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North Central Texas Council of Governments

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Abstract

TITLE: "Short-Term Transit Options for Restricted Energy Scenarios: A Case Study of Dallas Transit System, Dallas, Texas"

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SUBJECT: A study of impacts of a sudden energy shortage on Dallas Transit System

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ABSTRACT: Prepared for the Southwest Division of the Association of American Geographers and the Southwestern Social Science Association meeting in Dallas, Texas, April 1, 1977.

The paper discusses a study of the impact of a sudden energy shortage on the Dallas Transit System. Options which may be used to contend with the major anticipated problems of insufficient fuel supplies and large bus ridership increases are suggested and examined. Finally, the paper identifies the actions which would be most applicable to the transit system in the development of an emergency contingency plan to deal with these problems.

Acknowledgements

This paper was prepared in conjunction with transportation-related energy contingency planning efforts of the North Central Texas Council of Governments, Arlington, Texas. The author would like to acknowledge the assistance and guidance of the NCTCOG staff, especially that of Mr. William Barker, Senior Transportation Planner, and the staff of the Dallas Transit System, in the research and preparation of this project.

SHORT-TERM TRANSIT OPTIONS FOR RESTRICTED ENERGY SCENARIOS A CASE STUDY OF DALLAS TRANSIT SYSTEM, DALLAS, TEXAS

INTRODUCTION

The impact of the 1973-1974 Arab oil embargo and the resulting gasoline shortage was instrumental in reversing American transit ridership trends which have persisted since the end of World War II. In 1945, nearly 19 billion revenue passengers rode American transit; by 1972 this figure had dropped 72 percent to 5.3 billion passengers (Figure 1). Bus ridership followed a similar downward trend, from a peak of 8.3 billion revenue passengers in 1945 to a low of 3.5 billion passengers in 1972.[1]

A renewed public interest in using transit as an alternative to the automobile became evident by the end of 1973 as gasoline supplies in some urban areas began to dwindle. Because of this, national transit ridership in 1973 increased slightly (2.5 percent) from 1972 levels. By early 1974, nearly all urban areas in the nation experienced some degree of gasoline shortage. Transit ridership in 1974 was 12.2 percent higher than it had been in 1972.

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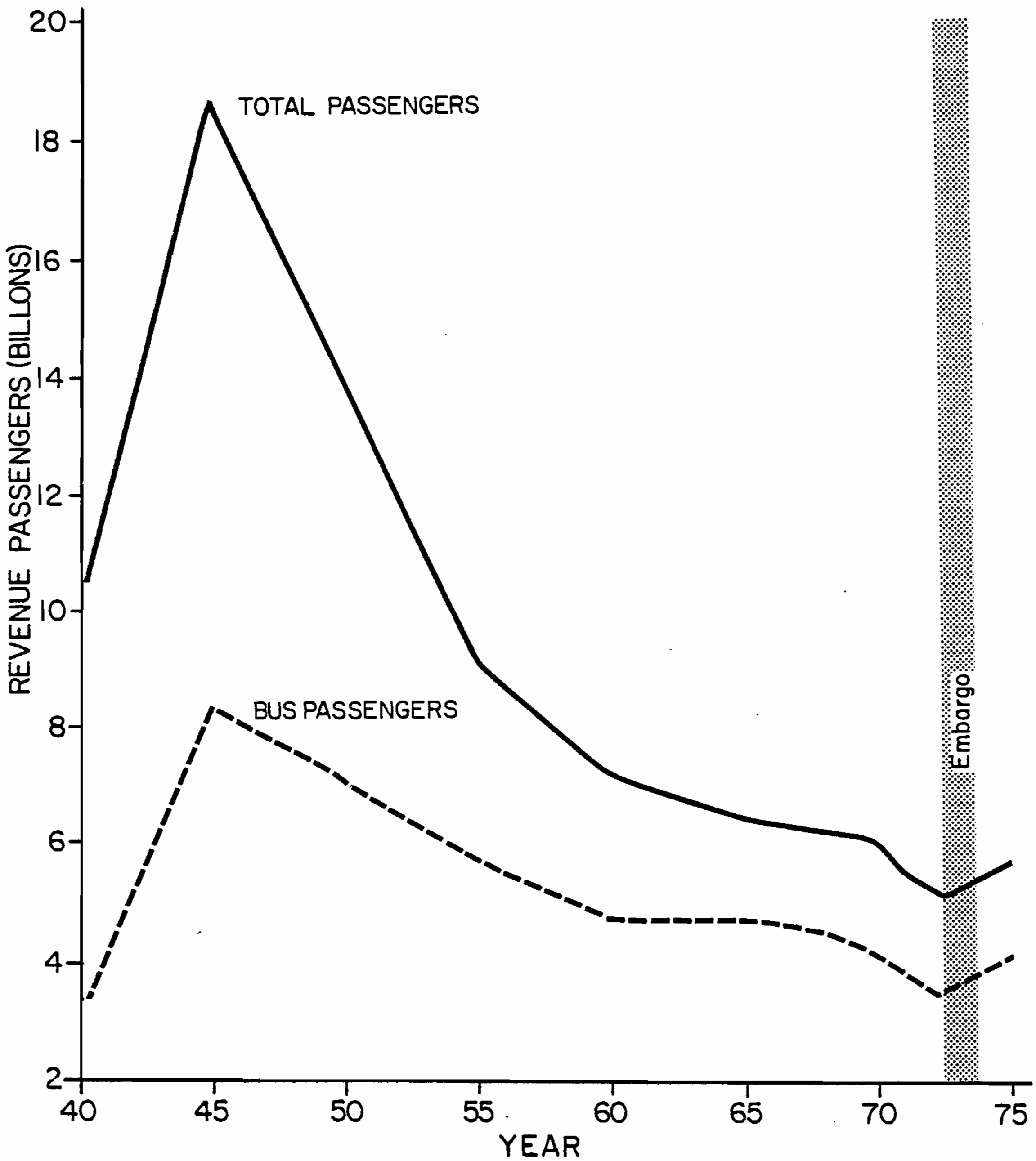
[1]American Public Transit Association, Transit Fact Book (Washington, D.C.: APTA Statistical Department, March 1976), p. 33.

FIGURE 1

TREND OF TRANSIT REVENUE PASSENGERS
UNITED STATES



Source: American Public Transit Association, Transit Fact Book (Washington, D.C.: APTA Statistical Department, March 1975).

While the local impact of this energy shortage has been analyzed by only a few transit systems, results of these studies have indicated sizable ridership increases as well as a considerable burden on transit service and operations. Data from Baltimore's Regional Planning Council and the Maryland Department of Transportation shows that transit ridership increased by more than 10 percent within a two-month period and weekly bus ridership in the Dutch Fork area, Columbia, South Carolina, more than doubled within a month (February, 1974) during the peak of the local gasoline shortage.[2]

A study[3] of the Seattle Metro transit system indicates that bus ridership during the embargo exceeded the seating capacity by 10 to 14 percent during the height of the peak travel period (7:30 to 8:00 a.m. and 4:30 to 5:30 p.m.) and that many transit routes during this time were so full that drivers were forced to leave patrons standing at the bus stops. Thus, it appears that some transit systems, unaccustomed to large influxes of riders, were unprepared or unable to meet the new demands for transit service.

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[2] United States Congress, Office of Technology Assessment, Energy, the Economy and Mass Transit (Washington, D.C.: U.S. Government Printing Office, December 1975), p. 67.

[3] The Municipality of Metropolitan Seattle, An Energy Crisis Contingency Plan for Metro Transit (Seattle, Washington: Seattle Metro Council, November 1975).

A Future Embargo?

While the event of another oil embargo or similar fuel interruption cannot be predicted to any degree of certainty, it is a possibility which cannot be dismissed. Since the 1973-1974 embargo, the United States has become more dependent on foreign oil and thus, more vulnerable to import interruptions. In 1973, imports supplied 36 percent of the nation's oil supply; today this figure is more than 40 percent and is increasing[4] (Figure 2). The Arab nations involved in the last embargo supplied 14 percent of the nation's oil demands in 1973; they now supply more than 20 percent. In addition, the political stability of this area of the world (as recent events in Lebanon have shown) has not improved much since the last embargo.

Transit Ridership During a Future Oil Interruption

Increases in transit ridership during another oil shortage will depend on the severity and extent of the shortage as well as the type of conservation policies applied by the federal and state governments. A fuel allocation program at the retail sales level (as during the last embargo) would probably encourage transit usage by those who wish to avoid the long lines and problems of purchasing gasoline at retail outlets. Under a coupon rationing system (as during World War II), the cost and difficulty in obtaining extra gasoline coupons would likewise promote new ridership.

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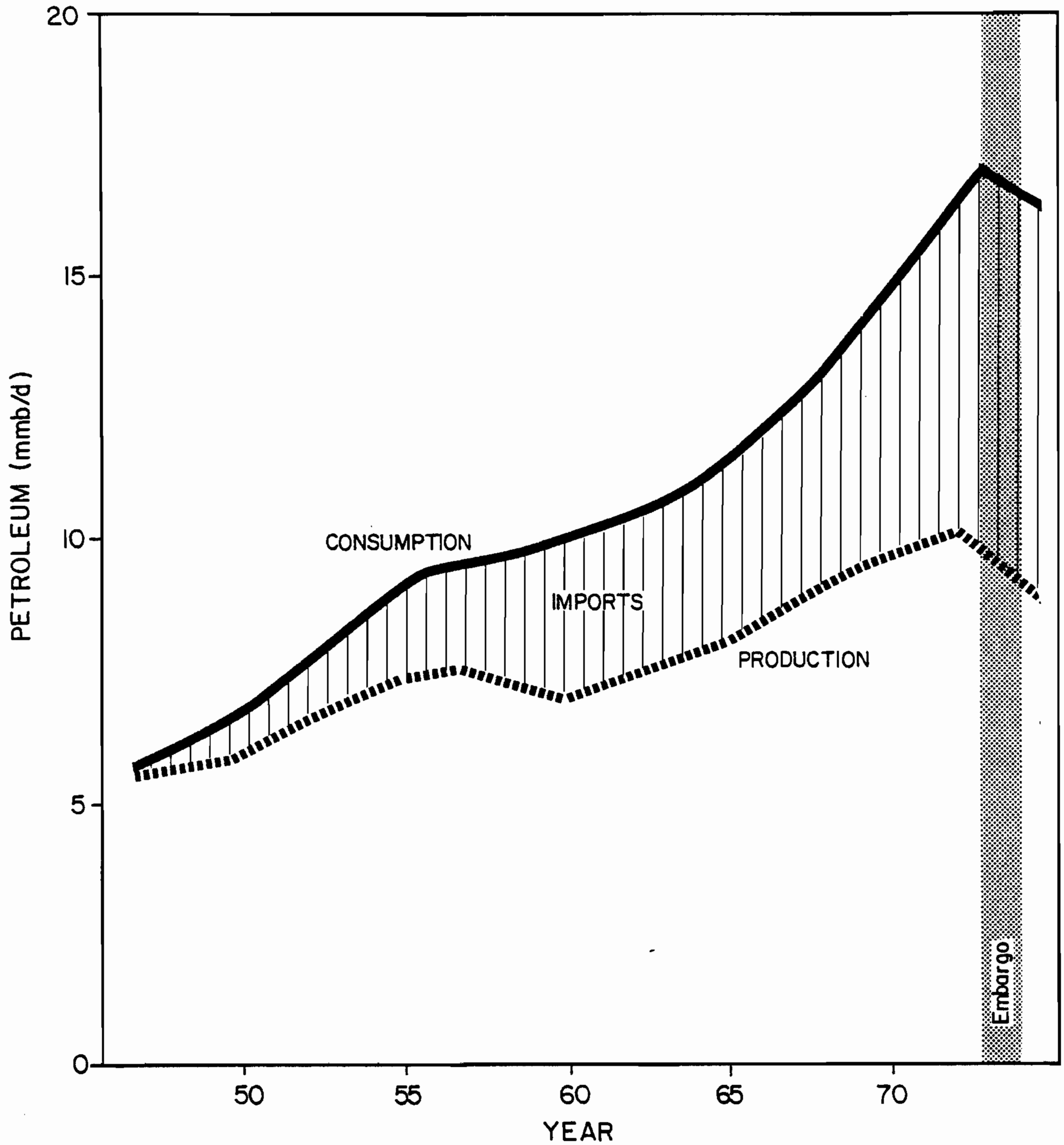
[4] Federal Energy Administration, Energy Reporter, December 1976/January 1977, p. 2.

