NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE **73**

# ALTERNATIVE WORK SCHEDULES: IMPACTS ON TRANSPORTATION

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

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RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

SUBJECT AREAS
- ADMINISTRATION
- PLANNING
- FORECASTING
- SOCIOECONOMICS
- ENERGY AND ENVIRONMENT

MODES
- HIGHWAY TRANSPORTATION
- PUBLIC TRANSIT

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. NOVEMBER 1980

## NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the Academy and its Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the National Academy of Sciences, or the program sponsors.

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The Transportation Research Board evolved from the 54-year-old Highway Research Board. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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## PREFACE

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the engineering ideas of men faced with problems in their day-to-day work. Because there has been a lack of systematic means for bringing such useful information together and making it available to the entire highway fraternity, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize the useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series attempts to report on the various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which they are utilized in this fashion will quite logically be tempered by the breadth of the user's knowledge in the particular problem area.

## FOREWORD

*By Staff*
*Transportation Research Board*

This synthesis will be of special interest and usefulness to planners and administrators of transportation agencies and others concerned with the use of alternative work schedules to relieve peak-period congestion of transportation facilities. Information is presented on implementation of staggered and flexible work hours and compressed workweeks and on the impacts of such measures on highways, transit systems, and ride-sharing programs.

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Administrators, engineers, and researchers are faced continually with many highway problems on which much information already exists either in documented form or in terms of undocumented experience and practice. Unfortunately, this information often is fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem frequently is not assembled in seeking a solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of synthesizing and reporting on common highway problems. Syntheses from this endeavor constitute an NCHRP report series that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems.

A major cause of peak-period congestion of transportation facilities is the relatively short duration of work arrival and departure times. As an alternative to increasing capacity, transportation system management concepts are being used to shift the demand to less congested times and to reduce the need to travel. This report of the Transportation Research Board includes a discussion of approaches such as staggered and flexible work hours and compressed workweeks and an evaluation of the impacts on highway transit facilities, ride-sharing programs, and mode choice. Specific steps are recommended for implementing a program to shift transportation demand to less congested periods.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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# ALTERNATIVE WORK SCHEDULES: IMPACTS ON TRANSPORTATION


## SUMMARY

Urban highway traffic demand during the peak hours is typically double the average hourly demand; for public transit the peak-hour traffic demand is 3 to 4 times the average hourly demand. The main cause of these peaks and the resultant congestion is the relatively narrow range of work schedules.

Traditionally, congestion relief consisted of accommodating demand with increased capacity—more highway lanes or expanded transit service. Recent transportation system management approaches include the concept that travel demand can be managed. Two ways to manage travel demand are (a) shifting demand to less congested times when surplus capacity is available, and (b) reducing the need to travel. Alternative work schedules can be used to manage transportation demand by shifting commuters away from the peak hours and by reducing the number of days that people need to travel to work.

There are three basic forms of alternative work schedules: (a) staggered work hours, where groups of employees are assigned staggered starting times such as at 15-min intervals over a 2-hr period; (b) flexible work hours, where individual workers have some control over their own working hours but all employees must be present during a core time; and (c) compressed workweeks in which the work schedule is condensed into less than 5 days per week (or less than 10 days per 2 weeks) by increasing the number of hours worked per day.

Staggered and flexible work hours bring about substantial reductions (as much as 50 percent) in the number of participating employees arriving and departing during the heights of peak periods (e.g., the highest 15 min). However, because of the large number of people who do not participate in alternative work schedules, reductions in peak-hour volumes of transit passengers and automobiles are not as striking. Evaluations of large-scale variable work hours programs show that peak-hour bus loads and automobile arrivals at parking garages decrease 10 to 20 percent, and peak-hour automobile traffic volumes on major approaches to work centers are reduced by 5 to 10 percent. Studies show that staggered and flexible work hours result in reduced travel times, reduced load factors, and thus less crowding on transit and less waiting time for elevators in office buildings. Reductions in travel time range from 2.5 to 8 min for commuters who participate in flexible work hours programs, and from 1 to 4 min for all commuters using the affected highways. There are conflicting hypotheses as to the effects of variable work hours on mode choice; the data are insufficient to draw firm conclusions, but

it appears that a flexible hours program has a positive effect on transit and carpool use.

Compressed workweek programs have been carried out independently by employers; little data on the impacts of these programs on transportation have been collected. Theoretical analyses indicate that compressed workweeks can significantly reduce peak-period work trips and congestion, although there may be negative effects on carpooling and transit ridership.

Implementation of an alternative work schedule program begins with the determination that there is a congestion problem that could be alleviated by shifting transportation demand to less congested periods. After commitments are obtained from public and private organizations, a lead agency should be established, preferably the same one that is coordinating ridesharing. The following implementation steps are suggested: (a) identify high-priority employment locations; (b) obtain support for feasibility studies; (c) conduct work schedule and transportation surveys of employers; (d) design work rescheduling plans; (e) obtain management decisions to implement; (f) provide implementation assistance; (g) evaluate impacts; and (h) refine and extend the program.

CHAPTER ONE

# INTRODUCTION

## BACKGROUND

Urban automobile traffic demand during the peak hours is typically double the magnitude of the average hourly demand. Urban public transit demand is even more steeply peaked with the peak-hour demand 3 to 4 times higher than demand during the average hour of the day. The "peaks within the peak hour" on the urban highway and transit systems add an even greater burden to the available supply of transportation facilities and services.

Transportation officials, as well as politicians, private interest groups, employers, and taxpayers, are becoming aware and accepting that it is neither economically feasible nor desirable to provide the entire transportation capacity needed to service peak demands, and that the provision of transportation service capacity must be systematically supplemented by more efficient operational management of available facilities. An essential element of improved urban transportation system management is the management of travel demand. No longer accepted as an absolute, travel demand is being viewed as a quantity whose overall magnitude and distribution can, to some degree, be managed.

Existing work schedules are the cause of the familiar twice-daily peaks of transportation demand; thus the approach to alleviating traffic and transit congestion by flattening the peak travel demands must involve the alteration of work schedules. Transportation officials have become increasingly interested and active in implementing alternative work schedules. Options being pursued include staggered work hours and flexible work hours, which are aimed at shifting commuter travel to less congested periods (i.e., the shoulders of the peak) and, to a somewhat lesser extent, the compressed workweeks concept, which reduces the number of days people need to travel to work.

With a few notable exceptions, work rescheduling efforts in the 1970s were pursued under the independent initiative of employers, usually for different or broader reasons than reducing traffic congestion (e.g., improved quality of work life, employee morale, productivity, etc.). Pioneering efforts by government transportation agencies to encourage and facilitate work rescheduling, focused mainly on employment in the central business district, were implemented in New York, Philadelphia, Toronto, Ottawa, and Madison, Wisconsin. Newer programs are in various stages of development, including programs in urban areas such as Boston, Seattle, Denver, Milwaukee, San Francisco, Richmond, and Honolulu. Many other urban areas have made some strides either in planning or studying the feasibility of alternative work schedule programs or in carrying out initial implementation steps. Clearly, increasing numbers of transportation agencies are becoming aware that government can play a constructive role in fostering more "transportation-efficient" work schedules.

Growing interest and activity have demonstrated the need for technical information on work rescheduling alternatives, the impacts on transportation system conditions, and implementation guidelines. This document has been prepared in response to the need for information on this subject.

## ORGANIZATION OF SYNTHESIS

This synthesis of practice in alternative work schedules focuses on the purposes for work rescheduling and the resulting impacts on transportation. Chapter 2 provides a broad background of the peak-period transportation problem and approaches to its solution. The rationale for and the role of alternative work schedules within this broad context are discussed. Formal definitions of work rescheduling alternatives are given, which emphasize the fact that many variations of flexible and compressed work schedules are possible.

Chapter 3 presents data on the observed time of day distributions of work schedules and travel demands to illustrate and quantify the nature of peaking on the highway and transit systems. Chapter 4 presents the findings of measurements and analyses of the impacts of alternative work schedules, including impacts on:

- Distribution of work arrivals and departures,
- Distribution of automobile and transit traffic,
- Quality of highway and transit service, and
- Travel mode choice.

In Chapter 5, the general approach to and key factors influencing the implementation of urban area alternative work schedule programs are discussed. The need to organize such programs in a manner that is sensitive to varying problems, needs, and policies of different urban areas is identified. Guidance is given on organizing these programs, and a sequence of implementation steps to follow is suggested. Legal barriers to the implementation of alternative work schedules are reviewed. Finally, a discussion is presented of the attitudes toward and acceptance of alternative work schedules by employees, management, and labor union officials.

The final chapter highlights the findings of the synthesis report. Conclusions and recommendations associated with each of the four preceding chapters are presented.

Alternative work schedules, as one of the many transportation system management strategies, offer significant potential for improving the efficiency and economy of the highway and transit system operation. It is hoped that this synthesis will contribute to an expanded and improved application of alternative work schedule concepts.

CHAPTER TWO

# APPROACHES TO THE PEAK-PERIOD TRANSPORTATION PROBLEM

## NEED FOR IMPROVED TRANSPORTATION SYSTEM MANAGEMENT

Growing interest in using alternative work schedules to alleviate peak-period urban traffic congestion is an important aspect of the emerging emphasis on better transportation system management (TSM). Until recently, solutions to transportation problems have focused chiefly on capital-intensive investments—expanded transportation facilities and improved design features to enlarge capacities and to accommodate future travel demands at congestion-free levels of service.

This preoccupation with high-capital investments for transportation facilities can be seen in both the highway and the mass transit systems. Nevertheless, urban transportation policymakers are becoming committed to a more balanced approach to system improvement, resulting in increased efforts to make better and more economic use of existing transportation facilities. Several factors have influenced this policy shift.

- Urban transportation facilities already have extensive physical plants that provide high levels of capacity and service efficiency (except during a few peak-demand hours each day in the most heavily traveled corridors and subareas).
- Tax resources for construction of new highway and mass transit facilities are severely limited.
- Rapidly escalating construction and maintenance costs are diminishing the buying power of funds available for transportation improvements.
- The costs of providing additional peak-period capacity —either in the form of highways or transit—are extremely high.
- Adverse effects of transportation facilities on energy, the environment, and communities are becoming increasing concerns.

Faced with these widespread problems, policymakers are shifting priorities from construction of facilities to TSM improvements that emphasize *operational, regulatory,* and *service policy* strategies. The idea is to make more efficient and less wasteful use of transportation resources. A key feature of this shift is *the notion that travel demand is not necessarily absolute and can, to some degree, be managed.*

## DEFINITION OF CONGESTION

Transportation congestion can be defined as too many people and vehicles using a facility at one time, and is caused by a lack of adequate transportation facilities and excessive concentrations of travel demand in space, time, and mode. Travel demand excesses are concentrated on routes to, from, and within major activity areas such as central business districts; occur mainly during short peak periods when most commuters are traveling; and can be blamed on the overuse of low-occupancy private vehicles, and the underuse of the substantial passenger capacity of private and some public transit vehicles.

The concentration of transportation demand at critical points in space and time will overload the service capacity of any transportation system and result in deterioration of its operational efficiency, which is determined by such factors as (a) travel time and delay, (b) user and system operating costs, (c) fuel consumption and air pollution, and (d) user comfort and convenience.

As noted by Rowan et al. (*1*):

> Most urban transportation systems operate satisfactorily during 20 to 22 hours of the day. It is the 2 to 4 remaining hours of the day during which the "wheels of progress" turn more slowly. The congestion, delay and other operational deficiencies are the direct result of transportation demand exceeding supply during these hours.

As similarly observed by Jones et al. (*2*): "Twice each day, the highway and transit systems are flooded with the lemming-like movement of the metropolitan labor force." The morning and afternoon commuter peaks ironically are known as rush hours, although these are the times of day when "there is precious little ability to rush anywhere very fast."

Severe congestion during peak periods does not occur uniformly, but usually occurs in corridors and subareas where commuter travel demands are especially heavy. Central business districts (CBDs) and the radial highway and transit routes serving them often suffer the worst congestion. However, congestion is not simply a CBD problem; in many urban areas, other activity centers also suffer excess travel demand and capacity deficiencies.

