necessarily the case. The concentration of activities would require some breathing space for pedestrians. Therefore, a Main Street Mall would become a viable concept. The proper spacing and proportioning of the structural members could give visual order to the street scene; the occurrence of overhead stations could break the scale down from the unending vista that exists now to a limited vista to which the pedestrian could relate; the visibility of all elements could give a comprehensible order to the whole.

Much depends on the quality and refinement which can be achieved in the transit vehicles themselves, the quietness of the operation, and the appropriate scale of the vehicles in relation to the scale of the city.

While it is possible here to imply a solution, the relationships between the movement system and the existing city structure have not been fully explored. The implication of movement are enormous, and should be thoroughly evaluated.

THE VIEW FROM THE ROAD, by Appleyard, Lynch, and Myer, was a pioneering work in establishing criteria and methodology for the design of movement systems. Also Walter A. Netsch has searched for a basis for evaluation:

Aesthetic logic, if such logic exists, requires in a movement system that participates in the environment a perceptive attitude on continuous interaction, such as exists in contemporary films. In an urban context short straights, equivalent zooms, wipes and changes of pace are similar. Added capabilities of varying height, interaction with interior and exterior form, could enhance the visual opportunities.
Fig. 37 STAGE THREE Circulation/Distribution
STAGE THREE: CIRCULATION/DISTRIBUTION SYSTEMS

Goals: To Increase Efficiency of Internal Circulation
To Extend the Reach of Rapid Transit Service
To Reduce Transit Labor Costs by Automation

Limitations: Technological Development
Physical Constraints of Built Infrastructure

Program A: Moving Sidewalks at Major Activity Areas
Program B: Minirail Distribution Loop

Stage Three considers optional developments for enhancing the internal circulation of the CBD. Such developments are optional because they do not deal with the primary issue of transporting people to the CBD, but rather with the secondary issue of saving them time and effort in moving around once they are there. However, the availability of such systems will have greater implications as the CBD expands in size and density, and will have considerable bearing on people's choice to go to the CBD, as well as their choice of what mode to use, as pointed out in Section B.

Stage Three systems would be alternatives to the mini bus system for internal circulation. Reasons for using these alternatives would be:

1. The demand for service being greater in certain areas than the buses alone can provide.

2. The demand for faster and more efficient service between certain points than the buses can provide.
Fig. 38  
STAGE THREE  C/D Systems
3. The desire to eliminate bus lanes in order that the space can be reassigned to either pedestrian or automobile use.

4. The overall cost advantages of automated systems over the high operator cost bus system.

Stage Three systems could be flexible regarding timing. While conceived to complement the major transit system, the internal circulation systems could be installed either currently with, before, or after the rapid transit line is installed, or not at all, if the demand can be satisfied as efficiently by existing systems.

Program A: Moving Sidewalks at Major Activity Centers: The potential of moving sidewalks can best be expressed by the concept "horizontal escalators." An appropriate usage would be as short range collection and distribution networks around the rapid transit stations. Figures 37 and 38 show an elevated pedestrian circulation network between two rapid transit stations. Figures 33 and 34 also illustrate the elevated moving sidewalks.

Figure 39 illustrates a view from an elevated moving sidewalk overlooking the Main Street Mall. Circulation at this level offers increased comprehensibility over that in underground tunnels.

Program B: Minirail Distribution Loop. Figure 37 shows a distribution loop system which would connect with the north
Fig. 39  STAGE THREE  Elevated Moving Sidewalk
and south rapid transit stations and would distribute passengers to the east and west sides of the CBD. It would be a single, one-way line to minimize the space requirements of the infrastructure.

Stops for the minirail loop could be in major public spaces, as shown in Figure 40, or could actually be integrated into a second floor lobby of a building.

The Circulation/Distribution Systems would provide focal points for a grade separated, second level pedestrian circulation system. As shown in Figure 33, the existing pedestrian tunnels could also be linked with the system by the use of moving stairways.

STAGE FOUR: RAPID TRANSIT, SECOND LINE.

As rapid transit systems are extended to other corridors of the city, it becomes necessary to add additional lines through the CBD core. One approach to this problem is to build in extra capacity in the first stage, such as additional subway tunnels to be used when the need arises. This approach not only increases the initial cost burden, but it is a heavy commitment to a plan without allowing for the possibility that future conditions may demand something else.

A more valid approach would be to allow decisions about when, where, and how to build second or third lines to remain open such that selection can take place not only from the alternatives we can arrive at now, but also the ones that will
Fig 40 Minirail Distribution Loop
present themselves later.

Another side of the issue, however, is to insure that actions preceding such delayed decisions do not preclude any of the significant alternatives. For example, the decision to allow private developers to build on air rights over the street may preclude a whole range of future transportation developments. Therefore, it is necessary to visualize and evaluate as many long range developments as possible and establish policy decisions designed to keep the alternatives open.

Figure 41 shows possible alignments for future rapid transit lines. A parallel alignment would greatly stimulate land use between the two lines. Interchange for passengers from one line to another would require an efficient people-mover system connecting two stations.

Crossing alignments would require grade separation and would suggest that subway construction would be necessary. Depending on routing decisions outside the CBD, on technological developments and the speed and scale of transit vehicles, this might be the proper alternative for alignment of future lines.