FIGURE 2

U.S. PETROLEUM PRODUCTION VS CONSUMPTION
1947-1974



Source: Federal Energy Administration, National Energy Outlook (Washington, D.C.: U.S. Government Printing Office, February 1976) p. xxiii.

A study[5] conducted by the U.S. Congress, Office of Technology Assessment, concluded that a near-term (present to 1980) oil shortage could result in a 10 to 40 percent increase (from 1974 levels) in national transit ridership depending upon the magnitude of the reduction. This means that a total cutoff of Arab oil in 1977 would be expected to produce a 25 to 30 percent rise in transit ridership (Figure 3). The transit systems, therefore, would have to deal with a sharp ridership increase within a short period of time. The following case study will examine the applicability of short-term measures to cope with these ridership increases as well as actions to contend with possible fuel reductions for the mass transit system of Dallas, Texas.

THE CASE STUDY: DALLAS TRANSIT SYSTEM

The service area of the Dallas Transit System (DTS) includes the city of Dallas and the enclaved cities of Highland Park, University Park, and Cockrell Hill (Figure 4). The total population of this service area is more than 900,000. DTS estimates that more than 80 percent of these persons have transit service available within one-quarter mile of their residence.

DTS operates a total fleet of 407 buses over 471.5 route miles. In 1976, a total of 25,100,000 revenue passengers were carried by the bus system.

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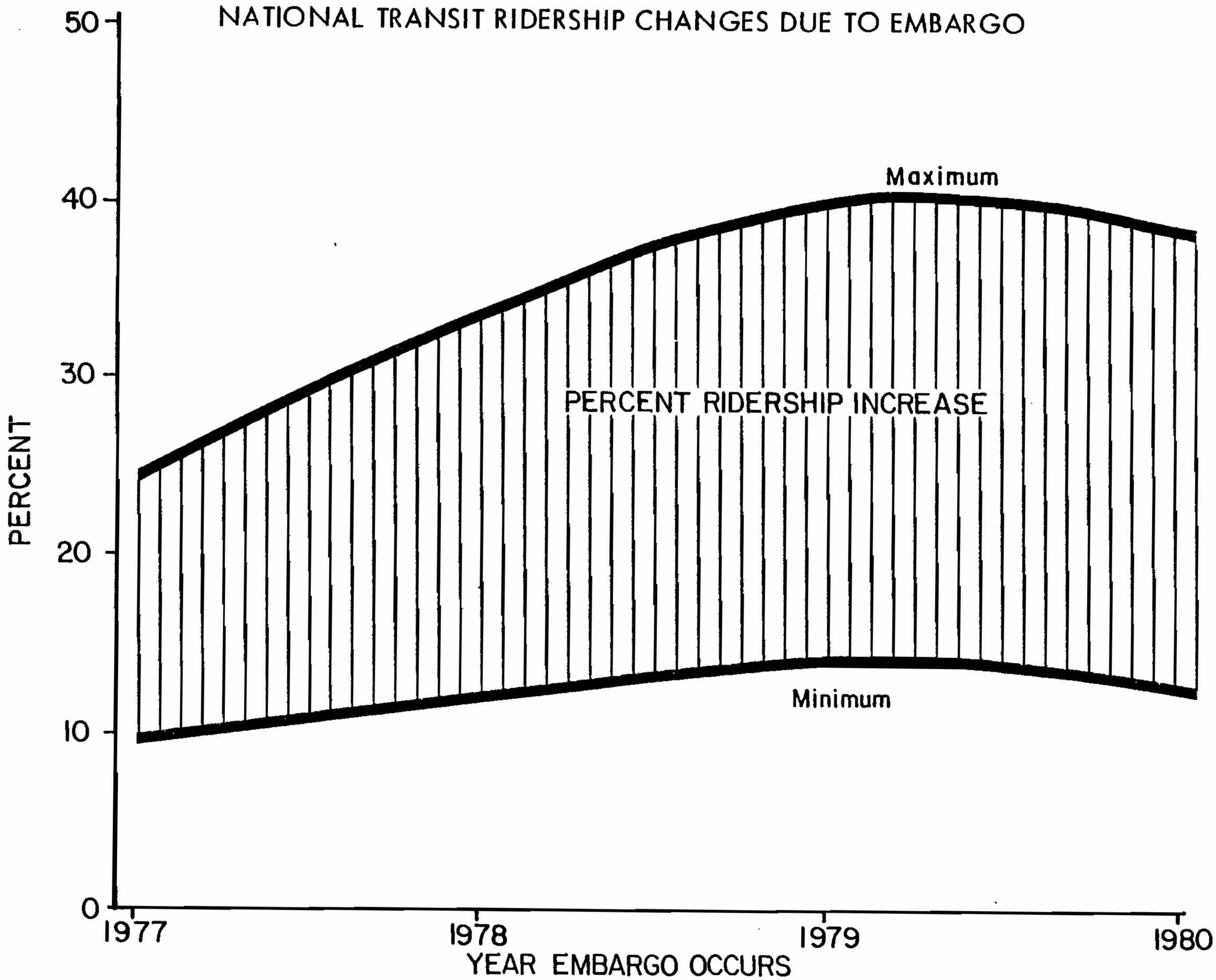
[5] United States Congress, Office of Technology Assessment, Energy, the Economy and Mass Transit, 1975.

FIGURE 3

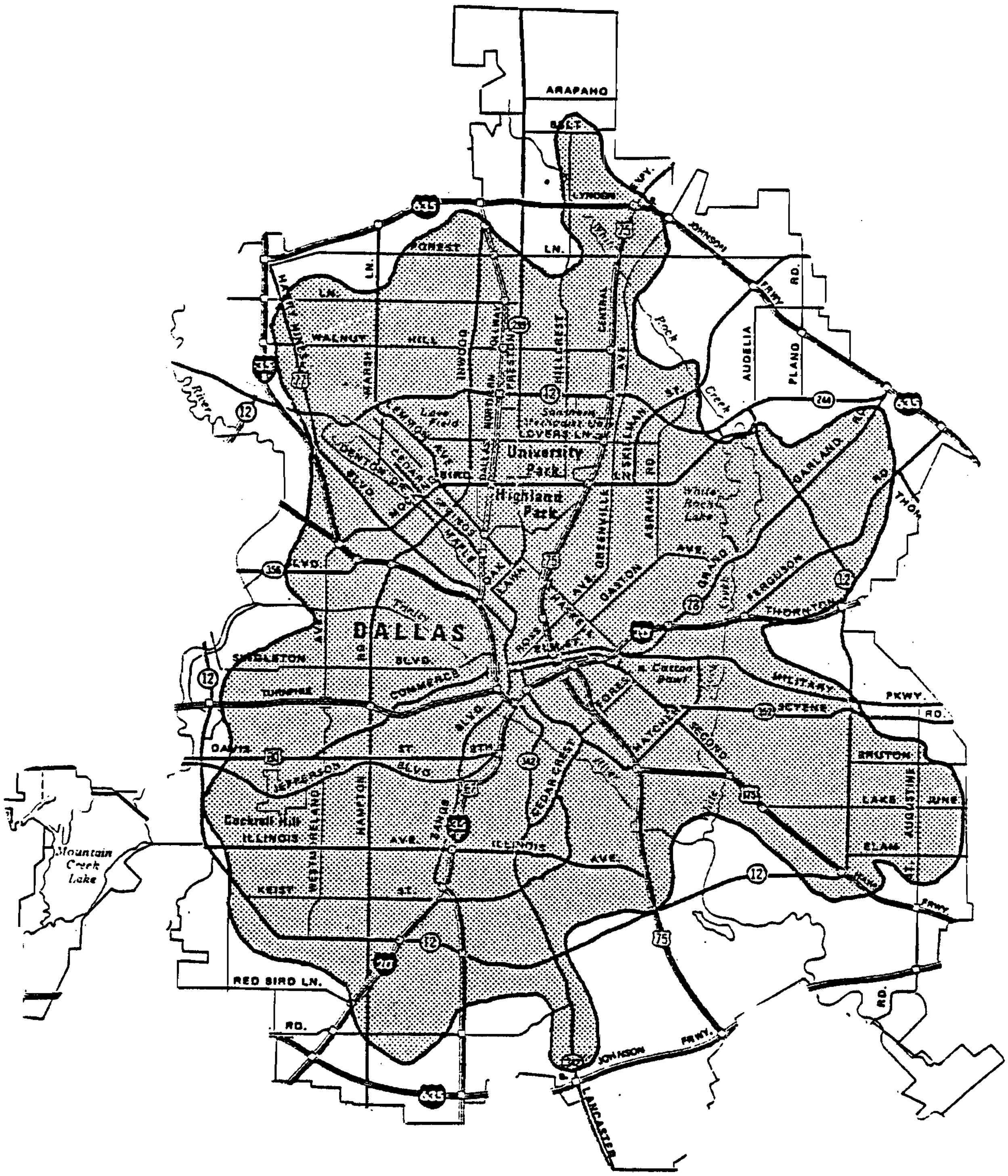


Source: U.S. Congress, Office of Technology Assessment, Energy, the Economy and Mass Transit, December 1975.

FIGURE 4

DALLAS TRANSIT SYSTEM

SERVICE AREA



Area Served by DTS

Source: Dallas Transit System.

Impact of the 1973-1974 Oil Embargo

Transit ridership on DTS experienced a dramatic rise during the 1973-1974 oil embargo period. Prior to the embargo, monthly revenue passenger levels were 5 to 10 percent below those of the previous year. By October, 1973, however, ridership began an upward trend which peaked in March, 1974, when ridership was 20 percent higher than it had been during the previous year (Figure 5). Total revenue passengers during fiscal year 1974 (27,032,000) was 6 percent greater than during 1973.

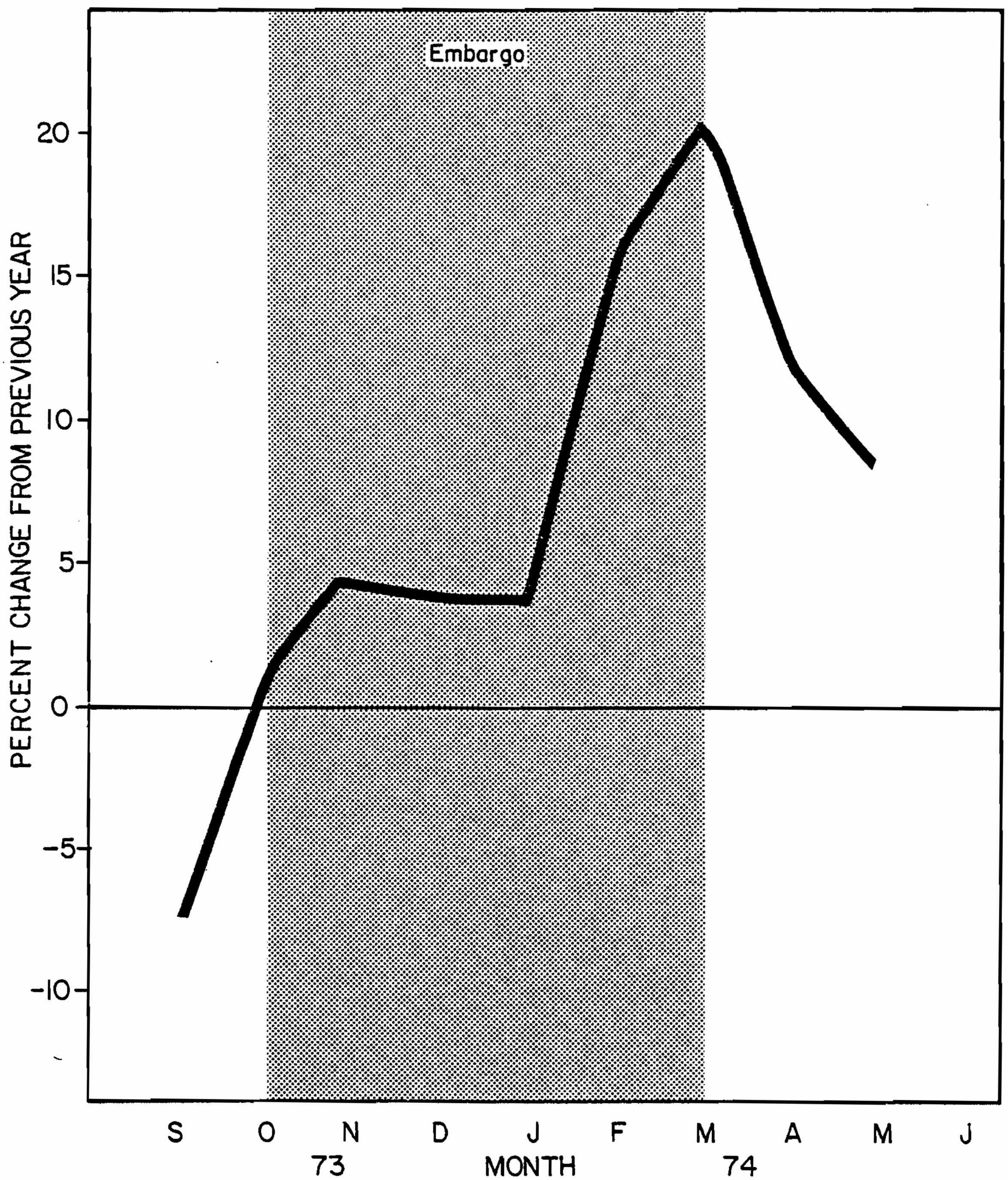
The Dallas Transit System's number of scheduled bus miles and hours of operating service declined steadily until 1973.[6] During fiscal year 1974, however, the upsurge in demand for the transit service resulted in a substantial increase in the number of bus miles and hours of service provided (Table 1). By 1975, however, as many of the embargo period patrons returned to their automobiles, the level of transit service had been reduced to preembargo levels.