It is also important to note that congestion severity is relative. In smaller urban areas or in outlying employment centers of larger urban areas, 15 min of congested operation may be viewed as a serious problem. In large metropolitan areas, 1 to 2 hr of congestion twice a day may be viewed similarly. In some cities, a delay of several minutes at a bottleneck arouses great frustration; in other cities, travelers may be resigned to a delay of 15 or 20 min in traversing a congested zone. Therefore, relieving congestion should not be limited to places where the duration and severity of congestion are greatest.

Often, too little attention is given to the fact that congestion is experienced by travelers on public transit systems as well as by those in private automobiles. Most transit ridership is in buses that share the highway space with other vehicles. Furthermore, more transit passengers *travel in* *locations and at times of day subject to congestion,* because there is a greater concentration of transit riders in radial corridors during peak periods as compared to automobile drivers.

Heavy transit passenger demands during peak periods also cause additional delays in terms of longer passenger boarding and alighting times. During peak periods, transit vehicles on heavily patronized lines are often overloaded; some riders must wait for a vehicle that has available space. Many peak-period transit riders also experience physical discomfort because of crowded conditions on overloaded vehicles; they are often forced to stand for long periods. Even when transit systems operate on separate rights-of-way, avoiding highway traffic congestion, they are still subject to the problems of passenger service delay and overloading.

## TRADITIONAL APPROACH TO CONGESTION RELIEF

The traditional approach to relieving or eliminating transportation system congestion has been to provide the spatial organization of capacity needed to satisfy travel demand. Transportation planners forecast where travel demand will occur (emphasizing the distribution of origins, destinations, and travel paths); highway designers then use estimates of design hour traffic volumes as a basis for sizing the additional capacity needed to accommodate demand.

The spatial organization of service capacity has also dominated the planning of transit systems, although capacity can be varied by scheduling more frequent service during periods of heavier demand. Although transit service flexibility is achieved, the practice of large numbers of transit vehicles being idle for most of the day is extremely wasteful.

Traditionally, in both highway and transit planning, *the magnitude and temporal distribution of travel demand have been taken as absolutes.* The main thrust has been directed to finding the most effective way to supply facilities and service capacity that satisfy demand. Economists have long argued that this transportation policy, in which capacity is provided to meet peak-period demands, making the system grossly underused most of the time, is an inherently wasteful overinvestment in transportation capacity.

Transportation policymakers are being forced by realities into greater agreement with the economists. The overall costs of providing marginal increases in capacity are escalating faster than inflation and beyond available resources. Overcoming community resistance to the construction of new facilities is becoming more difficult, and the adverse socioeconomic, environmental, and energy consequences of increasing transportation supply are becoming unaffordable. Finally, the forces of inflation are bringing great pressure on government to hold down taxes and to find more cost-effective ways of meeting demands for essential public services. Given these realities, it is clear that the transportation sector can no longer afford the luxury of simply supplying capacity to meet unbridled demand.

## DUAL APPROACH TO TRANSPORTATION SYSTEM MANAGEMENT (TSM)

Faced with difficult, uneconomic continuation of traditional solutions to congestion, national policymakers are emphasizing more efficient management (*3*), i.e., better use of existing transportation facilities and services. The approach to improved TSM is to apply relatively low-cost, operational, regulatory, and service policies to two major objectives: (a) enhancing the quality of travel service provided by the *existing* highway and transit systems, and (b) managing the quantity and distribution of travel demand in a manner that reduces the imbalance between supply and demand.

The first objective can be pursued by expanding the use of traffic engineering measures that process vehicle demands more efficiently and by improving deployment and management of available public transit resources to achieve higher quality and less expensive servicing of transit demand. These actions can improve transportation supply so that transportation demand can be accommodated at an improved standard of service. In the process, more consideration is given to allocating road space to optimize the number of people moved as opposed to vehicles moved.

The second TSM objective, managing demand, is a major departure from traditional transportation thinking. Travel demand is viewed as a quantity whose size and distribution can be carefully controlled. If the expansion and improvement of transportation supply in urban areas cannot keep pace with unrestrained growth in travel demand, then either demand must be systematically managed or congestion will worsen.

There are several possible approaches to managing travel demand.

- Travel demand can be shifted to more efficient modes, namely, from single-occupant vehicles to higher-occupancy modes (private ridesharing or public transit) or to nonmotorized modes (pedestrian and bicycle). A variety of means can be used to encourage mode shifts.
- Vehicle traffic can be shifted to less congested routes or restricted in congested zones or both.
- Travel demand can be shifted to less congested times of day when surplus capacity is available.
- Total travel demand can be reduced through (a) minimizing avoidable travel by better trip planning, (b) reducing the need to travel (e.g., compressed workweeks, substitution of communications for travel), and (c) shortening trip lengths through better spatial arrangement of land-use activities (a long-range approach).

## PURPOSES OF ALTERNATIVE WORK SCHEDULES

As can be seen from the previous discussion, two important elements of managing travel demand relate to implementing alternative work schedules.

First, the daily morning and afternoon peaks can be flattened by shifting more commuters to the "shoulders" of the peak where demand concentrations are lower. Considerable emphasis has been placed on two forms of variable work hours that flatten peaks: staggered work hours and flexible work hours.

Second, overall commuter travel demand can be reduced by introducing compressed workweeks that decrease the number of days needed to travel to work. Compressed workweeks mean shifting some workers from a standard 5 day per week, 8 hr per day schedule to fewer days of longer hours (e.g., 4 days per week, 10 hr per day). From a transportation point of view, compressed workweeks decrease total weekly travel to work. This measure can also flatten peak-period demand because longer working days make commuting times likely to fall before the highest morning and after the highest afternoon peaks.

Pratt et al. (*4*) elaborated on the variable work hours concept:

> The primary objective of variable work hours programs, from the urban transportation point of view, is to effect work schedule changes that will reduce the degree of vehicular traffic and transit passenger peaking that occurs during the normal workday. The idea is to spread out travel demand by changing the work hours for a segment of all employees in the employment center involved. Of interest is not only a reduction of AM and PM *peak hour* traffic and passenger loads, but also an evening out of the sharply peaked loads often prevalent during *short intervals within* peak hours. The resultant reduction in peak transportation demand is intended to reduce rush hour highway congestion and transit overcrowding, and to alleviate pressures for new transportation facilities or transit vehicle scheduling designed solely to serve heavy peak period demands.

Ronan (*5*) stressed the potential financial savings due to altered work schedules:

> Staggering working hours is definitely a program that could lead to savings on the part of public transportation operators throughout the country, if it is participated in fully enough.
>
> In highly congested CBD's, a major portion of the capital costs for transportation facilities is based on the demand which these facilities are expected to handle during peak travel periods. If this demand could be permanently altered downward by work schedule changes, we could alter downward the physical requirements.

## COMMUTER TRAVEL SCHEDULES—CHOSEN OR IMPOSED?

Because transportation demand peaking is a major cause of congestion, the question arises as to why larger numbers of commuters do not choose to alter their travel schedules to avoid peak periods. Two hypotheses have been formulated by Jones et al. (*2*) in response to this question.

Economists contend that people continue to travel in the most congested periods because the existing system for pricing travel is inappropriate. Both the costs incurred by travelers in congested peak periods and costs incurred in less congested periods are strongly correlated with costs per vehicle mile traveled. Peak-period user costs exceed user costs during less congested times by only small margins that do not fully reflect the costs to society of choosing to travel during the peak. Arguments have been made that implementation of a more realistic road pricing method, by which peak-period automobile commuters would be charged much higher prices to match the contributions their trips make to the social costs of congestion, would induce many more commuters to travel during less congested hours.

Jones et al. (*2*) present the counterargument that most workers do not have the freedom to make individual choices of work schedules and corresponding commuting schedules. He postulates:

> Most choices to travel in the peak period should be viewed as a joint decision of the individual *and* the employer because the "choice" of travel time is determined by work schedules. . . . Employers are likely to have far more discretion than their employees in scheduling work hours. . . . Most employees face a Hobson's choice between unemployment and work schedule conformance. . . . In this sense, it can be argued that congestion is in part an artifact of the scheduling and organization of work, and *not* just a socially perverse "individual choice" guided by inappropriate pricing rules. Framed in this fashion, "the peaking problem" is revealed as a paradox: We could enjoy open roadspace, but we are confined by closed schedules.

There is much truth in Jones' contention that for the majority of employees work schedules are imposed instead of freely chosen. It is evident that employers must bear a large share of the responsibility for implementing alternative work schedules aimed at reducing peak-period transportation congestion. The need for extensive employer involvement in bringing about desired changes in work schedules must be recognized by transportation planners.

## DEFINITIONS OF WORK RESCHEDULING ALTERNATIVES

Using alternative work schedules means making changes in the requirement that all employees of an organization be at work on the same days and during the same scheduled hours each day. Three basic forms of alternative work schedules are of primary interest in this synthesis:

- Staggered work hours,
- Flexible work hours, and
- Compressed workweeks.

The U.S. Civil Service Commission (now the Office of Personnel Management) (*6*) has developed the comprehensive set of definitions of alternative work schedules and related terminology used in this report. For flexible work hours and compressed workweeks, the definitions cover several variations on the basic concepts that must be considered in assessing the feasibility and transportation impacts of the alternatives. Shortened versions are taken largely from the Civil Service Commission's definitions, which illuminate the more important variations. [See Fiss and Martin (*6*) for further detail on specialized forms of the alternative work schedule concepts.]

### Staggered Work Hours

With this alternative work schedule, all employees in an organization work the same days each week and the same number of hours each workday. Daily starting and stopping times of different groups of workers within the organization (or between organizations within an employment locality) are varied by the employer by assigning staggered starting times—7:00 a.m., 7:15 a.m., 7:30 a.m., etc. Employees generally have no choice in their working hours; they are simply expected to be present each day during their assigned times.

Staggered work hours exist, to some extent, in virtually all multiemployer work locales by virtue of the fact that different employers impose different work schedules. Even though no single employer may stagger hours, an unplanned and uncoordinated form of staggered work hours exists. The prevailing distribution of starting and quitting times of all workers in multiemployer locations reflects the existence of such ad hoc hours.

### Flexible Work Hours (Flexitime)

Any system that gives individual employees some measure of control over their own working hours is classified as allowing flexible work hours, or flexitime. With this alternative, the range of possible hours within which an employee may choose to work is extended beyond the limits of fixed starting and quitting times. For example, the range could be designated as 6:30 a.m. to 6:00 p.m., which would consist of two different types of times: (a) core time, during which all employees must be present (9:30 a.m. to 3:00 p.m.) except for a lunch break, and (b) flexible time, the periods during which employees may select variable starting and quitting times (flexible starting times between 6:30 a.m. and 9:30 a.m. and flexible quitting times between 3:00 p.m. and 6:00 p.m.). Lunch breaks are specified to last a fixed length of time (e.g., 0.5 hr) that employees must take at some time during the core-time period, or a midday flexible range (e.g., 11:30 a.m. to 1:30 p.m.) that employees may use as desired is specified. Two sample flexitime work schedules are shown in Figure 1.

Included among the possible common forms of flexitime are the following:

*Gliding Schedule.* This is the classical flexitime scheme by which employees are free to select and vary their working hours each day, provided they are present during core times and a specified cumulative number of hours are worked within a given pay period (e.g., during 1 week, 2 weeks, 1 month). The number of hours worked each day can vary. In some cases, debit or credit hours may be carried forward from one pay period to the next.

*Floating Day.* This is a variation of the gliding schedule in which employees are required to work the same number of hours each day but still retain flexibility as to which hours will be worked.

*Flexitour.* This is a more rigid form of flexitime in which the employee selects a starting time from within the morning flexitime range. Once selected, this becomes the employee's regular time schedule until another opportunity arises (i.e., a new tour of duty) to select a different work schedule. Tours may be established as frequently as desired by the organization (e.g., each month, quarterly, etc.). Normally, the flexitour scheme has a single core time and a fixed-duration lunch break instead of a double core time and a flexible lunch period. Flexitour closely resembles staggered work hours—the only difference being that the employees, not the employers, choose the work schedules.