In any case, it would be wise to keep open two or more alternatives for future stages as well as the alternative to make no further public transit investments, until such time as the plans must be fixed. This would avoid "locking in" plans at too early a date and would allow planning to take advantage of
developments and data gathered during the interim period.
FOOTNOTES, SECTION C

1. San Francisco Bay Area Rapid Transit District, OFFICIAL STATEMENT RELATING TO $50,000,000 SALES TAX REVENUE BONDS, 1970.

2. Automotive Safety Foundation, URBAN TRANSIT DEVELOPMENT IN TWENTY MAJOR CITIES.

3. Tax Foundation, Inc., URBAN MASS TRANSIT IN PERSPECTIVE.

4. MPC Corporation, TRANSIT EXPRESSWAY REPORT.


SUMMARY AND CONCLUSIONS

The Houston Central Business District has its legacy from the past: an unimaginative but generous grid of streets. It also has a legacy from the 1950's: the Inner Loop Freeway which places the CBD at the hub of a classic automobile circulation network of radials and circumferentials, to which the Nineteenth Century street grid is connected.

The automobile has become the primary mode of transportation for Houston. Whether the desire for personal mobility created the demand for automobiles, or whether the desire for new and more spacious quarters necessitated them, public policy has encouraged and reinforced the automobile's dominant role.

The almost overwhelming response to the automobile suggests a great concensus between the personal desires of the masses and the broad economic forces which encourage high levels of consumption. The results, however, are now being felt as both environmental and economic strains.

The automobile has brought on widespread decentralization in cities. The effects of decentralization on the Houston CBD have been a rapid resorting of activities, with housing and industry moving out and with them, the more generalized activities, while specialized activities serving the whole metropolitan region or the whole country remain and grow. The fact that these activities have centralized and grown
during a period of general decentralization indicates that they are willing to pay high rents in order to occupy a centralized location, or to function in close proximity to related activities.

The viability of the CBD is dependent on the economic health of the region and on its accessibility from the region. Its greatest danger is congestion which cannot only choke access to the CBD but can choke the circulation system for the whole region.

The chief disadvantages of the private automobile, which show up in densely developed urban areas, are the space requirements for its operation and storage. In order to accommodate the automobile, many other considerations affecting the efficient operation of the CBD must be compromised. The chief advantage of public transit is more efficient utilization of space. Thus, public transit has an important range of implications for the CBD, but there is a need for new solutions to increase the comfort, convenience, and comprehensibility of public transit systems.

Improved public transit, then, should not be regarded as a civic luxury, but as a civic necessity. Instead of visualizing grandly monumental transit stations, we should be visualizing a system offering the highest quality and the most extensive service possible at the lowest cost.

Point to point transit service can best be improved by the
use of systems with exclusive right-of-way. Such systems, when added to developed areas, require grade separation from the existing circulation levels and have a choice of either going underground or overhead. Construction costs are generally three times as high for subway construction as compared to elevated right-of-ways, meaning that total costs for an all subway system would be approximately twice as much. It is significant that overhead right-of-way is also preferred by transit riders (as witnessed by the general popularity of the monorail concept). The major argument for underground movement systems, then, is based on environmental considerations. If overhead systems can be devised which are an overall enhancement of the environment, then their usage would be logical for Houston.

The foremost obstacle to the innovation of new solutions in transportation is the uncertainty or risk involved. There are uncertainties about performance, market acceptance, and side effects such as land use, particularly in a city like Houston where present usage of public transit is low. Without considerable assurances of success, the risks involved in developing new systems are simply too great to be taken.

Transportation systems analysis techniques have become highly sophisticated in recent years. Analysis can reduce uncertainties to the degree that simulation can represent the real world. However, there are always aspects of transportation which are difficult to quantify and analyze through mathematical
models. For these aspects, the other analytical tool is a real world test conducted on a full scale. Testing is recognized as a necessary step in developing technology; it should also be a necessary step in developing service and testing public response.

Existing public transportation, specifically the local bus system, offers the opportunity not only to improve transit service to the CBD, but the opportunity to conduct full scale tests which can aid in determining the response to be expected with new systems. The ability to use a mixed strategy in which short-run improvements based on presently available technology and operations are combined with longer-run programs for developing new systems is essential in developing evolutionary transportation systems.

Transportation planning takes place in a context of continuous change. While it is necessary to make long range plans, the planner must built in an opportunity to review and revise his strategy in order to accommodate the changing conditions. Implicit is such an evolutionary planning process is the necessity to avoid "locking in" the future with massive fixed investments, but rather the necessity for keeping open future alternatives.

The answer to the transportation problem lies not in any one mode or system of travel. All modes from foot to air travel should be regarded as integrated sub-systems in the
transportation system, with roles of relative importance, subject to continuous readjustment.

Likewise, transportation planning should not be tied to any single mode. Transportation institutions have generally been established according to mode, i.e., "Highway Department," "Rapid Transit District," etc., and have consequently limited their operations and concerns to that particular mode. Under such institutions, the potential to integrate modes of transportation has seldom been fully analyzed. Rather, transportation planning should take place in a setting that encourages consideration of all modes of travel.

Transportation planning should be conducted in a setting that encourages serious consideration of all modes of travel, that has available the techniques for a quick testing of all available alternatives, that allows user feedback in the way of real world tests, that considers the interfacing between various urban and interurban modes, and that includes systems research in new transportation technologies. Only under such competent and comprehensive planning can we have integrated and evolutionary transportation systems in the future.

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