The increase in transit ridership during and immediately after the crisis resulted in a slight (1.8 percent) rise in operating revenue for fiscal year 1974 over the 1973 level (Table 2). At the same time, the system experienced a dramatic (16.65 percent) rise in operating expenses. The cost of fuel, which nearly doubled from 1973 to

[6] North Central Texas Council of Governments, Transportation Department, 1976 Transportation Program (Arlington, Texas: 1975), p. V-15.

FIGURE 5

RIDERSHIP CHANGE: DALLAS TRANSIT SYSTEM



Source: Dallas Transit System

TABLE 1

CHANGES IN OPERATING STATISTICS
DALLAS TRANSIT SYSTEM

Year*	Route Miles	Scheduled Miles	Scheduled Hours
1971	372.6	13,007	980
1972	375.5	12,928	963
1973	377.4	12,630	942
1974	460.7	13,570	993
1975	450.6	13,578	971

*Fiscal Year - October 1 to September 30

Source: North Central Texas Council of Governments, Transportation Department, 1976 Transportation Program (Arlington, Texas, 1975), p. V-15.

TABLE 2

TRENDS IN REVENUES AND EXPENSES
DALLAS TRANSIT SYSTEM

Year*	Operating Revenue (000)	Operating Expense (000)	Revenue Per Scheduled Hour	Cost Per Scheduled Hour
1971	$11,225	$11,209	$11.45	$11.44
1972	11,737	11,838	12.19	12.29
1973	11,217	12,426	11.91	13.19
1974	11,414	14,496	11.49	14.60
1975	10,601	15,447	10.92	15.91

*Fiscal Year – October 1 to September 30

Source: North Central Texas Council of Governments, Transportation Department, 1976 Transportation Program (Arlington, Texas, 1975), p. V-28.

1974, was a major contributor to this rise. In 1973, fuel accounted for 4 percent of operating expenses, and for 1974 it equaled 7.8 percent.[7] The system, therefore, did not benefit from the additional revenues since they were offset by the spiraling operating expenses.

Perhaps the major impact of the energy crisis on the Dallas Transit System, as well as on many other transit systems, was the realization that a significant market of high-income, suburban automobile users was willing to utilize transit, given certain incentives (e.g., high gasoline prices, desire to conserve fuel) and reasonable service. A number of service improvement decisions, such as those involving the development of programs such as park-and-ride facilities and express bus service, have thus been given added impetus due to the effects of the embargo.

One such improvement in service was the first DTS park-and-ride facility (North Central Expressway) with express bus service to the Central Business District, which was initiated on November 27, 1973. At that time, approximately 900 riders utilized this service each way per weekday and about 600 autos were parked at the facility

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[7] North Central Texas Council of Governments, 1976 Transportation Program, p. V-29.

parking lot.[8] Two additional park-and-ride lots were subsequently developed by the end of 1974 (Figure 6) to serve outercity commuters in the southern and southeastern sections of the city.

PROBLEM ANALYSIS

Under the basic assumptions that the impact of a sudden severe oil shortage in the near future will affect the Dallas Transit System in ways similar to, but more severe than, that of the 1973-1974 embargo and that the federal government will implement a policy of fuel allocation and/or rationing, the transit system will be faced with two basic problems:

- Reducing fuel consumption if adequate supplies cannot be obtained
- Coping with transit ridership increases

The following discussion examines possible actions which could be utilized to alleviate these problems.

Reducing Fuel Consumption

Under the federal conservation programs, especially the allocation plan, it is conceivable that the transit systems' fuel supplies may be reduced in direct proportion

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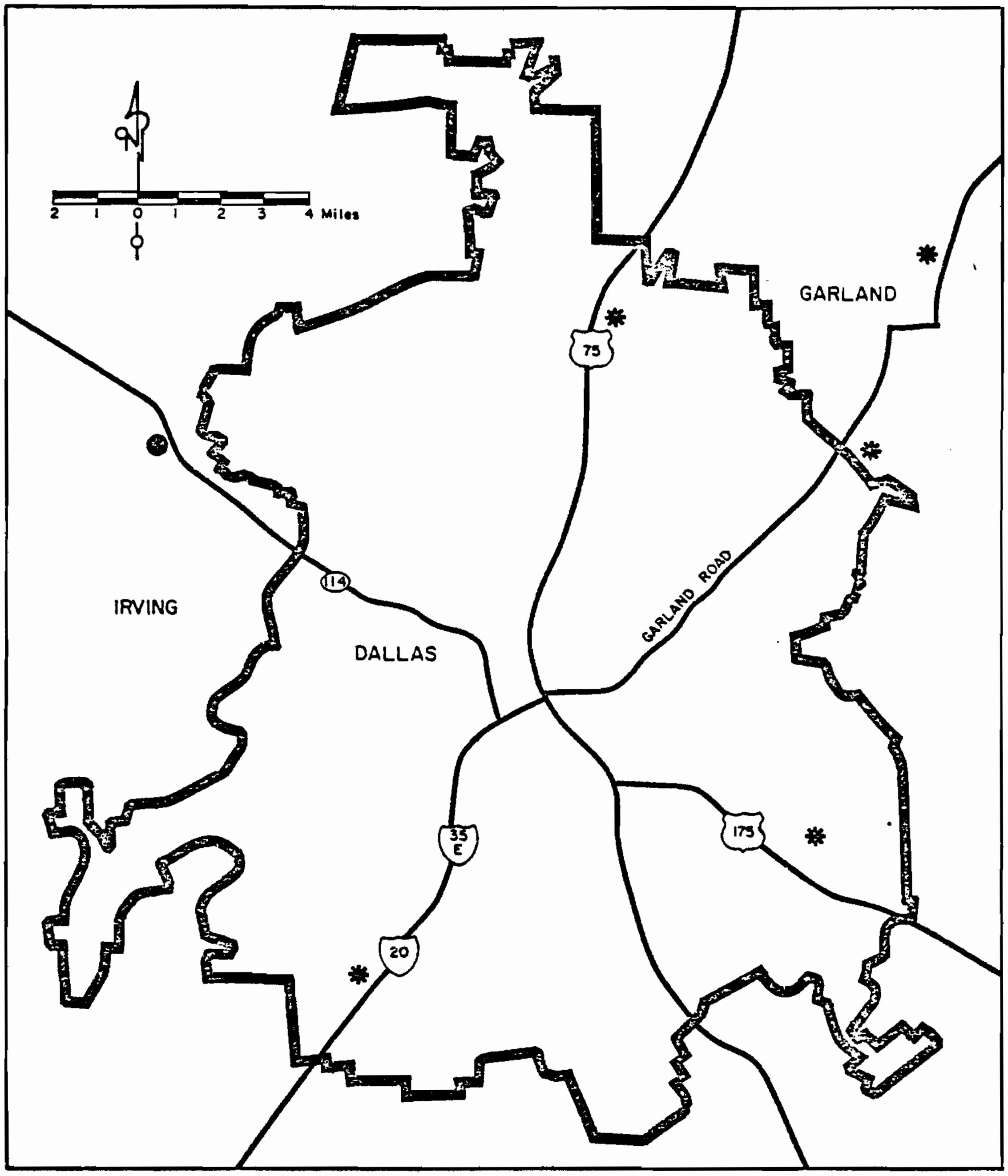
[8] North Central Texas Council of Governments, 1976 Transportation Program, p. VI-28.

FIGURE 6

EXISTING AND PROPOSED PARK AND RIDE TERMINAL LOCATIONS
IN DALLAS COUNTY



Source: 1976 Transportation Program, p. II-29, Fig. III-14.

LEGEND

✱ Park and Ride Facility in Operation

● Park and Ride Site Specified

to an anticipated national fuel shortage of 10 to 25 percent.[9] If this occurs and if additional fuel cannot be obtained through other sources, i.e., state hardship allotments, local reserve supplies, etc., the transit system will be forced to modify or reduce operations in order to conserve the available supplies. This can be accomplished by (1) reducing or eliminating service, and/or by (2) operating the service more efficiently.

Reduce Service

If it is necessary to cut back service, the nonpeak hours should be those first affected. Late night, midday, and/or weekend service could be eliminated or reduced to achieve this goal. The total elimination of this service by the Dallas Transit System would save an estimated 50 percent of the total fuel consumption. In addition, by increasing the bus headway (the time between bus arrivals), fewer bus trips would be made and thus, fuel would be saved. This implies that a 10 percent increase in the time between headways could reduce fuel consumption by 10 percent.

Increase Efficiency

A number of strategies to increase the efficiency of current transit operations could also be utilized during a fuel shortage. These include actions which:

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[9] The Federal Energy Administration estimates a 12 to 21 percent shortage is possible during the 1977-1978 period. FEA, Economic Impact Analysis, Proposed Gasoline and Diesel Fuel Rationing Contingency Plan (Washington, D.C.: U.S. Government Printing Office, September 1976), p. 8.

- Reduce the number of bus stops
- Change some local to express service
- Improve the flow of buses in traffic
- Decrease the number of "deadhead" bus miles

Figure 7 shows that, as the number of bus stops increases, the fuel efficiency of the buses decreases. This suggests that if the number of stops is cut in half, say from four (about average for local transit service) to two stops per mile, fuel consumption could be reduced by about 25 percent.