The above definitions of alternative forms of flexible work hours are not currently in wide use; however, they represent a first step toward standardization of terminology.

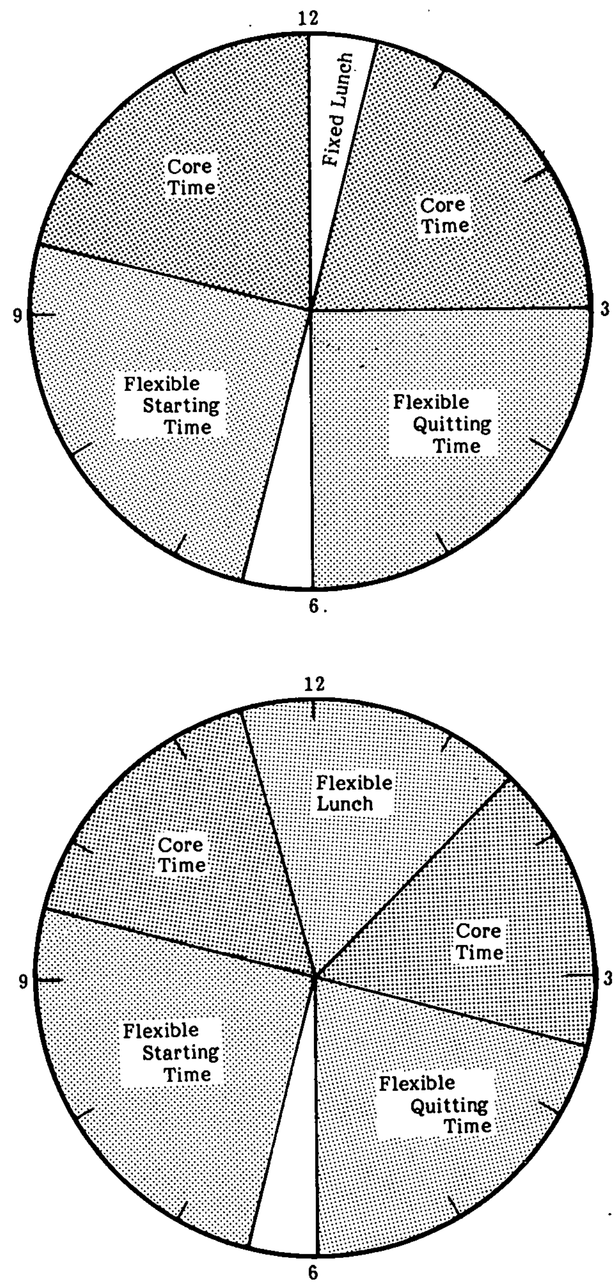



FIGURE 1 Two examples of flexible work schedules.

**Compressed Workweeks**

This schedule compresses working hours into fewer than 5 days per week or fewer than 10 days per 2-week period. Employees are usually assigned fixed working hours on the days they are present. Numerous forms of the compressed workweek are possible, but the following are the most common:

*Four-day week.* Employees work 9 to 10 hr per day (depending on the total hours in the workweek), 4 days per week.

*Four-and-a-half-day week.* Employees work 8 to 9 hr per day, 4 days per week, and a half day on the fifth day.

*Three-day week.* Employees work 12 to 13 hr per day, tings that operate continuously throughout the 24-hr day 3 days per week. This scheme has been used in work set- (e.g. data processing centers).

*The 5-4/9 plan.* Employees work 9 hr per day, 4 days during 1 week and 5 days the succeeding week on a 2-week cycle.

Variations on these compressed workweek schedules are feasible, depending on whether the entire organization operates on the compressed schedule or business operations are maintained for 5, 6, or even 7 days a week, and on the methods used to rotate the workdays of individuals. For example, the 4-day workweek might take several forms:

- Equal rotation of workdays from Monday through Friday, with 80 percent of the employees assigned to work on each day.
- Half the employees work Monday through Thursday; half work Tuesday through Friday.
- Half the employees work Monday through Thursday; half work Wednesday through Saturday.
- A third of the employees work Monday through Thursday; a third work Tuesday through Friday; a third work Wednesday through Saturday.

The effects on transportation will vary substantially according to which type of compressed workweek is established by the employer. The possible variations are numerous, especially if one considers work settings in which 24-hr per day operations must be maintained with varying workforce sizes assigned to different shifts. Clearly, all possible variations of compressed workweeks must be taken into consideration, because of the differences in the operating characteristics of organizations.

CHAPTER THREE

# TIME-OF-DAY DISTRIBUTIONS OF WORK AND TRAVEL

The following information on the observed time-of-day distributions of work schedules and travel demands serves to illustrate and quantify the characteristics of peaking on highway and transit systems.

## WORK SCHEDULES

At the root of the transportation peaking problem is the scheduling of working hours. Data on working hours collected by the U.S. Department of Labor in 1973 and 1974 were reported by Hedges (*7*). Workers were asked to report their work starting and quitting times to the nearest hour. Figure 2 shows the hourly distribution of work starting times of full-time nonagricultural workers, with 8:00 a.m. being the nearest starting hour for about 42 percent of the national full-time work force. In another study, Hedges (*8*) reported that 84 percent of workers were on day shifts; thus 8:00 a.m. is the nearest starting hour for approximately one-half of all dayshift workers. A total of 80 percent of the full-time workers (nearly all of the dayshift personnel) reported their nearest starting hours were 7:00, 8:00, or 9:00 a.m.

For these data on work hours to be of value for transportation planning and analysis purposes, much shorter time intervals that characterize the shape of peak-period demand distribution should be examined. Various time increments have been used by different researchers, but 15-min intervals appear to be used most often. It is strongly urged that 15 min be adopted as a standard time increment for measuring traffic demand patterns.

Data on work schedules that have been tabulated by 15-min time periods reveal that severe peaking can occur *within* the peak hour. An extreme example of this phenomenon was documented among employees in downtown lower Manhattan by O'Malley (*9*).

The Downtown Lower Manhattan Association obtained information in 1970, before a program of staggered work hours was implemented, on work schedules of 113 firms employing 136,000 individuals. Extremely high 15-min peaks were found for scheduled starting times between 9:00 and 9:15 a.m. and quitting times between 5:00 and 5:15 p.m. (see Figure 3). Nearly two-thirds of the starting and quitting times were concentrated in the morning and afternoon peak 15-min periods. Similarly, extreme 15-min peaks were found among employees in midtown Manhattan.

An example of a much flatter 15-min-interval distribution of work schedules was found in a Washington, D.C., study by Wilbur Smith and Associates (*10*). Figure 4 shows the distribution of work starting times in the central employment area of Washington, D.C., an area where many people already have staggered work hours. A relatively uniform peak period lasts for 1.25 hr (8:00 to 9:15 a.m.), during which 76 percent of the employees report to work. The peak 15-min interval is about 20 percent higher than the average of the five highest 15-min intervals. Government workers tend to work earlier hours than workers in the private sector, which contributes significantly to the flatter peaks exhibited in the graph.

It is difficult to generalize about the exact shape of work-schedule distributions. Major differences are found between specific employment sites and between cities, as can

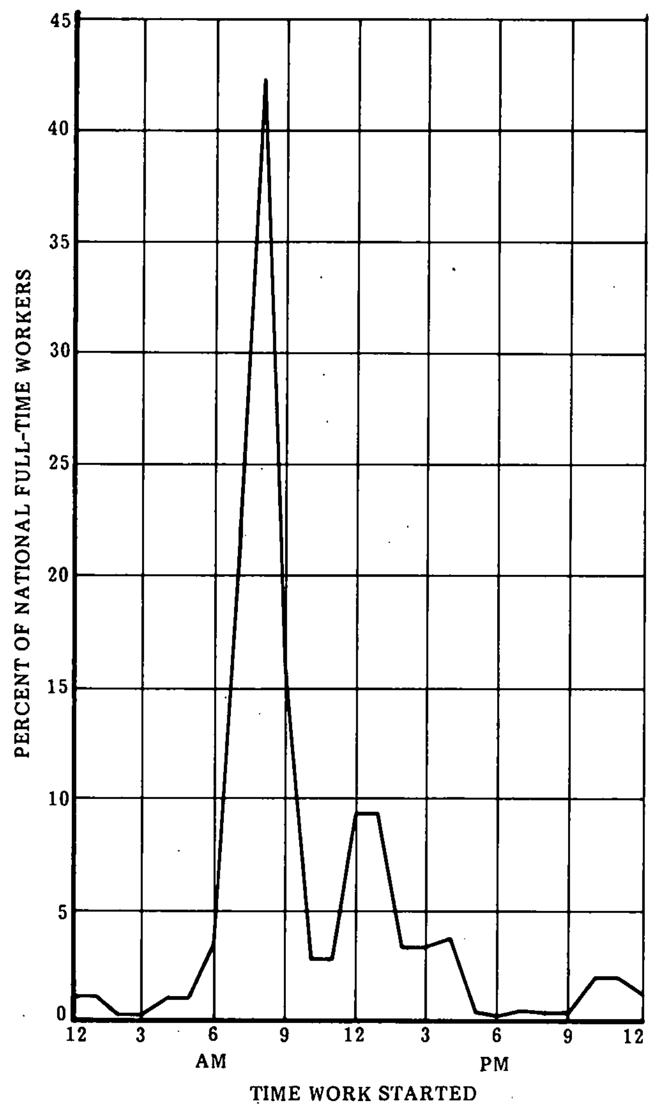



FIGURE 2 National distribution of work starting times [based on data from Hedges (*7*)].

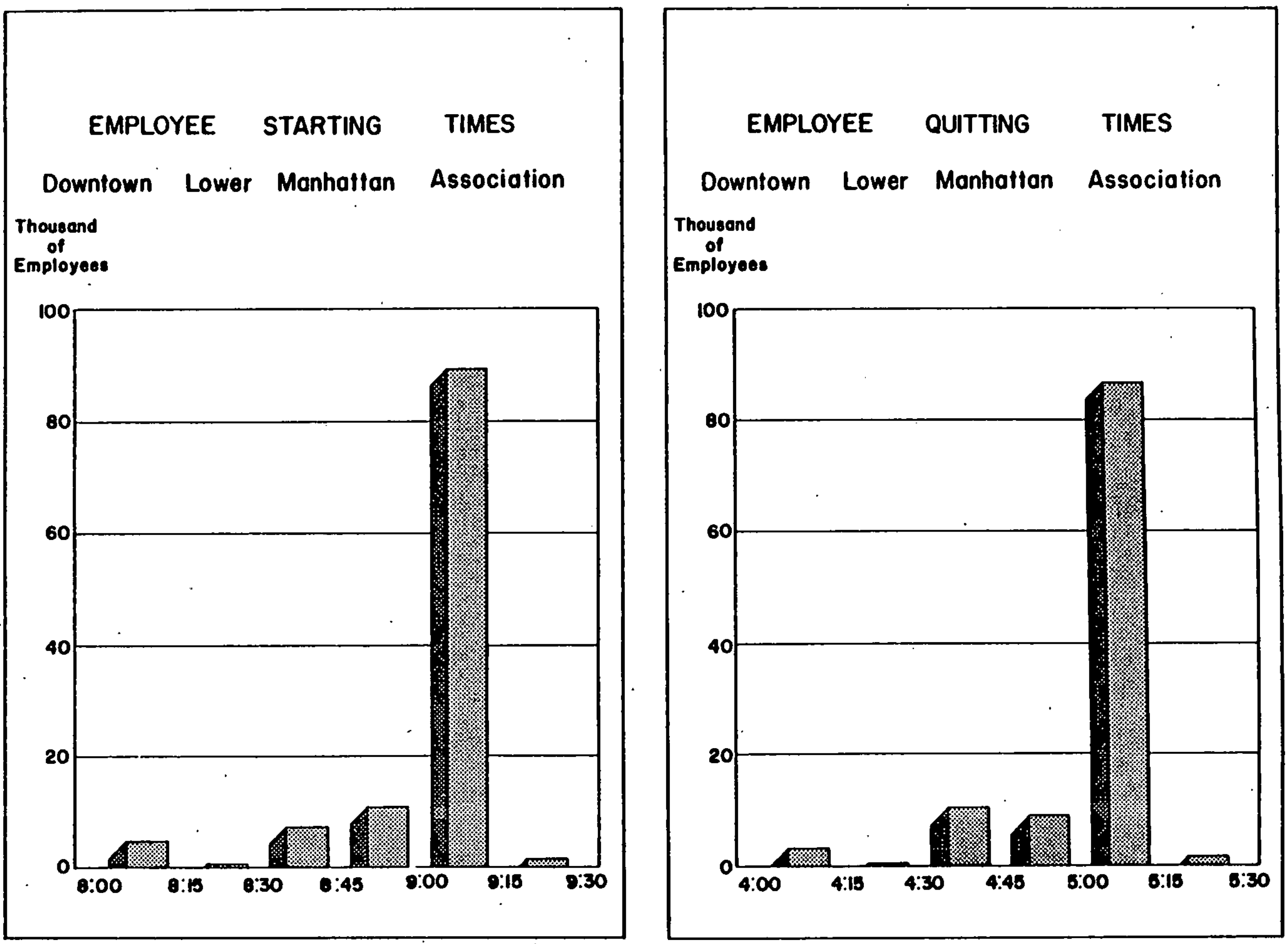



FIGURE 3 Employee starting and quitting times (downtown lower Manhattan) (*9*).

be seen in the examples of Washington, D.C., and downtown lower Manhattan. In order to fully understand the distributions, however, one must always obtain data for time intervals shorter than 1 hr. Because employers and workers tend to use 15-min time periods to establish work schedules, the use of 15-min time intervals in data-collection and analysis efforts by transportation analysts appears appropriate.

## HIGHWAY TRAFFIC

A source of information on the time distributions of highway traffic is an analysis by Peat, Marwick, Mitchell & Co. (*11*) of urban travel by time of day. Extensive data from areawide origin-destination studies and traffic count surveys were compiled for eight cities representing a variety of types and sizes of U.S. urban areas. Data were analyzed in both 1-hr intervals and 0.1-hr increments and summarized for a variety of functional classes of highways in different locations within the cities.

### Hourly Distributions

Figure 5 depicts the hourly distribution of vehicle work travel and total travel averaged for the following urban areas: Boston, St. Louis, Seattle, Louisville, Oklahoma City, Colorado Springs, Stockton, and Fall River, Massachusetts. These data were organized by clock hours and, therefore, the peak hours shown do not represent the highest 1-hr volumes, which typically do not start on the hour. However, the graphs depict the familiar twice-daily peaks characterizing urban area travel demand.

The figure reveals the difference between work travel and total travel distributions. Work travel, of course, is much more heavily concentrated in the morning and afternoon peaks than is total vehicle travel. Work travel between 7:00 and 8:00 a.m., for example, accounts for 20.2 percent of the daily work travel, whereas only 8.4 percent of total travel occurs during that hour. The two highest clock hours of travel demand in the afternoon (4:00 to 5:00 p.m. and 5:00 to 6:00 p.m.) are roughly equal; each hour ac-

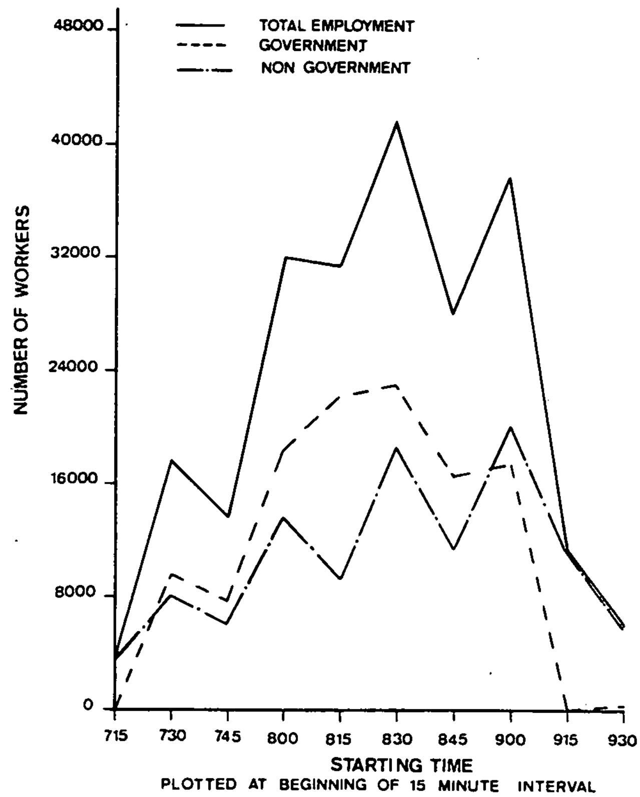



FIGURE 4 Distribution of work starting times in the central employment area of Washington, D.C. (*10*).

counts for 13 to 14 percent of daily work travel and just over 9 percent of total travel. Vehicles being used for work trips constitute a larger percentage of traffic in the morning peak than in the afternoon peak.

### Similarities Between Cities

The hourly distribution of total vehicular travel is given in Table 1. The data indicate that, with a few minor exceptions, the hourly fluctuations are very similar for the eight cities examined. However, the data do not support the hypothesis that peak periods in smaller cities tend to be steeper and shorter than those in large cities. (The cities are tabulated from left to right in the table in order of decreasing population.) More similarities than differences among cities are revealed by the data.

### Comparison of Morning and Afternoon Peaks

Peat, Marwick, Mitchell & Co. (*11*) also examined peak-period patterns, determining when (to the nearest 0.1 hr) the peak hour occurred and then computing volumes for the highest 1 hr, for each of the preceding 2 hr, and for the succeeding 1 hr. These calculations were made for both the morning and afternoon peak periods and the results, averaged for the eight cities, are displayed in Figure 6.

On the average, the morning peak hour begins at 7:09 a.m.; during this hour 8.59 percent of total daily travel occurs. The afternoon peak hour begins at 4:26 p.m.; during this time 10.17 percent of total daily travel occurs.

As shown in Figure 6, a comparison of the morning and afternoon hourly distributions reveals that the morning has a lower traffic volume during the peak hour and also lower "shoulders" (i.e., hours just before or after the peak). This can be attributed to the fact that far less traveling for non-work purposes is done during the morning than the afternoon. The patterns suggest that the lower traffic volume during the peak hour and lower shoulders in the morning make it more feasible to relieve congestion substantially in the morning peak period by using variable work hours techniques. In the afternoon peak period, demand concentrations are more severe and less surplus capacity is available on the shoulders of the peak.

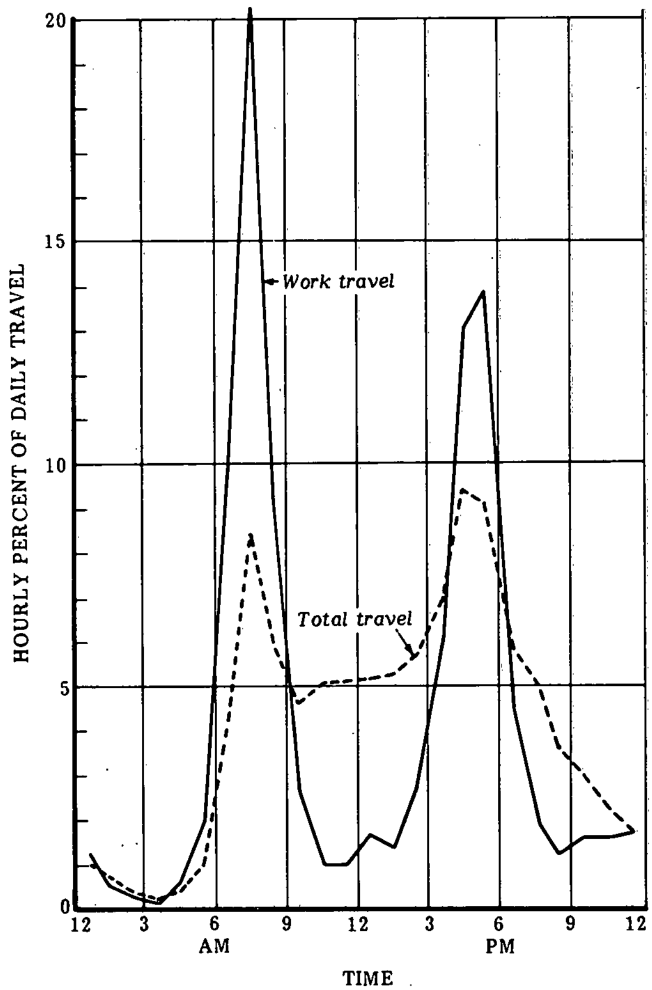



FIGURE 5 Hourly distribution of vehicular travel in selected urban areas [based on data from Peat, Marwick, Mitchell & Co. (*11*)].

### *Highway Capacity Manual* Data

The *Highway Capacity Manual* (HCM) (*12*) contains data on peak-hour characteristics for selected facilities in a large number of urban areas. Although the HCM data were published in 1965, they corroborate the Peat, Marwick, Mitchell & Co. findings (*11*), indicating a strong consistency over time of peak-period highway traffic patterns.

Directional traffic-count data from 32 urban freeways and 14 arterials were averaged to yield percentage values for the 100th and 200th highest hourly traffic volumes annually. The results are summarized in Table 2.

As there are approximately 250 normal (nonholiday) weekdays per year, the 100th highest hourly volumes closely approximate typical values for the highest peak hour of the day. There are 500 normal weekday peak hours per year (morning plus afternoon); thus the 200th highest hour should closely approximate the average of the daily morning and afternoon peak-hour percentages. The peak-hour values are slightly higher than those found by Peat, Mar-

TABLE 1

HOURLY DISTRIBUTION OF TOTAL VEHICULAR TRAVEL IN SELECTED AREAS (%) (*11*).

| Hour Beginning | Boston | St. Louis | Seattle | Louisville | Oklahoma City | Colorado Springs | Stockton | Fall River | Average |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.0 | 1.3 | 1.4 | 1.2 | 0.7 | 1.0 | 1.0 | 0.7 | 1.0 |
| 1 | 0.5 | 0.7 | 0.7 | 0.6 | 0.4 | 0.5 | 0.7 | 0.3 | 0.6 |
| 2 | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.5 | 0.2 | 0.4 |
| 3 | 0.2 | 0.3 | 0.2 | 0.4 | 0.2 | 0.2 | 0.4 | 0.2 | 0.3 |
| 4 | 0.3 | 0.4 | 0.2 | 0.5 | 0.3 | 0.4 | 0.5 | 0.2 | 0.4 |
| 5 | 0.7 | 1.2 | 0.8 | 1.4 | 0.6 | 1.2 | 1.0 | 1.1 | 1.0 |
| 6 | 3.9 | 4.7 | 4.2 | 5.7 | 3.0 | 4.3 | 3.5 | 4.0 | 4.2 |
| 7 | 8.7 | 9.5 | 8.8 | 8.2 | 9.0 | 6.8 | 7.1 | 9.2 | 8.4 |
| 8 | 7.0 | 6.1 | 6.0 | 5.9 | 6.8 | 4.7 | 6.1 | 5.8 | 6.0 |
| 9 | 4.7 | 4.3 | 4.3 | 4.6 | 4.9 | 4.7 | 5.0 | 4.5 | 4.6 |
| 10 | 4.9 | 4.5 | 4.9 | 4.9 | 5.2 | 5.3 | 5.3 | 5.1 | 5.0 |
| 11 | 4.9 | 4.6 | 5.1 | 4.7 | 5.4 | 5.6 | 5.7 | 4.9 | 5.1 |
| 12 | 4.7 | 4.2 | 4.8 | 4.9 | 5.2 | 6.3 | 6.0 | 5.4 | 5.3 |
| 13 | 4.9 | 4.7 | 5.2 | 4.9 | 5.6 | 5.9 | 5.7 | 5.7 | 5.3 |
| 14 | 5.6 | 5.1 | 5.6 | 5.7 | 5.7 | 6.2 | 6.2 | 5.2 | 5.7 |
| 15 | 6.7 | 6.7 | 7.2 | 7.6 | 7.1 | 6.9 | 7.5 | 6.4 | 7.0 |
| 16 | 9.2 | 10.2 | 10.0 | 9.3 | 8.9 | 10.2 | 8.6 | 8.9 | 9.4 |
| 17 | 9.7 | 9.4 | 9.2 | 8.6 | 10.2 | 8.3 | 9.6 | 7.7 | 9.1 |
| 18 | 6.0 | 5.5 | 5.5 | 5.3 | 6.4 | 5.5 | 6.1 | 5.8 | 5.8 |
| 19 | 5.0 | 4.7 | 4.6 | 4.6 | 4.7 | 5.1 | 4.8 | 6.1 | 5.0 |
| 20 | 3.7 | 3.6 | 3.5 | 3.7 | 3.2 | 3.8 | 2.8 | 4.5 | 3.6 |
| 21 | 3.1 | 3.1 | 2.9 | 3.2 | 2.9 | 2.7 | 2.4 | 3.8 | 3.0 |
| 22 | 2.4 | 2.4 | 2.4 | 2.0 | 1.9 | 2.2 | 2.0 | 2.7 | 2.2 |
| 23 | 2.0 | 2.0 | 1.8 | 1.6 | 1.2 | 1.7 | 1.6 | 1.8 | 1.7 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