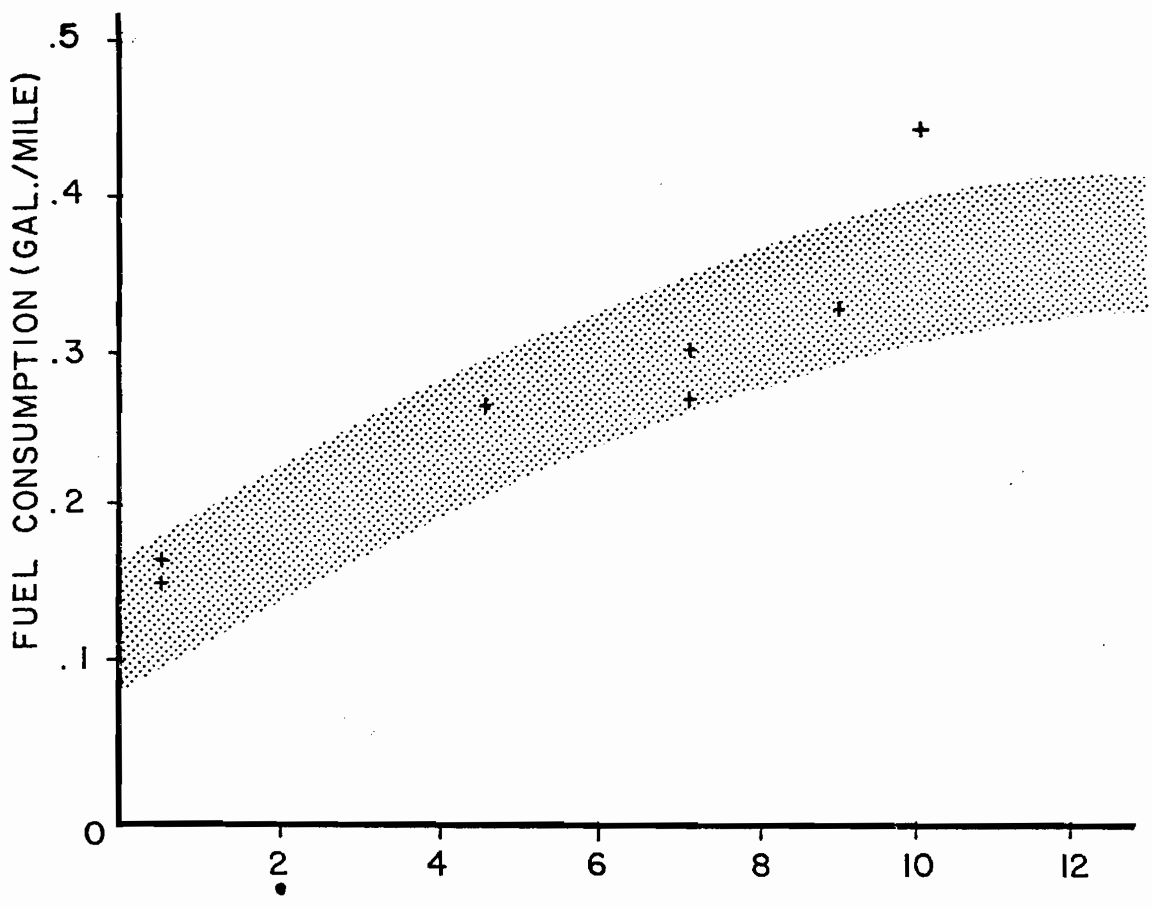
Another possible way to save fuel would be to modify some existing service from local to express operations. This would have the effect of increasing the bus speed and thus, saving fuel. As can be seen by Figure 8, bus fuel economy increases with speed. The average speed of local service DTS buses is currently 12-14 miles per hour. Express bus service, however, averages more than 20 miles per hour.[10] Thus, it appears that considerable fuel savings could be realized by increasing the average bus speed through local to express bus service modifications.

The major disadvantage of strategies such as these which reduce the number of bus stops or change local to express operations is that the level of service is reduced below

[10] North Central Texas Council of Governments, Transportation Department, Transit Development Program for the North Central Texas Region (Arlington, Texas: June 1973), p. 39.

FIGURE 7

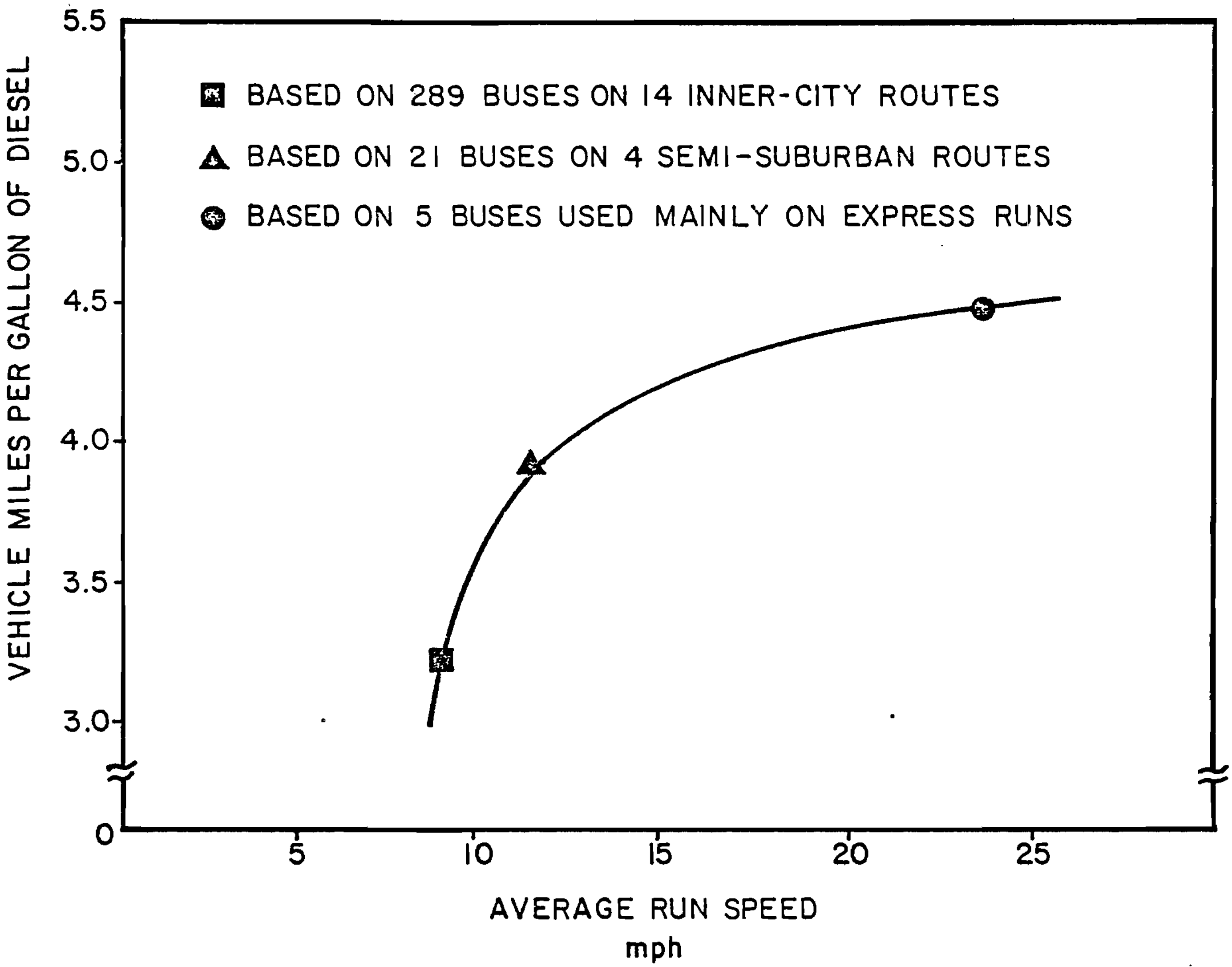
BUS FUEL CONSUMPTION
AND BUS STOP FREQUENCY



SOURCE: DeLeuw, Cather, and Co., Case Studies of Transit Energy and Air Pollution Impacts, Prepared for the Environmental Protection Agency, June 1975.

FIGURE 8

DIESEL BUS FUEL UTILIZATION VS. SPEED



Source: Martin J. Bernard, III, and Sarah Labelle, "Energy Conservation in Urban Transit Systems". Presented at Energy Conservation: A National Forum, Ft. Lauderdale, Florida, December 1-3, 1975.

normal levels, thereby discouraging transit use. Also, the number of bus drivers would be cut back as service was reduced. Increasing system efficiency while maintaining or increasing the level of service would be more desirable.

The speed of all bus service and hence, fuel efficiency, could be increased by implementing actions which would increase the bus flow through traffic. Such measures include bus-activated signals and reserved bus lanes.

The utilization of bus-activated signals would tend to speed the flow of buses through congested intersections. Such a system is currently being developed in Dallas which would provide bus signal preemption at 42 intersections.[11] These measures, however, require considerable time and expense to develop and cannot be considered as short-term strategies unless they have been implemented prior to the energy shortage. Their effect on fuel reduction, however, could be considerable since time delays due to the traffic signals account for 10 to 20 percent of overall trip time.[12]

Reserved bus lanes provide a greater potential as a short-term action to increase the bus speed. Bus lanes, which can be in the form of reserved curb lanes along normal

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[11]City of Dallas, Application for a Section 5 Capital Assistance Grant for a Bus Priority System (Dallas, Texas: Department of Traffic Control, April 1975), p. 70.

[12]U.S. Department of Transportation, State-of-the-Art Bus and Carpool Priorities. Presented at the Workshop on Priority Techniques for High Occupancy Vehicles, Miami, Florida, April 29, 1975.

flowing traffic, median lanes, contraflow lanes, or exclusive busways on bus streets are in operation in numerous American and European cities (i.e., Washington, D.C., Atlanta, Chicago, Toronto, London, and Paris). Speed increases along these existing lanes generally range from 1 to 5 percent.[13] Dallas currently provides reserved bus lanes in the downtown area and has established two experimental reserved lanes on arterial bus routes, one along Harry Hines Boulevard and one along Fort Worth Avenue.[14] A number of other potential locations for additional bus lanes in Dallas have been identified.[15] They are shown in Figure 9. Other preferential actions, such as reserved bus ramps on highways or reserved turning lanes at intersections, should also be considered.

Another possible method of decreasing bus fuel consumption would be to reduce the number of "deadhead" miles (i.e., miles to garages or other destinations when the bus is not in service). Unlike the automobile, not every bus vehicle mile produces

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[13] Wilbur Smith and Associates, Inc., Bus Rapid Transit Options for Densely Developed Areas. Prepared for U.S. Department of Transportation (Houston, Texas: Wilbur Smith and Associates, Inc., February 1975), p. 104.

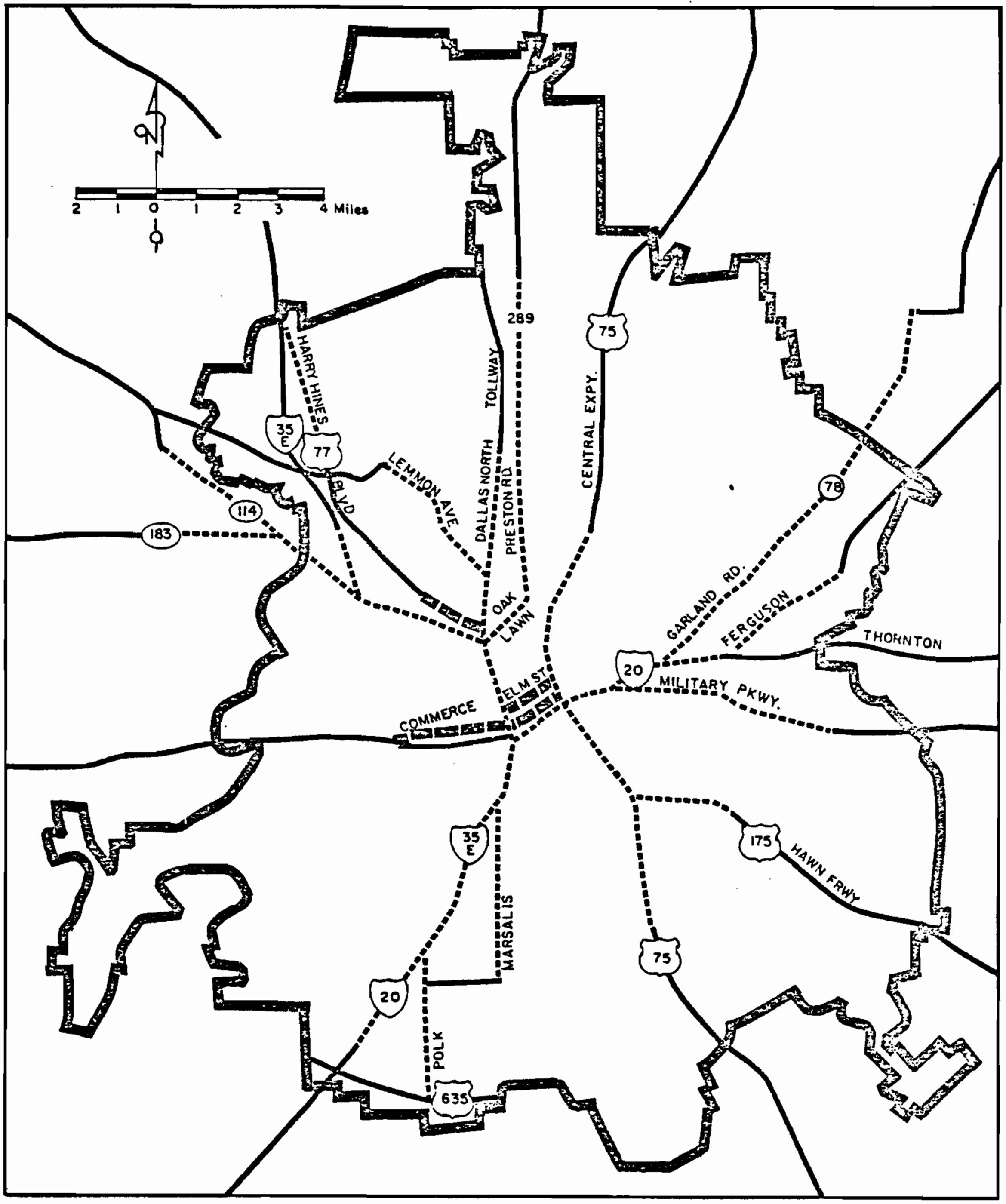
[14] City of Dallas, Report on Effect on Traffic Operations When Bus Lanes are Reserved on Major Thoroughfares (Dallas, Texas: Department of Traffic Control, September 1975).