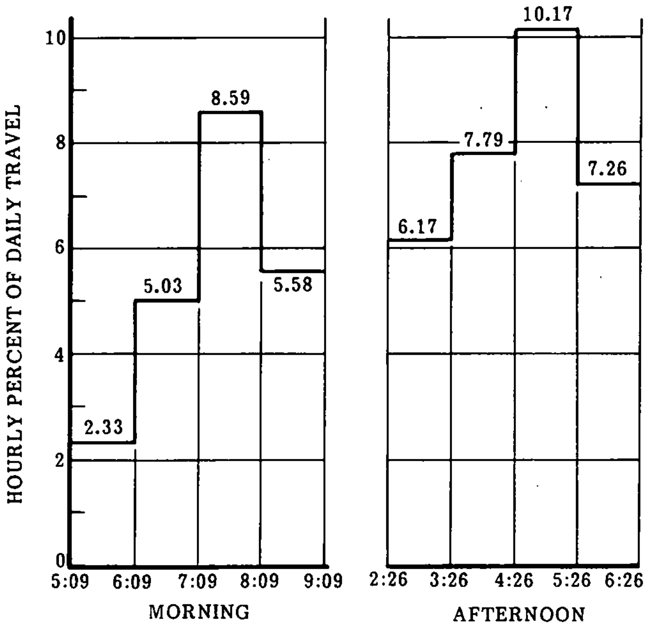



FIGURE 6 Average hourly distribution of travel during morning and afternoon peak periods for eight cities [based on data from Peat, Marwick, Mitchell & Co. (*11*)].

wick, Mitchell & Co. (*11*). This is not surprising, as the HCM data are from unidirectional traffic counts, whereas the Peat, Marwick, Mitchell & Co. data represent aggregate urban travel. In any event, the differences between peak-hour percentages for the two sources are small.

### Peak 15-Min Volumes

HCM data provide insight into the relation between traffic volumes during the peak hour and the peak 15 min. Traffic counts from 792 signalized intersection approaches indicate that the peak 15-min volume averages 29.3 percent of the peak-hour volume. Thus the hourly flow rate in the peak 15 min is higher than the peak hour by a factor of 29.3 percent over 25 percent, or 1.17; i.e., the peak 15-min flow rate averages 17 percent higher than the peak-hour rate.

TABLE 2

PEAK-HOUR PERCENTAGES ON URBAN HIGHWAYS (UNDIRECTIONAL VOLUMES) (*12*)

| | Percentage of Annual Average Daily Traffic | |
|---|---|---|
| Facility Type | 100th Highest Hour | 200th Highest Hour |
| Average of 32 urban freeways | 11.4 | 10.3 |
| Average of 14 urban arterials | 10.3 | 9.6 |

TABLE 3

PEAK-HOUR AND PEAK 15-MIN TRAFFIC VOLUME PERCENTAGES AT A MAJOR SUBURBAN EMPLOYMENT SITE (3M COMPANY, ST. PAUL, MINNESOTA) (*13*)[a]

| | Percentage of Daily Traffic | | | |
|---|---|---|---|---|
| | Morning Arrivals | | Afternoon Departures | |
| Location | Peak Hour | Peak 15 Min. | Peak Hour | Peak 15 Min. |
| 3M entrances and exits | 57 | 23 | 55 | 25 |
| Highway locations near 3M | 16.5 | 5.2 | 15.7 | 5.2 |

[a] Before implementation of staggered work hours program.

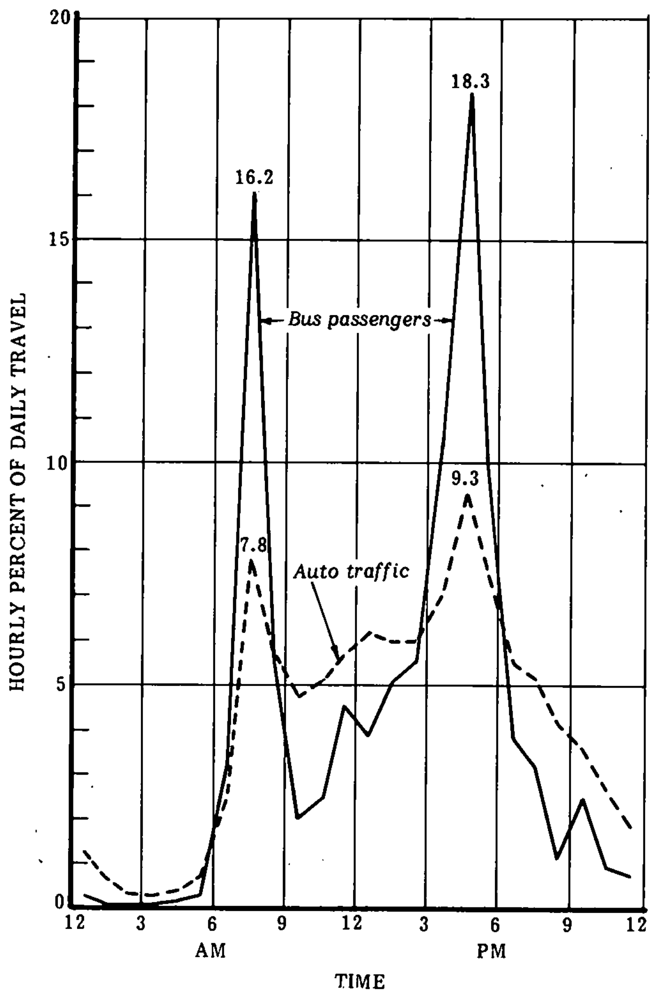



FIGURE 7 Hourly distribution of transit and automobile travel in Madison, Wisconsin (based on J. McLary, unpublished data, from the 1965 Bus Study in Madison, Wisconsin).

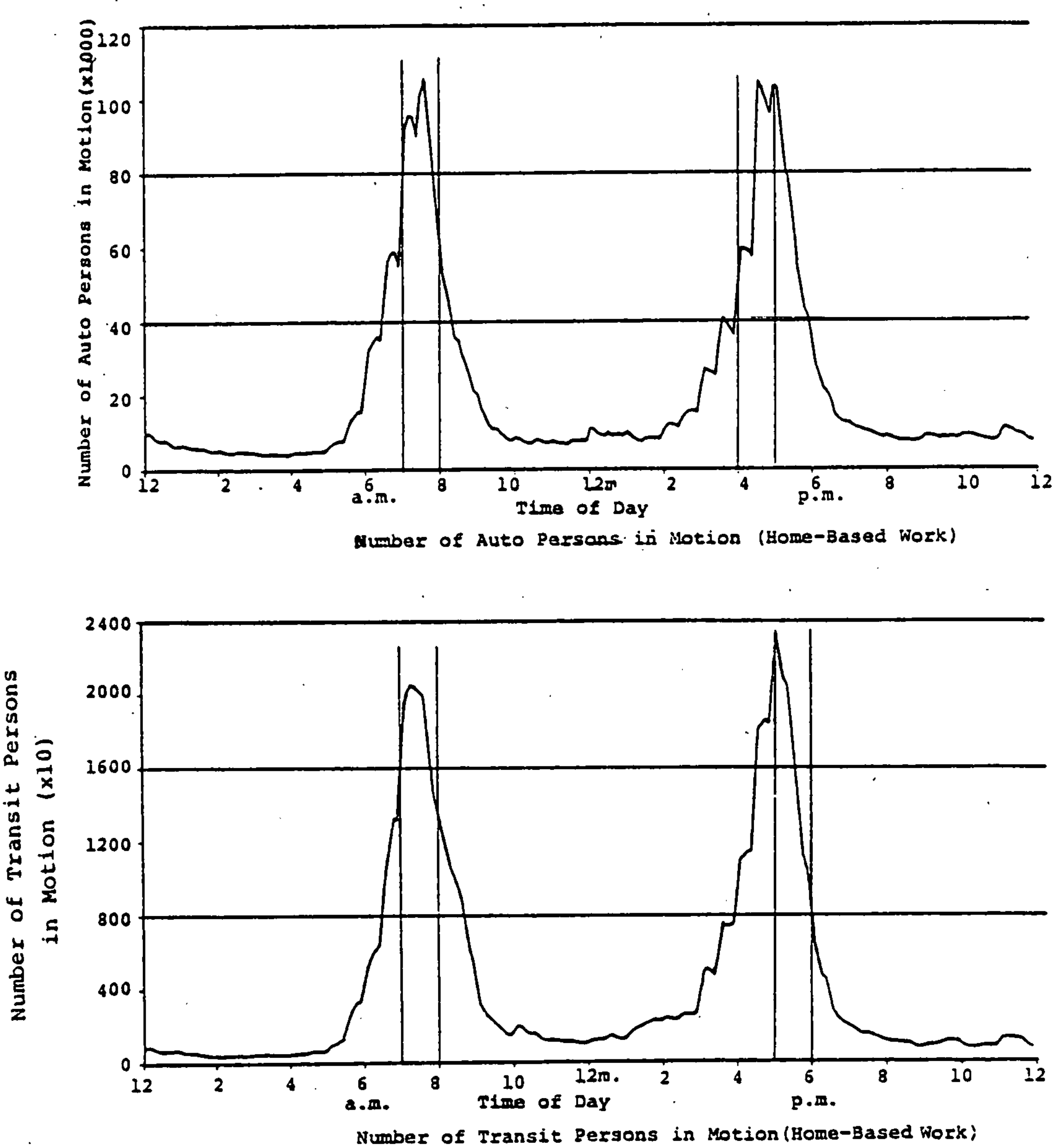



FIGURE 8 Comparison of automobile and transit work-trip distributions by time of day (*11*).

**Traffic Peaks at Isolated Employment Sites**

Areawide averages of the type discussed above can be misleading. The large variations in peak-hour and peak 15-min distributions depend on the specific location of concern in an urban area. This is particularly true if the problem being addressed is congestion at the entrances to and exits from large, isolated employment sites. An example of the peaking characteristics at such a major site (the 3M Company in St. Paul, Minnesota) was documented by Owens and Van Wormer (*13*).

Table 3 summarizes peak-hour and peak 15-min traffic volume percentages at 3M entrances and exits and nearby highway locations. The peaking of traffic entering and leaving the site is, of course, closely correlated with the distribution of work schedules, and the unidirectional peak hours (55 and 57 percent) and peak 15 min (23 and 25 percent) are dramatically higher than those observed on the highway system in general.