[15] Barton-Aschman Associates, Inc., Dallas Urban Area Public Transportation Plan, Dallas Subregional Public Transportation Study (Chicago, Illinois: Barton-Aschman Associates, Inc., November 1975).

FIGURE 9

POTENTIAL BUS LANE LOCATIONS FOR EXISTING BUS ROUTES

DTS



Potential Bus Lane

Existing Bus Lane

Source: Dallas Transit System, North Central Texas Council of Governments passenger miles. This is due to unbalanced loading on different portions of some routes and to the need to return vehicles to yards or garages after each service period.

A strategy to reduce these "deadhead" bus miles would be to lease land for bus parking near or in the Central Business District. Here, buses which are used only during peak service could be parked during the midday rather than running them empty back to their respective garages. Such a storage would need to handle 237 buses in Dallas during the current off-peak hours.[16]

A study of the Chicago Transit Authority has estimated that approximately 1 percent of its bus fuel could be conserved by this strategy.[17] In Dallas, an estimated 1 to 4 percent savings could be realized in this manner. The disadvantages, however, are that there would be the additional expense of leasing the downtown lots and of providing security for the buses. A single bus from each remote lot could be used to shuttle the drivers to and from the main bus garage.

Table 3 lists these strategies which could be utilized to reduce fuel use by eliminating service and by increasing the system's fuel efficiency. The table also indicates the

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[16] North Central Texas Council of Governments, 1976 Transportation Program, pp. V-23, V-39.

[17] Martin J. Bernard, III, and Sarah Labelle, "Energy Conservation in Urban Transit Systems." Presented at Energy Conservation : A Nation Forum, Ft. Lauderdale, Florida, December 1-3, 1975, p. 5.

TABLE 3

TRANSIT STRATEGIES TO REDUCE FUEL CONSUMPTION

Dallas Transit System

Strategy	Percent Fuel Savings	Impact on Service	Impact on Operating Expenses	Implementation Costs
Eliminate night service	8-12	Decrease	Decrease	None
Eliminate weekend service	16-20	Decrease	Decrease	None
Eliminate midday service	20-25	Decrease	Decrease	None
Increase bus headways (by 10-25 percent)	10-25	Decrease	Decrease	None
Reduce number of bus stops (by 20-50 percent)	10-25	Decrease	Decrease	None
Modify local to express service (10 percent of local)	8-10	Uncertain	Decrease	None
Increase bus flow by: 1) Bus lanes	1- 5	Increase	Decrease	Low-Medium
2) Priority Signalization	1- 2	No effect	Uncertain	High
Decrease "deadhead" bus miles	1- 2	No effect	Uncertain	Low-Medium

Source: Based on information provided by DTS.

Alan M. Voorhees and Associates, Inc., Guidelines to Reduce Energy Consumption Through Transportation Actions. Prepared for the Urban Mass Transportation Administration (McLean, Virginia: Alan M. Voorhees and Associates, Inc., May 1974).

U.S. Department of Transportation, Priority Techniques for High Occupancy Vehicles (Washington, D.C.: U.S. Government Printing Office, November 1975).

approximate fuel savings which would be realized by DTS through each action. The total savings from implementing all the actions listed would, of course, be less than the sum of the percentages indicated.

Coping with Mass Transit Ridership Increases

Public reaction and modifications in travel habits were instrumental in producing many of the transportation-related changes during the 1973-1974 oil embargo. It would, therefore, be reasonable to assume that similar changes would occur during a future embargo. A local survey[18] has explored public reaction by the citizens of Dallas to this possibility by asking respondents how they would change their travel habits in the event of a large increase (to one dollar or more) in the price of gasoline. The most common public responses to this scenario were to use public transportation more (35 percent of respondents), carpool more (32 percent), and buy smaller cars (27 percent) (Figure 10). The impact of this potentially large increase in demand for public transportation will present a dilemma for transit operations: how can service be maintained or increased at a time when fuel supplies and rolling stock are limited?

In addition, the changes in transit ridership will probably vary by line and time of day. The Seattle Metro study points out that:

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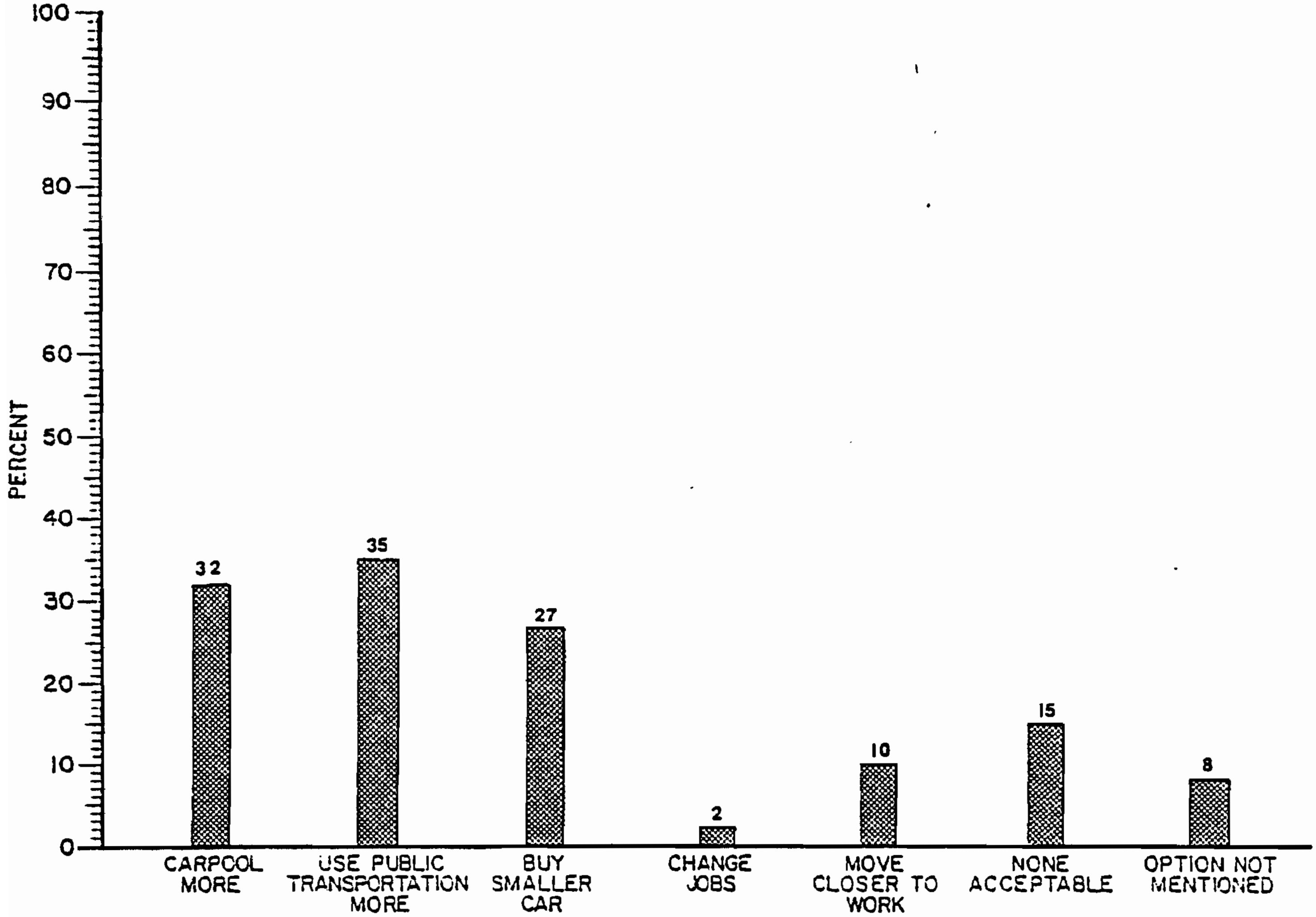
[18] North Central Texas Council of Governments, Transportation Department, Urban Panel Project, Macro-Level Data Analysis, 1976 (Arlington, Texas: 1976), p. VIII-8.

FIGURE 10

PUBLIC REACTION TO SEVERE GASOLINE COST SCENARIO

Dallas, Texas



Question: Suppose the price of gasoline were to rise to one dollar or more. Would one or more of these options be attractive to you?

Source: North Central Texas Council of Governments, Transportation Department, Urban Panel Project, Micro-Level Data Analysis, 1976 (Arlington, Texas: October 1976), p. V-III-10.

> The energy crisis had different impacts on different routes – an important point when dealing with strategy where extra buses are available for allocation to routes needing extra service, as was the case during the crisis. The question becomes, "How to assign more service temporarily to those routes that need it?" The answer is in the detailed information for the 1974 crisis period.[19]

As Figure 11 shows, a 10 percent fuel deficit would mean an additional 65,000 weekly bus riders on DTS, while a 25 percent fuel shortfall would produce more than 250,000 additional weekly riders. Assuming fuel is available, strategies which could be implemented by the transit system to cope with this anticipated ridership increase include:

- Filling unused capacity
- Spreading peak period ridership
- Temporarily increasing the bus fleet size by:
    - (1) Renting additional buses from other sources
    - (2) Utilizing public school buses
- Increasing the capacity of the existing bus fleet by:
    - (1) Increasing bus availability by modifying maintenance operations
    - (2) Decreasing headways by increasing bus speeds
- Increasing the current bus fleet prior to contingency

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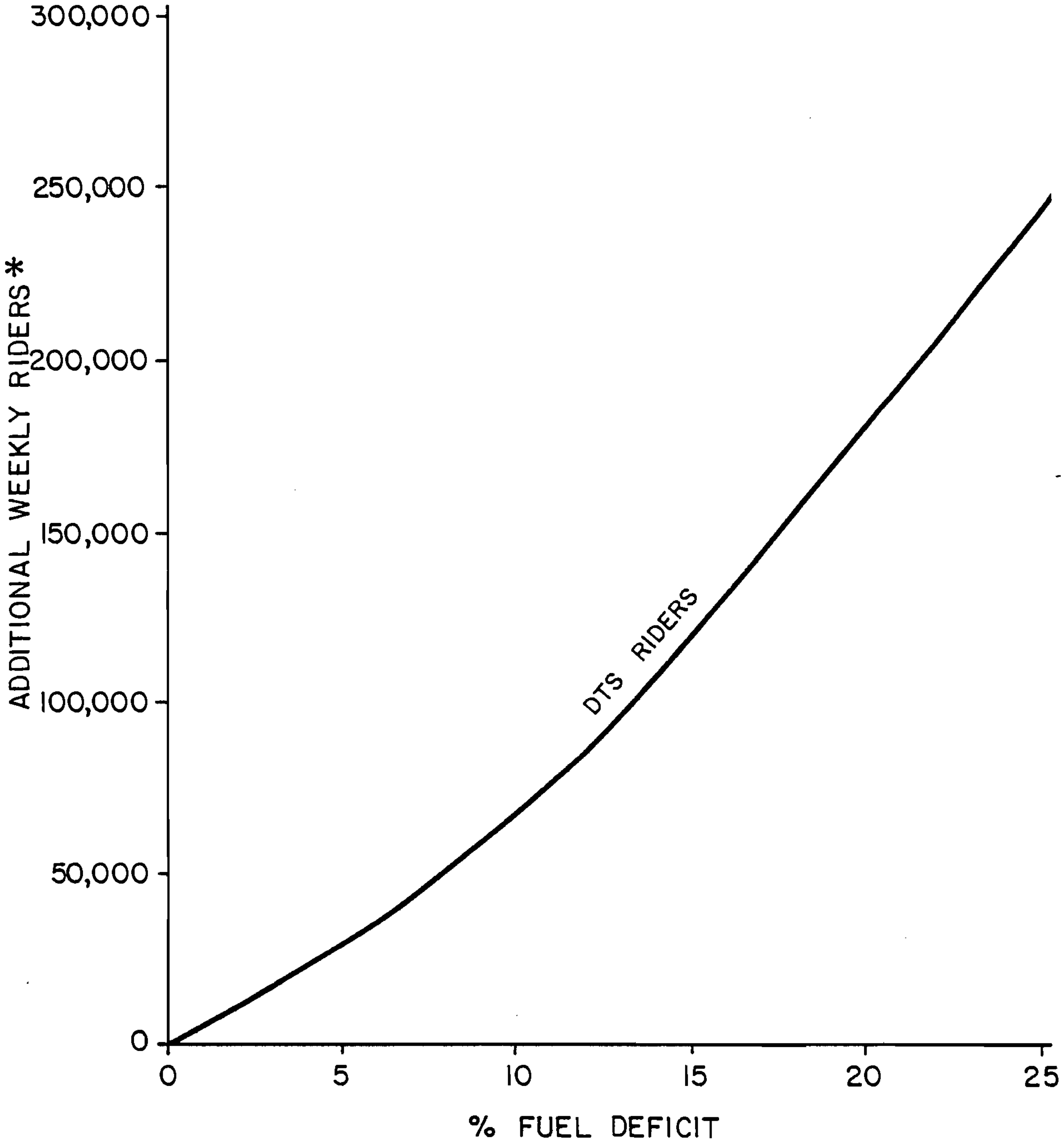
[19] The Municipality of Metropolitan Seattle, An Energy Contingency Plan for Metro Transit, p. 9.

FIGURE 11

THE EFFECT OF FUEL SHORTAGE ON LOCAL TRANSIT RIDERSHIP



* Increase from 1976 average

Source: Local application of Office of Technology Assessment estimates.

Unused Seating Capacity

The initial response of the transit system to a sudden passenger increase along established lines should be to allow use of the reserve transit seating capacity. During the height of the peak rush hour, approximately 10 percent of DTS seats are unused.[20] There are, however, buses on certain lines which are currently operating at or above capacity. On these lines, it may be necessary to increase service on short notice at the onset of the shortage. Methods of achieving this will be suggested in the following discussion.

Spread Peak Period Ridership

During the past embargo, the greatest increases in transit ridership occurred during the peak periods. Since, however, the maximum utilization of transit vehicles occurs during these times, it holds the least potential capacity to absorb these ridership increases.

If a sudden ridership increase were to occur, transit services during these peak times would be overtaxed, while earlier or later peak period service would probably remain underutilized. A solution to this problem would be to spread this peak ridership uniformly over the entire period so that no additional buses or drivers would be needed

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[20] Dallas Transit System, "Passenger Count," June-July 1976.

to accommodate ridership increases. This could be accomplished by varying the work hours of employees so that workers using transit service may travel at earlier or later times to avoid the overcrowded buses.

A number of different variable work hour systems have been identified.[21] These include:

- Staggered Hours - the starting and quitting times are fixed, but vary among employees or business (e.g., 7:00 a.m. to 3:00 p.m., or 7:30 a.m. to 3:30 p.m.).
- Shorter Work Week - the number of hours worked are concentrated into a shorter work week with the off day varying among employees or business.
- Flexible Work Hours - the employer determines a range of starting and quitting times and a core time during which all employees must work. For example, employees may start between 7:00-9:00 a.m. and leave between 3:00-5:30 p.m. as long as the total required hours are met.

The flexible work hour plan appears to be the most popular variable work hour option[22] and is, perhaps, the most likely to alleviate the peak period transit problems. Flexible work times have been introduced in several U.S., Canadian, and European cities and

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[21] The Municipality of Metropolitan Seattle, An Energy Contingency Plan for Metro Transit, p. 34.

[22] A survey of federal employees conducted by the Region 10 Federal Energy Administration in 1974 indicated that 70 percent of those responding preferred the flexible working hour concept. Ibid.

have reportedly reduced absences, raised employee morale, and increased employee productivity.[23]

Most importantly, however, flexible work hours would allow considerable individual modifications in travel times as well as adjustments of transit service. With flexible hours, the transit system could advise riders which buses on specific routes have seating and which are operating at capacity. Transit patrons could choose to ride at earlier or later than usual times to avoid crowds and still arrive at work at a time acceptable to the employer. Thus, while the other variable work hour options would potentially help to distribute transit loads more broadly, flexible time would be the most effective because it would allow the employees to adjust to the transit service in his or her area. Also, the addition of a peak-hour surcharge on transit fares along with flexible work hours would act to discourage discretionary travel at these times as well as raise some much needed revenue.

The impact of varied work hours on bus ridership has been examined during a variable work project in Ottawa, Canada.[24] On March 4, 1973, due to a serious overtaxing

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[23] The Municipality of Metropolitan Seattle, An Energy Contingency Plan for Metro Transit, p. 33.

[24] Reza Safavian, and Keith G. McLean, "Variable Work Hours: Who Benefits?", Traffic Engineering, Volume 45, No. 3, March 1975, p. 17.

of the bus system, federal agencies implemented a varied work hour plan for approximately 50 percent of the city's 70,000 CBD workers. The program consisted of a combination of staggered work hour options. As a result of the program, the study concluded that bus ridership was significantly improved and the peak period was dispersed. Figure 12 shows a before and after comparison of bus ridership along one checkpoint. During the maximum peak 15-minute period, for instance, inbound demand was reduced by 21 percent.

A less successful staggered hours project has been introduced in Atlanta.[25] Although the idea was backed by the Chamber of Commerce and funding for the project was obtained, employee opposition to the plan resulted. Reasons given for this were:

- There would be difficulty in adjusting present carpooling arrangements since many people rode with others who were not asked to stagger their hours.
- Bus scheduling problems can arise if certain large employers simply shift their work hours. This can move the peak on particular bus lines without reducing the peak load.

In addition, Atlanta has few really large firms to which these work changes would be most applicable. Other reasons given for the opposition include an interference

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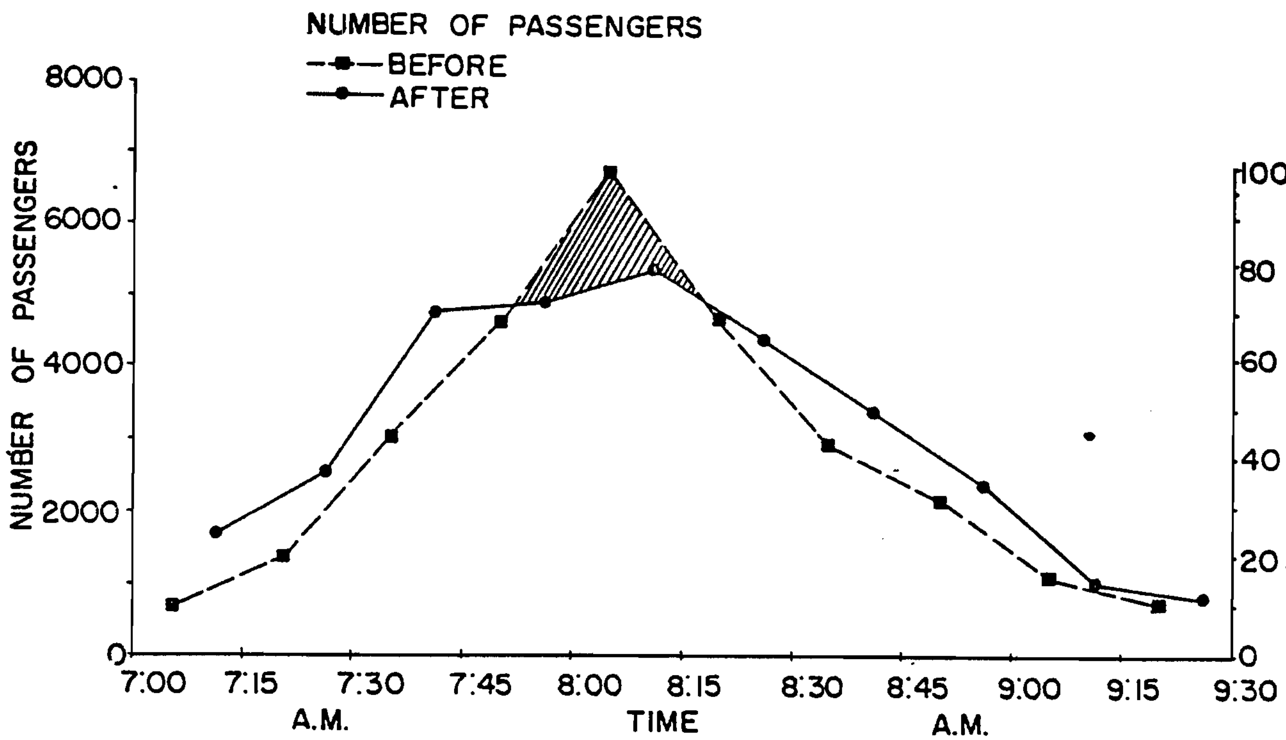
[25] R. H. Pratt Associates, Inc., Results of A Survey and Analysis of Twenty-One Low Cost Techniques, Volume I. Prepared for U.S. Department of Transportation (Kensington, Maryland: R.H. Pratt Associates, Inc., January 1973), p. 42.

FIGURE 12

BEFORE AND AFTER COMPARISON OF BUS RIDERSHIP, OTTAWA VARIABLE WORK HOURS EXPERIMENT



Source: Reza Safavian, and Keith G. McLeon, "Variable Work Hours: Who Benefits?", Traffic Engineering, Volume 45, No. 3, March 1975, p. 17.

with goods and supply deliveries schedules, existence of restrictive national labor contracts, and the problems of operating with national headquarters.[26] Thus, the success of a staggered work strategy appears to be highly dependent on employer and employee acceptance of the plan.

How applicable would a flexible work plan be to the Dallas area? The problem of an unbalanced distribution of commuters during peak period times also exists locally. In Dallas, a recent DTS passenger count indicated that during the height of the morning peak period (7:30-8:00) at least 13 bus lines (out of 54) experienced capacity of standing-room only crowds.[27] However, during the time periods before and after this time, an excess of seating capacity exists on these lines (Figure 13). During a gasoline shortage, these problems would be further complicated by sudden ridership increases on most lines during these peak periods.

The applicability and success of a varied work plan appears to be determined to a great extent by the size and type of economic activity groups in the target area. Small employers, for example, may find it difficult to vary their work hours since insufficient