TABLE 4

PEAK-PERIOD CHARACTERISTICS ON MAJOR BUS ROUTES IN ATLANTA, GEORGIA (*14*)

| Bus Routes | Percentage of Total Daily Passengers: Peak 3 Hours | Peak Hour | Peak 30 Min. |
|---|---|---|---|
| 32 inbound routes | | | |
| Average | 33 | 14 | 8 |
| Range | 21 - 49 | 10 - 20 | 5 - 11 |
| 31 outbound routes | | | |
| Average | 35 | 15 | 8 |
| Range | 25 - 44 | 10 - 20 | 4 - 11 |

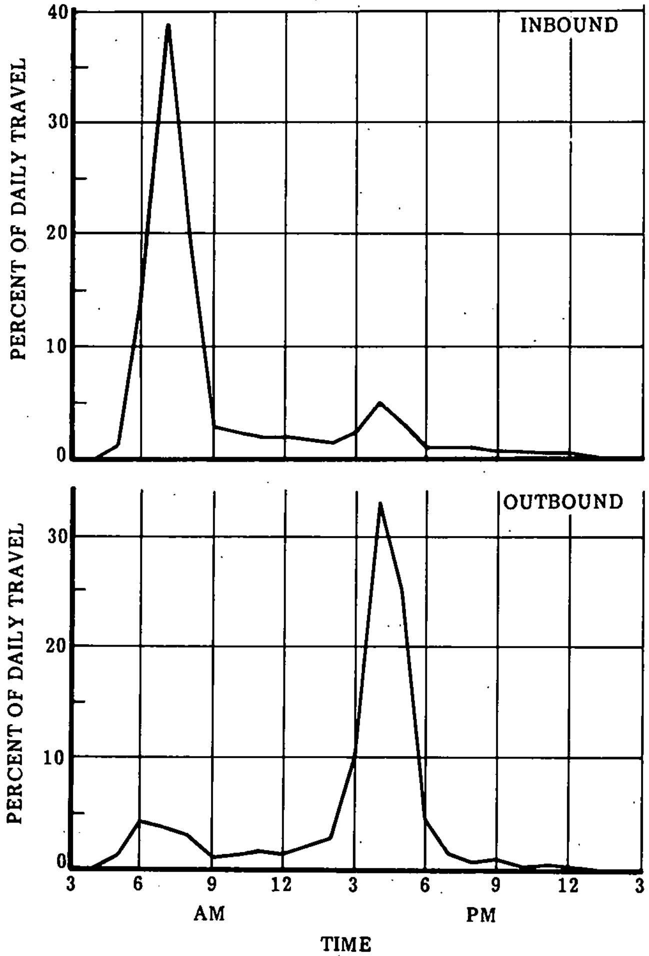



FIGURE 9 Hourly distribution of bus-passenger trips crossing the Potomac River in Washington, D.C., in 1974 [based on data from Wilbur Smith and Associates (*10*)].

## TRANSIT TRAFFIC

### Systemwide Transit Distributions

The systemwide distribution of transit passengers tends to be much more highly concentrated (more steeply peaked) than automobile traffic during the morning and afternoon peak hours. The example given in Figure 7 is based on estimates of the systemwide hourly distribution of bus passenger and automobile traffic in Madison, Wisconsin, made by J. McLary (unpublished data from the 1965 Bus Study in Madison, Wisconsin). Peak-hour percentages for bus passengers in Madison are roughly double those for automobile traffic, or 16.2 and 18.3 percent in the morning and afternoon peak hours for bus traffic compared to 7.8 and 9.3 percent for automobile traffic. The distinct differences are attributable to the fact that work trips usually comprise a higher percentage of total transit travel than total automobile travel.

If only work trips are considered, the time distributions of daily automobile and transit trips exhibit a high degree of similarity. The work-trip data for St. Louis presented in Figure 8 show strong similarities in the daily patterns for automobile and transit work trips.

Similar to automobile traffic peaks, transit travel demand peaks vary greatly according to the nature of individual routes and their locations in the urban area. Data collected in 1977 by the transit agency in Atlanta (*14*), summarized in Table 4, show that during peak hours, buses on major local routes carry from 10 to 20 percent of total daily passengers (averaging about 15 percent). Local transit routes, such as those serving Atlanta's inner city riders, typically carry a more balanced mix of work and nonwork riders, and, therefore, have lower peak hours than transit routes serving primarily suburban commuters traveling to and from the CBD.

### Major Commuter Transit Distributions

The bus routes crossing the Potomac River in the Washington, D.C., metropolitan area, which primarily serve suburban Virginia commuters to and from the central employment area, are typical of major commuter transit services. Figure 9 shows the hourly distribution of ap-

TABLE 5

PEAK-PERIOD TRANSIT RIDERSHIP IN SELECTED CITIES

| | Percentage of Daily Total Passengers | | |
|---|---|---|---|
| Location | Peak 3 Hours | Peak Hour | Peak 30 Min. |
| Madison, Areawide (Bidirectional) | | | |
| Morning | 24.8 | 16.2 | |
| Afternoon | 38.8 | 18.3 | |
| Atlanta, Major Local bus routes (Unidirectional) | | | |
| Morning | 33 | 14 | 8 |
| Afternoon | 35 | 15 | 8 |
| Washington, D.C., Potomac River Screenline (Unidirectional) | | | |
| Morning | 72.1 | 38.4 | |
| Afternoon | 68.3 | 33.0 | |
| Toronto, Downtown Cordon (Unidirectional) | | | |
| Morning | 60 | 32 | 16 |
| Afternoon | 62 | 30 | 16 |

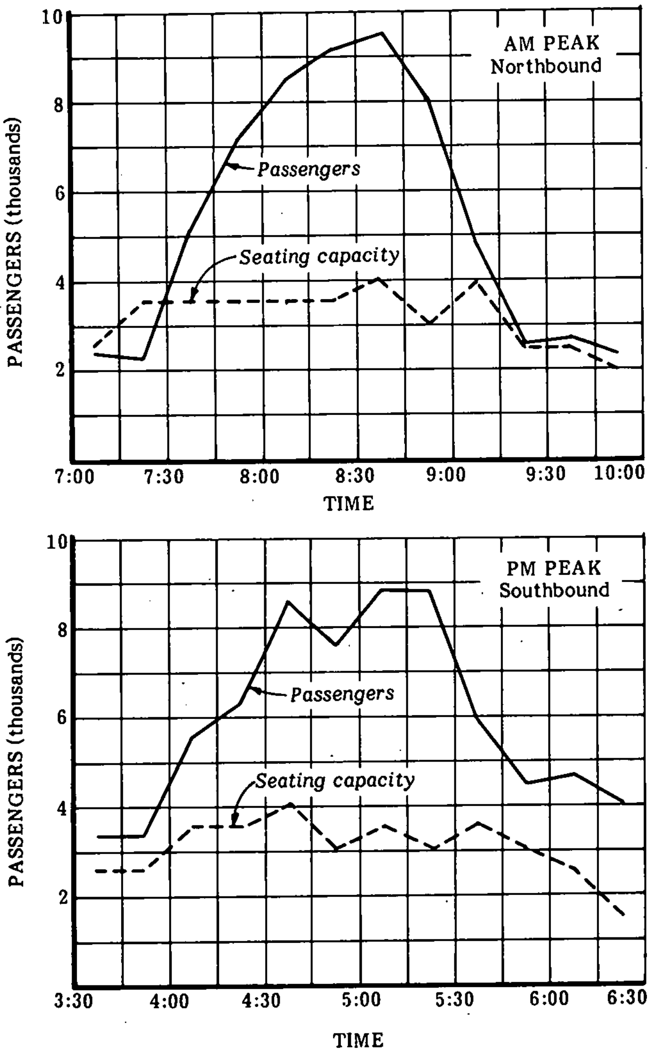



FIGURE 10 Passenger demand and seating capacity during peak periods on a crowded section of the Yonge subway in Toronto (*15*).

proximately 30,000 bus-passenger trips in each direction. Peak-hour percentages are very high, approximating 38 percent of the daily inbound total between 7:00 and 8:00 a.m. and 33 percent of the daily outbound total between 4:00 and 5:00 p.m. Approximately 70 percent of the daily directional totals are carried in the 3 highest morning and afternoon hr.

Peak-period concentrations of transit passengers traveling to and from Toronto's downtown area are similar to those observed in Washington, D.C. Approximately 50 percent of transit riders entering downtown Toronto do so in the 2 peak morning hr (7:30 to 9:30 a.m.), and 32 percent of the daily total arrive during the peak hour. Similar concentrations are observed for passengers leaving the downtown area during the afternoon peak period. The Yonge subway in Toronto carries 30,000 passengers in the peak hour, 7.5 times the 4,000 riders per hr averaged during the remainder of the day (*15*).

#### Comparison of Systemwide and Commuter Patterns

A summary of the peak-period transit ridership in the four cities of Madison, Atlanta, Washington, and Toronto is given in Table 5. Patterns are very similar for Madison and Atlanta; the data used closely resemble systemwide transit passenger demand, and peak-hour percentages average about 16 percent of total daily passengers. In the Washington, and Toronto studies, the ridership is heavily dominated by commuters traveling to and from downtown; the peak-hour percentages are twice as high—approximately 33 percent of the daily totals. Similar contrasts are shown for the peak 3-hr and peak 30-min percentages, which show that the commuter-dominated peak-period values in Washington and Toronto are roughly twice the systemwide peak-period concentrations in Madison and Atlanta.

#### Crowding on Transit Vehicles

Figure 10 shows the crowding on transit vehicles that results from peak concentrations and the relation between

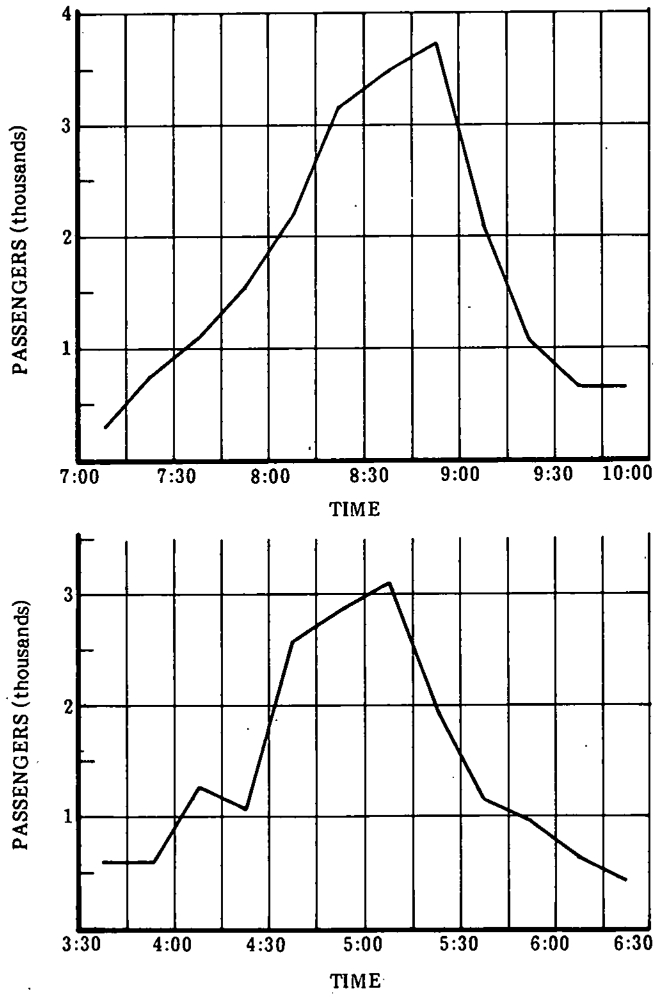



FIGURE 11 Passenger arrival and departure traffic at a major subway station in downtown Toronto (*15*).

15-min volumes and seating capacity during the peak periods on critical sections of the Yonge subway in Toronto. Passenger demands exceed seating capacity throughout the 3-hr morning and afternoon peak periods, and loads at the height of the peak hour are as much as 2.5 times seating capacity.

It should be noted that seating configuration and passenger capacity of rail transit are very different from those on buses. The Port Authority of New York and New Jersey (*16*) used the following three measures of capacity to define relative levels of passenger loading for one type of New York City subway car:

1. Seated capacity—80 people per car.
2. Comfort capacity—180 people per car (80 seated, 100 standing).
3. Crush capacity—250 people per car (80 seated, 170 standing).