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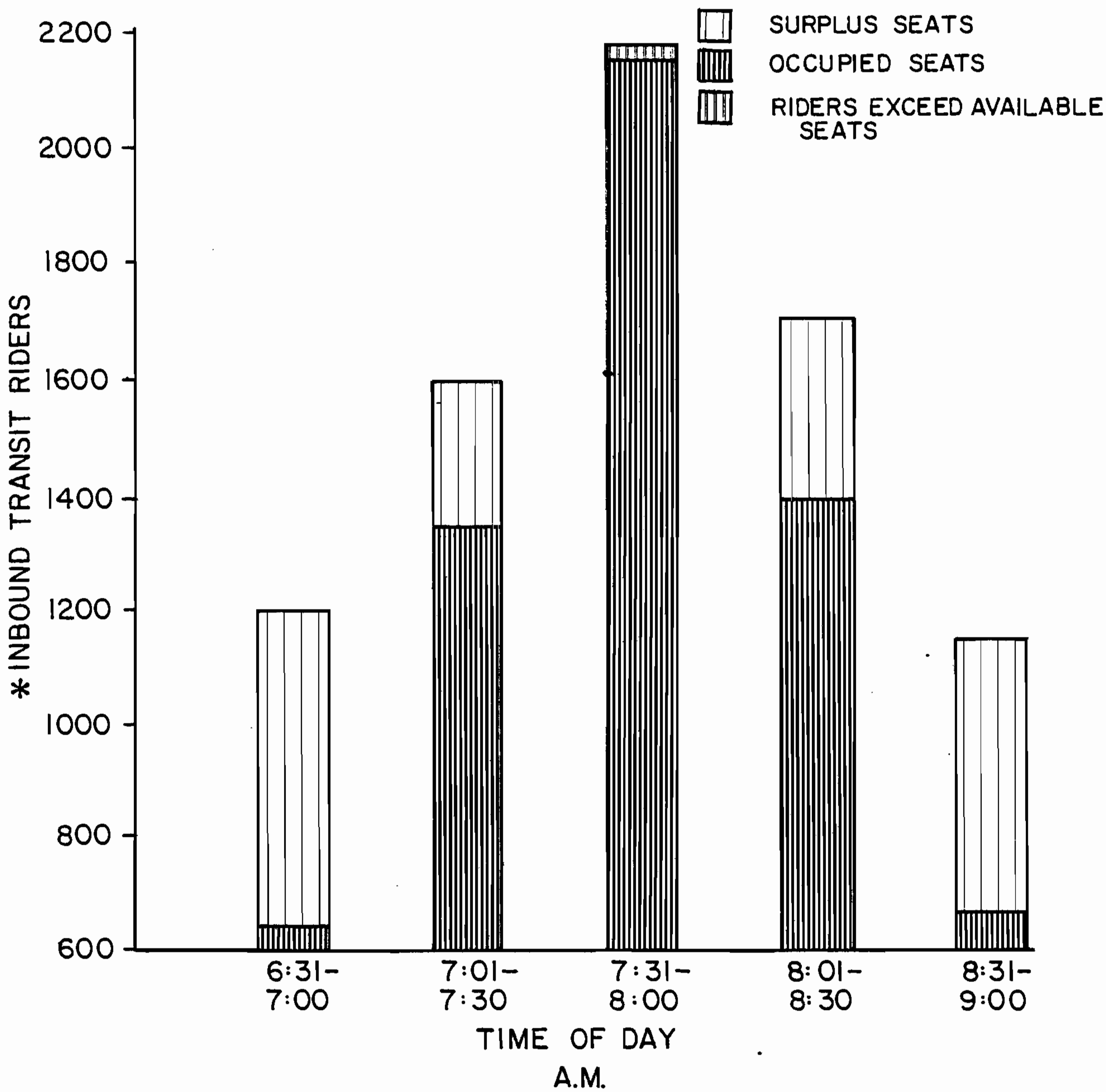
[26] R.H. Pratt Associates, Inc., Results of A Survey and Analysis of Twenty-One Low Cost Techniques.

[27] Dallas Transit System, "Passenger Count," June-July 1976.

FIGURE 13

TRANSIT RIDERS VS. AVAILABLE SEATS
DTS



* for 13 selected DTS lines

Source: Dallas Transit System, "Passenger Count," June-July 1976.

manpower would be available to cover for those not at work. In addition, some types of business, especially large government, service, and manufacturing, can alter work hours more easily than others such as education, transportation, or utility activities (Table 4).[28]

The Dallas area has a diversity of employment activities. Activities in the downtown areas, however, are largely of the government and service type, making them prime targets for varied work hours. There are approximately 130 such activities (having 100 or more employees) in downtown Dallas which employ more than 80,000 persons.[29] An estimated 20 percent of these employees in downtown Dallas utilize transit service. Additionally, employees in these target activities constitute more than 50 percent of the peak hour transit riders.[30] Therefore, if a program of varied work hours was implemented by each of these employers, the impact on transit ridership times could be considerable.

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[28] Roman Krzyczkowski et al., Joint Strategies for Urban Transportation, Air Quality and Energy Conservation (Santa Barbara, California: INTERPLAN Corporation, December 1974), p. 2-92.

[29] North Central Texas Council of Governments, estimates, March 1977.

[30] Ibid.

TABLE 4

Applicability of staggered work hours to basic economic activity groups.

Employment Classification	Schedule Freedom	Staggered Hours Potential
Federal Government	Free[1]	Good; many small agencies
State Government	Free	Good
Local Government	Free	Good
Trans-Comm-Util.	Fixed[2]	Poor; transportation (trade oriented)
Education	Fixed	Poor
Service	Free	Good; banks (trade oriented)
Retail	Flexible[3]	Fair; large firms only
Manufacturing	Free	Fair +
Wholesale	Flexible	Poor

1. "Free" indicates organizations with considerable latitude to set work hour schedules. In theory, schedules could encompass any period in the day if it were not for employee preferences. Shifts of at least one to two hours appear possible.

2. "Fixed" indicates organizations with no flexibility to change work patterns to any schedule other than existing ones.

3. "Flexible" indicates organizations which could potentially alter work hour schedules, but only if related firms (i.e., firms in the industry, customers, suppliers, and so forth) do the same. Since such shifts from established economic relationships usually involve a great number of firms and business practices, the extent of schedule change acceptable to such organizations is probably one hour or less.

Source: R. H. Pratt Associates, Inc., Results of A Survey and Analysis of Twenty-One Low Cost Techniques, Volume I. Prepared for the U.S. Department of Transportation (Kensington, Maryland: R. H. Pratt Associates, Inc., January 1973).

The success of a varied work program in Dallas will depend to a large extent on employer and public cooperation in these efforts. The emergency conditions which would exist during these "crisis" scenarios would probably encourage a greater public feeling of cooperation which may make this program easier to implement. The support of the local Chamber of Commerce, city government, and transportation providers is essential.

The administration and implementation of a local staggered work hour plan could be handled by the city carpool program offices in conjunction with the Chamber of Commerce. These offices already have contacts with local employers and could, therefore, facilitate the rapid implementation of the program. The costs could be very minimal. Most costs are one-time charges for feasibility studies and establishment of organizational procedures. The Downtown-Lower Manhattan Association spent $50,000 to implement a staggered work hour project in Manhattan in 1970 which included surveys, information programs, and before-and-after data collection. [31] Since, however, a local program would be a short-term action with voluntary employer support, this lead-in study and expense would not be necessary.

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[31] Roman Krzyczkowski et al., Joint Strategies for Urban Transportation, Air Quality and Energy Conservation, p. 2-107.

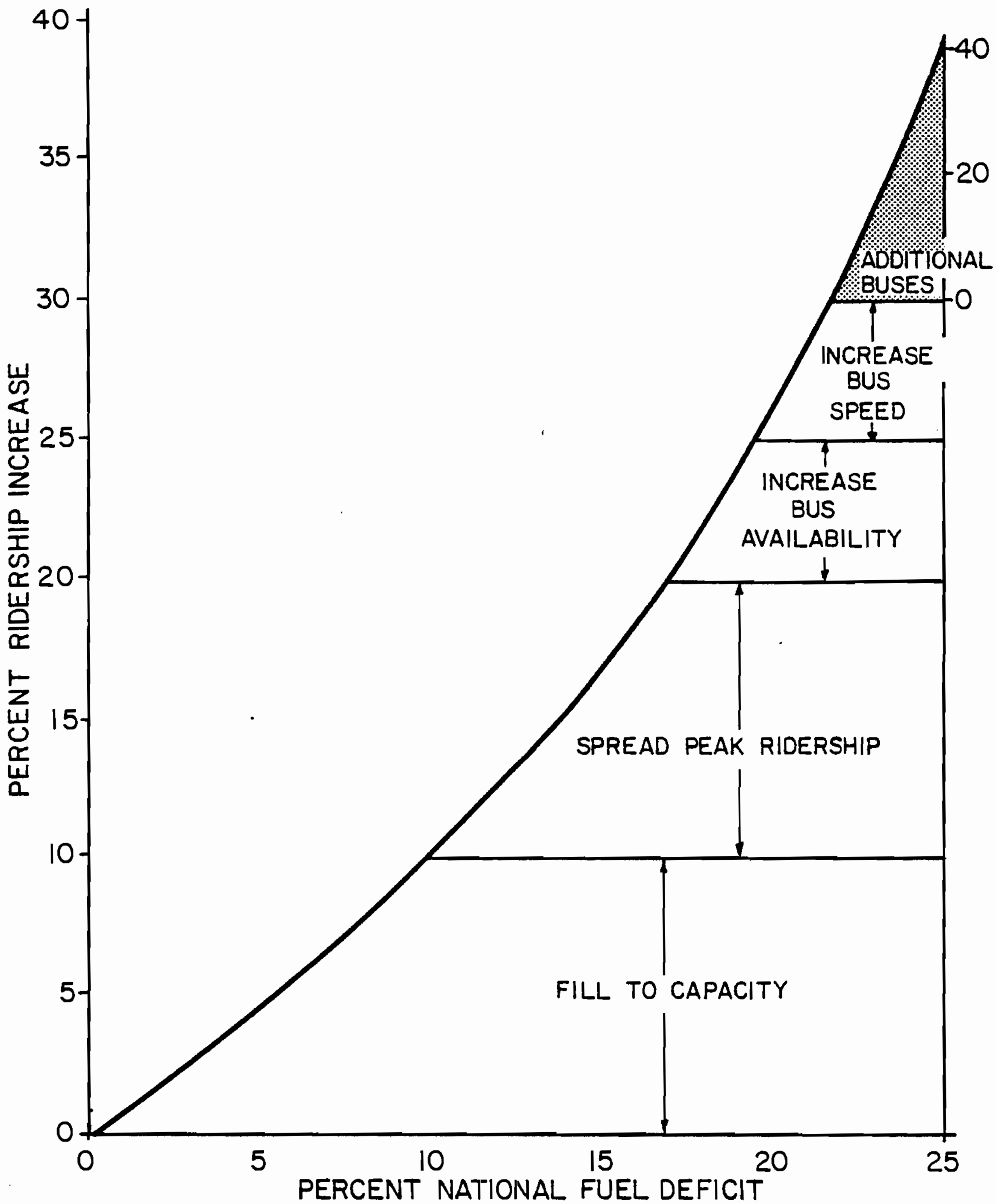
Increase the Bus Fleet Size

Would additional buses be needed by local transit systems? Figure 14 shows the effect of ridership increases on the current bus fleet of DTS. By using alternate strategies, such as allowing the seating capacity to fill up and staggering work hours, ridership increases under the 10 percent gasoline shortfall could be accommodated. DTS would experience difficulty accommodating total ridership when the gasoline shortfall reaches approximately 17 percent. If a 20-25 percent deficit is realized, the bus system would have to obtain up to 40 additional buses to accommodate a ridership increase of 30 to 40 percent. It should also be remembered that, since ridership increases will vary by line and time of day, it is conceivable that specific cases may require additional service even during the early strategies of allowing the capacity to fill or spreading the peak hour ridership. The close monitoring of ridership changes along each line could identify these special problem cases and service modifications could be made accordingly. Recording fare boxes, such as those now used by CITRAN in Fort Worth, could be useful in providing this information. The following discussion will examine strategies which could increase the bus availability for DTS and suggest ways of obtaining additional vehicles.

Since it would not be possible to order and receive additional new buses within a short-term basis (the normal process takes from one to two years), other avenues of procurement must be considered. The easiest action would be to utilize (rent or borrow) some of the Dallas metropolitan area's buses which are not owned by DTS.

FIGURE 14

EFFECT OF RIDERSHIP INCREASES ON BUS USE
D T S



Source: North Central Texas Council of Governments estimates based on Office of Technology Assessment and local data.

As can be seen in Table 5, this noncity transit fleet is nearly six times the size of the city transit fleet. Obtaining the use of the buses, however, presents serious legal and administrative problems.

The use of school buses for public transportation is now prohibited by Article 16.55 of the State Education Code which states:

> School buses shall be operated to and from school upon approved school bus routes and no variations shall be made therefrom. The penalty for varying from authorized routes and for unauthorized use of buses shall be withholding of transportation funds from the offending county or school district. In the event the violation is committed by a district which receive no Foundation School Program Funds, the penalty provisions of Section 4.00 (sic; should read 4.02) of this code shall be applied.

Section 4.02 proscribes misappropriation of funds and/or misrepresentation of local board use of them; such malfeasance is considered a felony punishable by a one- to five-year prison term.[32]

A proposed change to this regulation is being introduced to the State of Texas Legislature during this present session. House Bill 349 would amend the Texas Education Code. It states:

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[32] Robert Means et al., Legal Obstacles to the Use of Texas School Buses for Public Transportation (Austin, Texas: University of Texas at Austin, Council for Advanced Transportation Studies, January 1975), p. 2c.

TABLE 5

DALLAS METROPOLITAN AREA BUS FLEET INVENTORY

Public Intra-City Transit	Fleet Size (latest estimate)
Dallas Transit System	407 (1976)
CITRAN	121 (1976)
Total	528
Other Buses	
Texas Motor Coaches	32 (1976)
Surtran	45 (1976)
Continental Trailways (local and regional)	300 (est. 1975)
Church Owned	1,567 (1975)
School	1,023 (1975)
Other	70 (est.)
Total	3,037
Total Dallas Area	3,565

Source: North Central Texas Council of Governments, estimates.

> Subject to the rules and regulations of the commissioner of education, a school district or county school board governing a countrywide transportation system may contract with non-school organizations for the use of school buses.[33]

The various area churches combined operate the largest bus fleet in the Dallas metropolitan area. However, they will probably be reluctant to rent their buses to outside concerns.[34] In addition, other bus fleets (CITRAN, Texas Motor Coaches, Continental Trailways, Transportation Enterprises, Inc., etc.) will probably experience increased ridership demands and will thus have few, if any, buses to rent to others.

Another way to obtain additional buses would be to simply utilize more of the existing fleet. DTS currently utilizes approximately 80 percent of its total fleet during peak hours. If the number of out-of-service buses (those being repaired or maintained) were to be reduced, it would be possible to increase the number of operable buses available to the system. An estimated 90 percent of a fleet may be operable under such conditions. Therefore, as a contingency strategy, transit operations could increase their shop work to reduce the number of buses waiting for repair. Increasing the number of operable DTS buses from 80 to 90 percent would produce 17 additional vehicles for the system's use.

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[33] State of Texas Legislature, HB. No. 349, 1977.

[34] This opinion was expressed by the majority of churches surveyed by the North Central Texas Council of Governments, July 1976.

The Seattle Metro Study estimated that by employing 10 percent more mechanics and using swing and graveyard shifts to repair buses, or by jobbing out maintenance, the number of operable buses could be raised by 10 percent. The initial labor and materials cost, however, would be high, an estimated $5,000 per vehicle.[35]

Another method of increasing bus service with the existing fleet would be to increase the speed of the buses to the extent that more trips could be made within a time period. If, for example, the average bus speed for the system were increased by 5 percent, it would be possible to increase the service by 5 percent, i.e., run 5 percent more bus trips. The priority signalization and bus lane strategies mentioned previously could be helpful in increasing service as well as reducing fuel consumption. If bus lanes were established on these identified routes in Dallas, and were utilized by the existing bus routes, a 4 to 5 percent increase in speed during the peak period would result. This is equivalent to placing an additional 15 buses into service during this time.

Additional opportunities for DTS may exist to increase the system's fleet size by retaining replaced buses after future bus purchases have been made. Between 1977 and 1980, DTS plans to purchase 174 new buses.[36] Fifty of these new DTS buses will be purchased

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[35] The Municipality of Metropolitan Seattle, An Energy Contingency Plan for Metro Transit, p. 46.

[36] North Central Texas Council of Governments, Transportation Department, 1977 Transportation Program for North Central Texas (Arlington, Texas: 1976), pp. V-II-18-VII-29.

during 1978. If these old buses can be maintained, placed in reserve, and then replaced by subsequent purchases, probably no additional buses would be needed during a severe energy shortage. It is difficult to justify this standby capacity in practice, however, and the efficacy of this alternative is uncertain.

To summarize, numerous short-term opportunities exist to expand the DTS transit fleet size and to increase the bus availability in order to cope with sudden future ridership increases. Table 6 lists these mentioned strategies and the estimated impact of each on service capabilities.

CONCLUSIONS

If sufficient fuel supplies cannot be obtained by the transit system, the first step should be to implement those measures which could improve the efficiency of the operations. These measures, as shown in Table 7, are generally inexpensive to implement and have a minimal impact on service. If the fuel shortfall cannot be accommodated by these actions, it will become necessary to reduce service. In order to accomplish this, the transit system must first prioritize a list of cutbacks with regard to the routes and times to be considered for a reduction in service. Such decisions should involve consideration of each transit line utilization characteristics, such as the occupancy rate, trip purpose, and the existence of alternate transport modes. It can also be anticipated that political pressures will be influential in determining this priority list.

TABLE 6

TRANSIT STRATEGIES TO INCREASE RIDERSHIP CAPACITY

Dallas Transit System

Strategy	Percent Capacity Increase	Remarks	Implementation Costs
Allow capacity to fill	10 - 15	Some lines already at capacity	None
Spread peak period Ridership	5 - 10	Employer cooperation essential	None - Low
Route private buses	Unknown	Private owners may not have spare equipment	Uncertain
Use public school busses	5 - 10	Currently prohibited by State law. School hours would have to be rescheduled	Uncertain
Decrease out-of-service buses	10	High costs involved	High
Increase bus speed through bus lanes and priority signalization	1 - 5	Could be difficult to enforce	Medium - High
Retain replaced buses	10 - 15	Difficult to justify	Uncertain

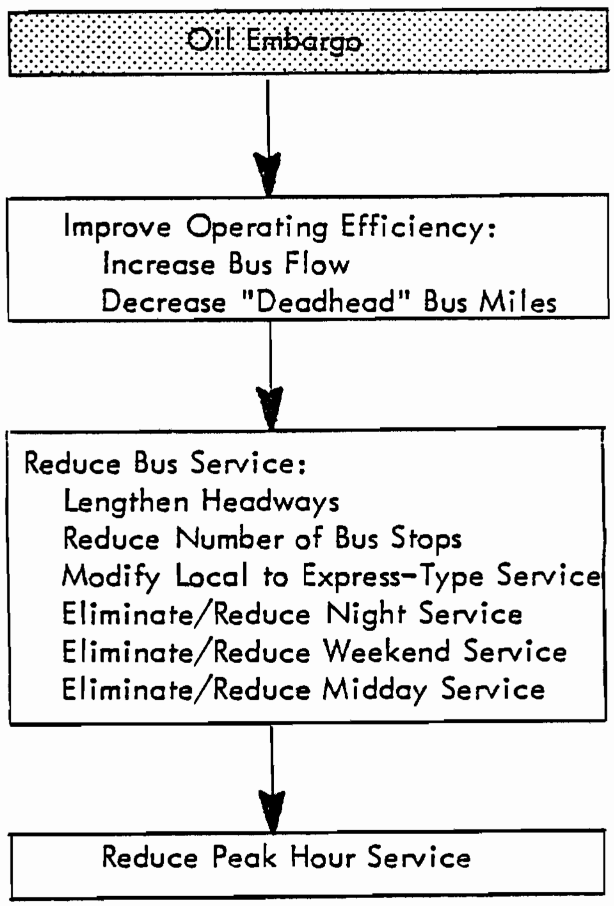
Source: Based on information provided by DTS

Alan M. Voorhees and Associates, Inc., Guidelines to Reduce Energy Consumption Through Transportation Actions. Prepared for the Urban Mass Transportation Administration (McLeon, Virginia: Alan M. Voorhees and Associates, Inc., May 1974).

U.S. Department of Transportation, Priority Techniques for High Occupancy Vehicles (Washington, D.C.: U.S. Governments Printing Office, November 1975).

TABLE 7

SHORT TERM MEASURES TO CONTEND WITH REDUCED FUEL SUPPLIES FOR TRANSIT OPERATIONS



Moreover, this prioritization process will be much more difficult to resolve if large ridership increases occur in all areas of the city. Nonetheless, if no other choice to reduce fuel consumption exists, sacrifices of this type must be made.

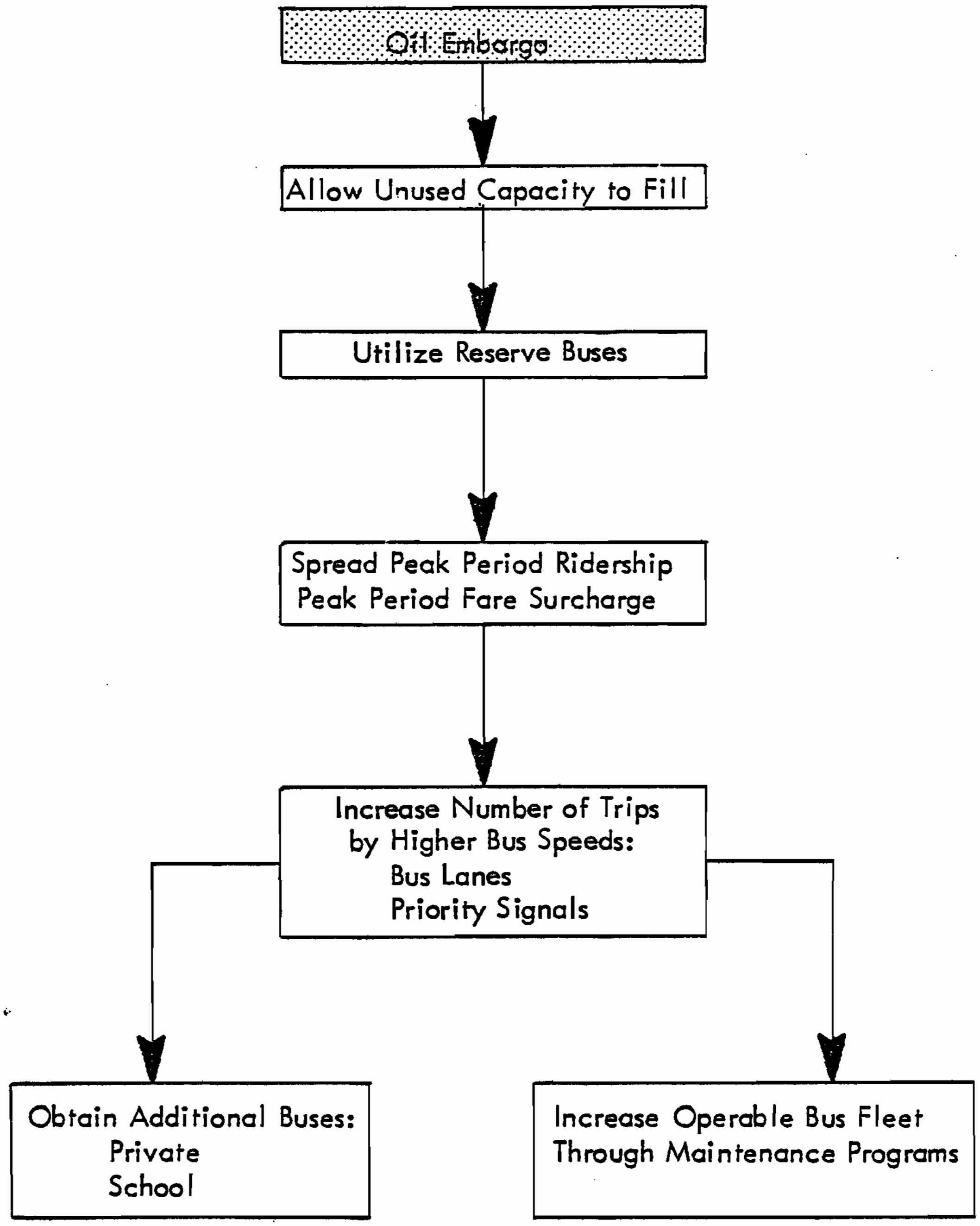
The list of suggestions to cope with bus ridership increases should also be considered in order of effectiveness as well as cost (Table 8). The first actions should be to allow the unused seating capacity to fill as attempts are made to spread peak period ridership by encouraging flexible work hours and possibly imposing a peak period fare surcharge. When it becomes clear that additional buses will still be needed, the transit system must choose among the available options. If, for example, additional used buses are available for rent purposes, it should be decided if renting would be more cost effective than increasing the usable fleet size through an intensive maintenance program.

Many of these decisions will not be easy ones. Most options involve either added expenses or a reduction in the transit service provided. In addition, the number of available options may be very few. For example, the use of school buses may be legally prohibited and other outside bus sources may not exist.

If such future problems are to be minimized, Dallas Transit System should begin a contingency planning effort before a crisis situation develops. A set of strategies, such as those mentioned in this study, should be developed. Inquiries should be made

TABLE 8

SHORT-TERM MEASURES TO CONTEND WITH SUDDEN BUS RIDERSHIP INCREASES



into the possibilities of obtaining additional buses under an emergency situation. Dialogue between the city government and local employers should be initiated to encourage cooperation in staggered work hour programs. And finally, the bus system itself must assess its service and ridership by line and time. A priority cutback list should be developed now so as to avoid delays which may be caused by political uncertainties during the "crisis" period.

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