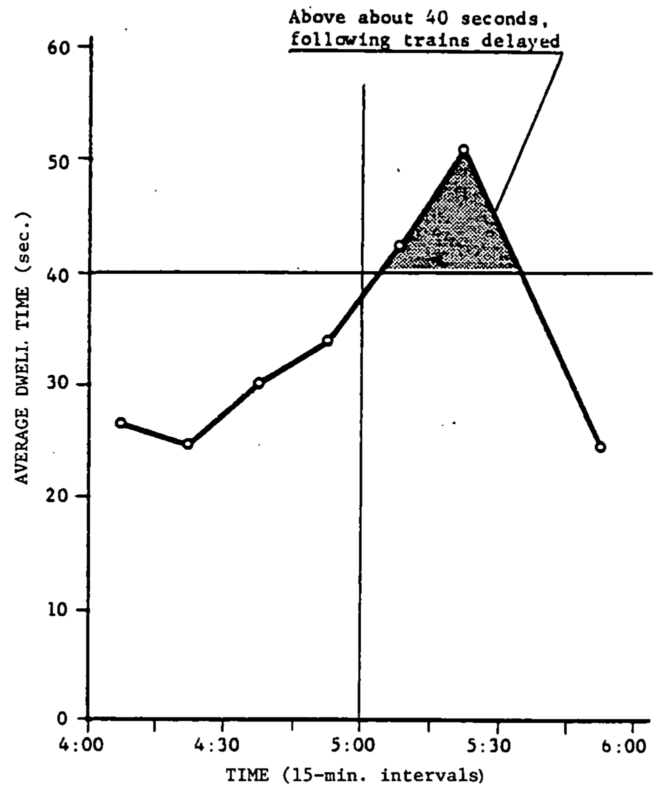



FIGURE 13 Subway train dwell times at Grand Central Station in midtown Manhattan (*9*).

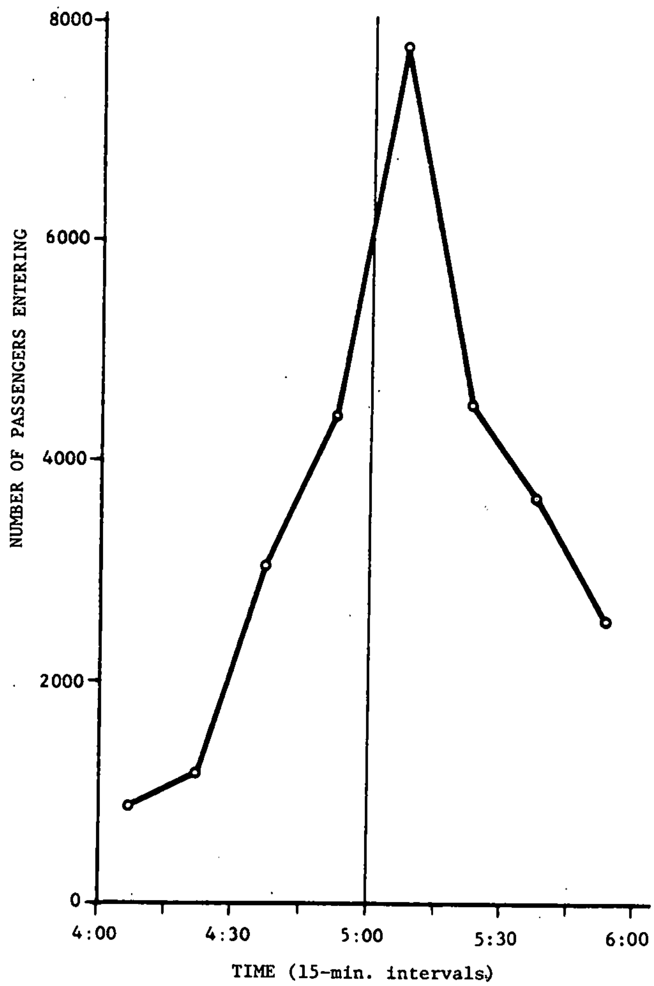



FIGURE 12 Passengers entering the Rockefeller Center subway station during the afternoon peak period (*9*).

In Toronto, the "practical" capacity of a rail transit car is defined as 2.7 times seating capacity. The Port Authority states: "Capacity is therefore not just an absolute, single value for any transportation system as it varies with many different factors in each situation by mode."

#### Peaking at Major Downtown Transit Stations

Passenger counts at high-volume subway stations also have highly variable peaking characteristics. Data from Toronto and New York provide an interesting comparison. At the King subway station in downtown Toronto, as shown in Figure 11, the heaviest part of the peak lasts for 45 min, and the passenger arrival and departure rates during the peak 15 min are only 18 percent higher than the average rate for the peak hour.

However, counts at the Rockefeller Center subway station in midtown Manhattan, as shown in Figure 12, are much more steeply peaked. This reflects the preponderance of 5:00 p.m. quitting times. The 15-min peak arrival rate at the station is 52 percent higher than the average rate for the peak hour, and 75 percent more passengers arrive between 5:00 and 5:15 p.m. than arrive in the 15-min interval either immediately before or after.

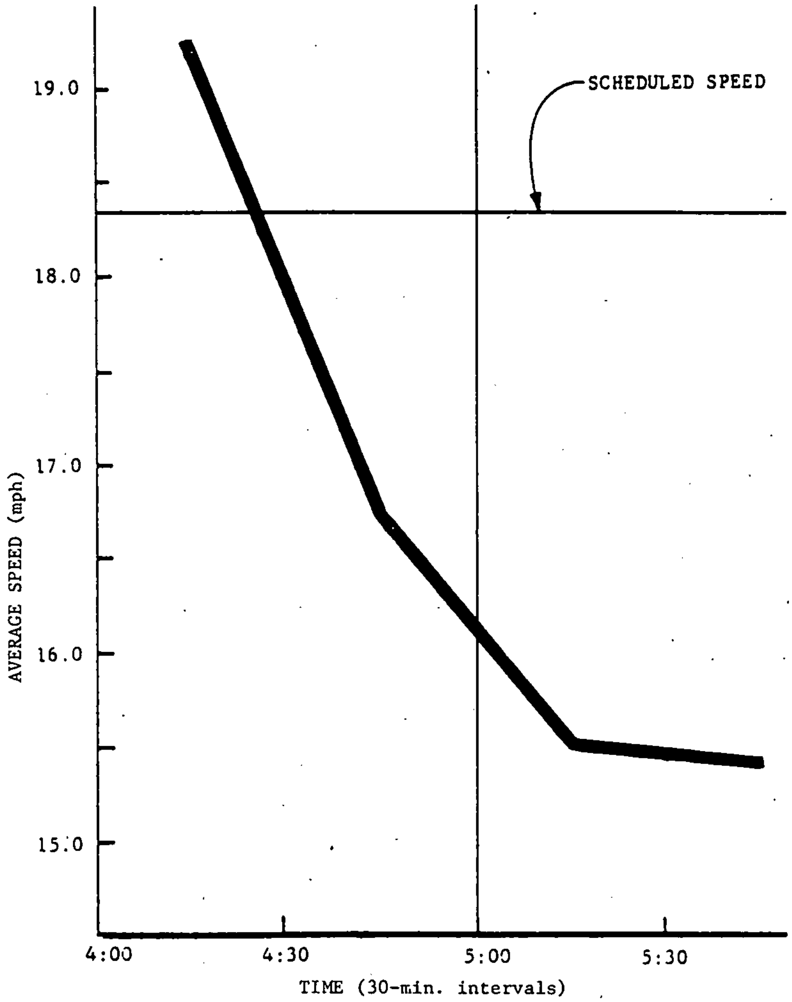



FIGURE 14 Effects of increased dwell times on average train speeds in midtown Manhattan subway (*9*).

**Impact of Peaking on Transit Congestion**

O'Malley (*9*) documented the effects on congestion of the extreme peaking on the New York subway system: "Subway train operations on several midtown lines were found to become strained immediately after 5:00 p.m. as concentrated passenger arrivals contribute to large increases in station *'dwell times,'* which are the times trains remain in stations to discharge and take on riders." For example, as shown in Figure 13, for subway trains at Grand Central Terminal, dwell times at 5:15 p.m. are 50 sec, or nearly double the normal dwell time. From 5:00 to 5:50, dwell times are 40 sec or longer, resulting in delays to succeeding trains.

O'Malley (*9*) shows the effects of increased dwell times on average train speeds (see Figure 14). "On the IRT Lexington Avenue line, average subway speeds on the northbound express traversing midtown are 19.2 mph between 4:00 and 4:30 p.m., and steadily plummet with increasing passenger loads to 15.5 mph between 5:00 and 5:30, a 19 percent reduction in operating speed. This pattern . . . serves to show that it may be physically impossible to adhere to short-headway train schedules if the inundation of 5:00 p.m. quitters causes doorholding which then fouls up the entire operation." The travel time and delay effects on the transit system are analogous to the congestion effects at overloaded highway bottlenecks during peak hours.

Perhaps the most graphic illustration of congestion caused by extreme passenger demand peaks is shown in Figure 15 (*9*). "Commuters arriving for 9:00 a.m. work starting times suffer heavy back-ups on various escalators in Grand Central Station. On escalators from the IRT Flushing line exiting to Third Avenue, for example, an unbroken queue forms for 30 minutes through 9:00 a.m., the queue sharply reduces to no waiting just minutes later after 9:05 a.m." Although this is one of the more extreme cases, similar queuing on access paths to stations at fare gates and on station platforms occurs at many subway stations at peak times.

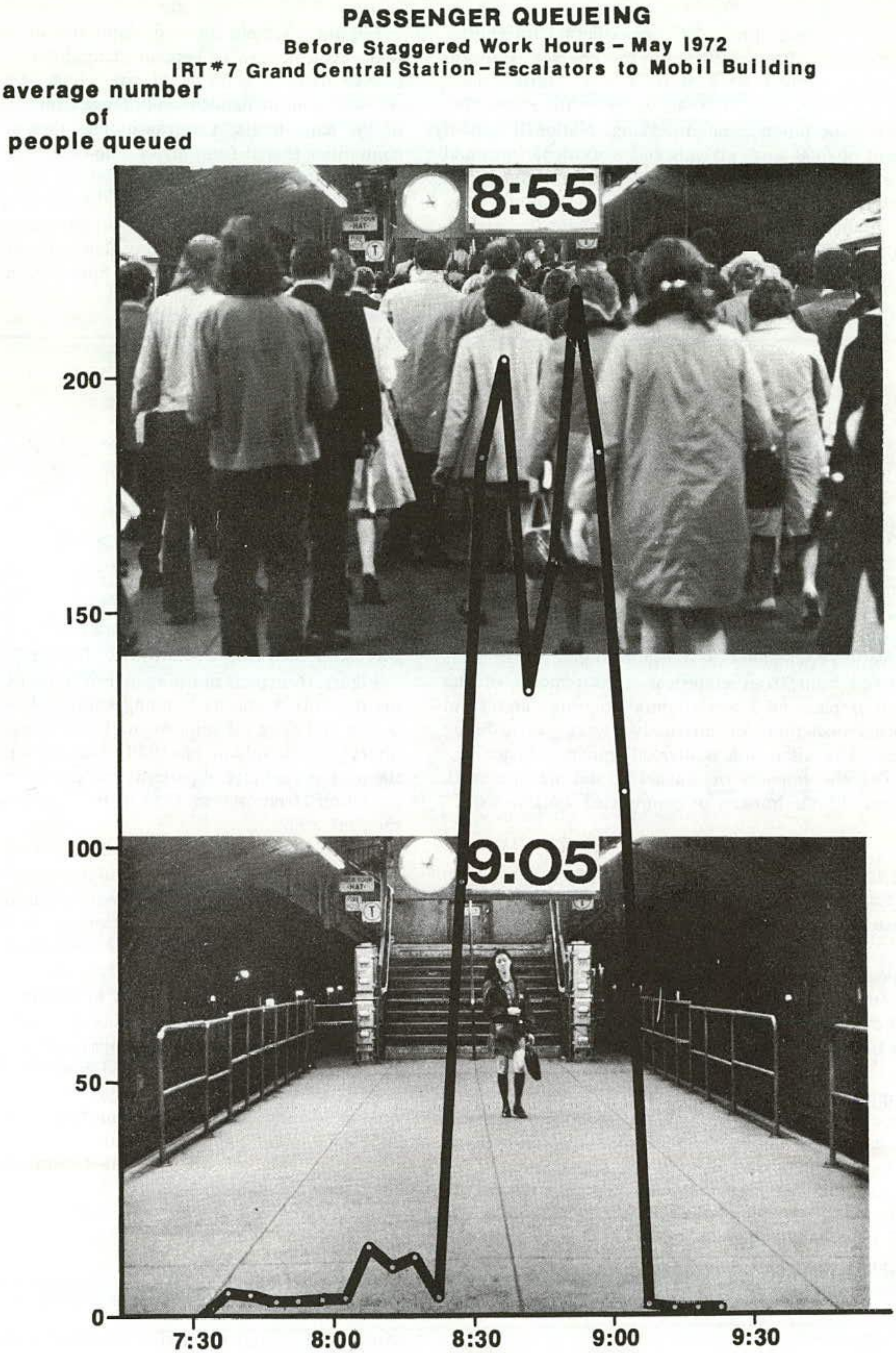



FIGURE 15 Subway passengers queuing at escalators in Grand Central Station in Manhattan (before implementation of staggered work hours) (*9*).

## DISCUSSION

The nature and magnitude of the peak-period transportation problem have been discussed in this chapter. Concentrations of scheduled work starting and quitting times during peak hours have been shown to be the underlying cause of transportation demand peaking. Nationally, about 40 percent of total work arrivals and work departures and 50 percent of day-shift arrivals or departures occur during the peak hours. Individual employment locations have highly variable peak-hour concentrations, and, in extreme cases, the majority of arrivals or departures may occur during periods as short as 15 min.

For total vehicle travel demand for all purposes, peak hours typically are 10 percent of total daily travel. In the case of areawide work travel, either by automobile or transit, peak-hour demands usually range from 15 to 20 percent of the daily totals. On transit lines that primarily serve commuters to and from major employment concentrations, the morning and afternoon peak-hour volumes are one-third or more of the total daily directional passenger demand. Thus critical sections of urban mass transit systems may experience peak-hour percentages that are 2 or 3 times greater than highway traffic peak-hour percentages.

CHAPTER FOUR

# IMPACTS ON TRANSPORTATION

The information presented in this chapter on the impacts of alternative work schedules on transportation in urban areas was derived both from empirical measurements of the results of implemented work hours programs and from theoretical predictions of alternative work rescheduling strategies. The discussion is divided into two major sections: (a) the impacts of staggered and flexible work hours, and (b) the impacts of compressed workweeks.

## STAGGERED AND FLEXIBLE WORK HOURS

### Time Distribution of Work Arrivals and Departures

The fundamental purpose of variable work hours programs is to "flatten" the peak concentrations of commuter travel demand by changing the time-of-day distributions of worker arrivals and departures. Related impacts on transportation, such as reduced overloading of highway and transit facilities, improved levels of transportation services, possible shifts in commuter travel modes, and energy and emissions reductions, stem from the basic changes in the time distribution patterns of worker arrivals and departures.

The following sections report the actual changes in working hours that have occurred as a result of the implementation of staggered and flexible work hours programs in several cities.

#### *New York City*

The most thoroughly evaluated variable work hours program in the U.S. is the one implemented in New York City by the Port Authority of New York and New Jersey, which was comprehensively documented (*16, 17*).

Figure 16 depicts morning arrival times of people entering the Port Authority building lobby in lower Manhattan before and after the implementation of the staggered work hours program initiated in 1970. The dramatic flattening of the peak-period arrival patterns was caused by a 29 percent reduction (from 460 to 355) in the number of arrivals in the peak 5 min.

Subsequently, 750 of the 2,000 Port Authority employees at the World Trade Center Building in lower Manhattan were put on a flexible work hours program. Many of these employees had already been working on various staggered hours schedules, but some had been on fixed 8:45 a.m. to 4:45 p.m. nominal schedules before the experiment.

Figure 17 shows the changes in arrival and departure times for a sample of Port Authority employees who had previously been on fixed schedules. Arrivals during the morning peak 15 min comprised 31 percent of the previous total for 7:30 to 10:00 a.m. This 15-min peak was lowered to 18 percent of the 2.5-hr morning period after flexible work hours were instituted. Although changes in afternoon peak departures were less dramatic, peak 15-min departures fell from 34 percent of the 3:30 to 6:00 p.m. total to 25 percent after implementation.

#### *Toronto*

Another thorough evaluation of the effects of a variable work hours program was conducted in the Queen's Park area of Toronto, where a demonstration program involving approximately 11,000 government employees was imple-

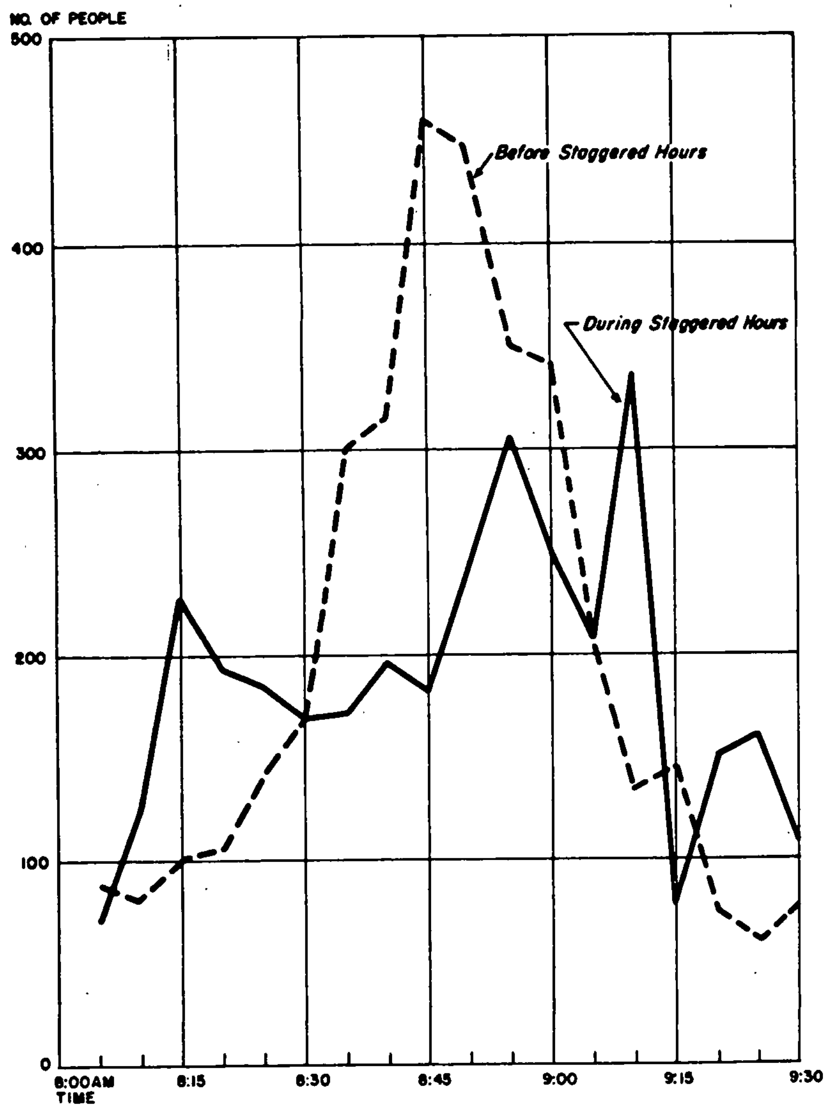


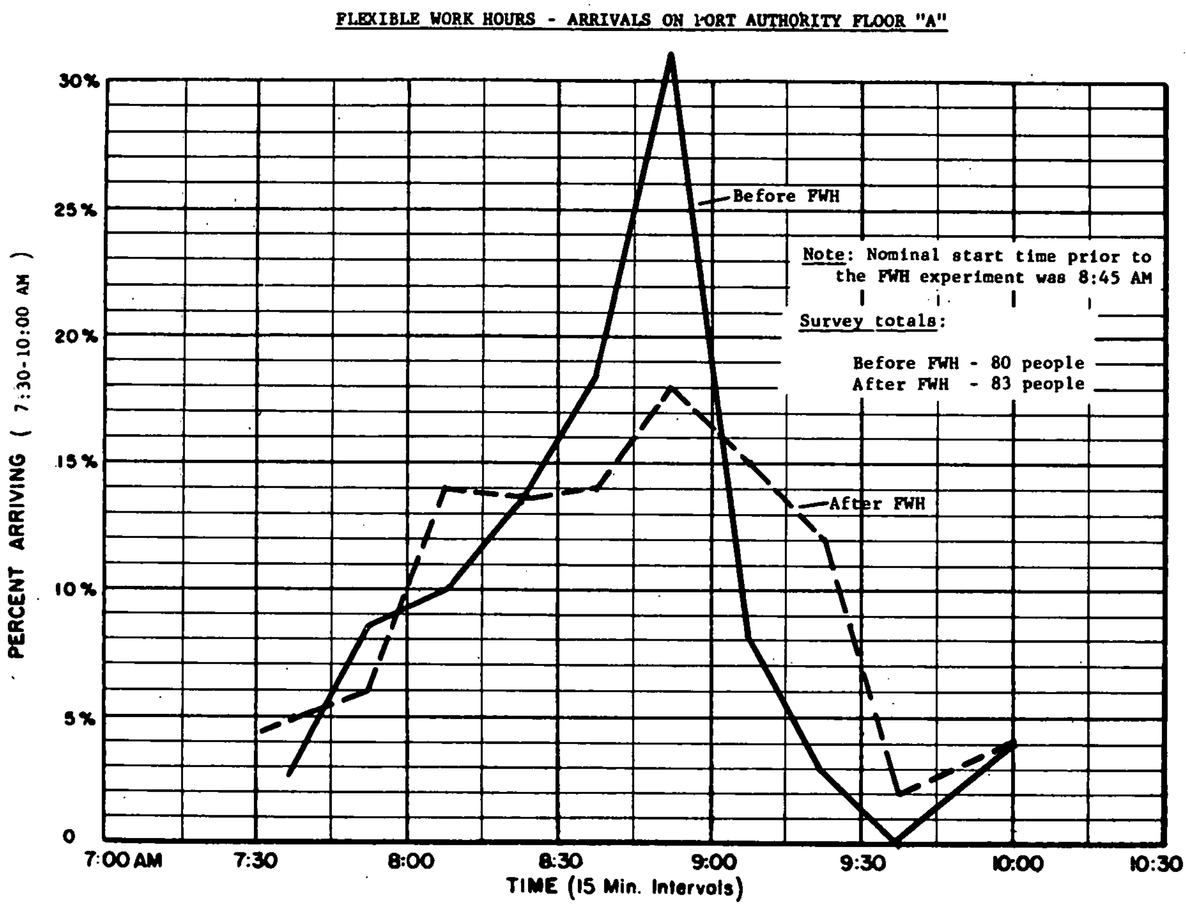

FIGURE 16 Impact of staggered work hours program on worker arrival times (*16*).

mented in October 1973. Sixty-eight percent of the employees were assigned to staggered hours and another 23 percent were placed on flexible work hours. The results were reported by Greenberg and Wright (*18*). As shown in Figure 18, more than 90 percent of the workers arrived during the 8:00 to 9:00 a.m. peak hour before the demonstration program was implemented; after implementation, peak-hour arrivals were cut in half—52 percent arrived at work before 8:00 a.m. and 43 percent arrived between 8:00 a.m. and 9:00 a.m.

In the Queen's Park demonstration, the percentage of employees arriving in the peak 15-min period was also cut in half—from 70 percent to 34 percent for those who had revised work schedules. For the employees on flexible work hours, 40 percent chose to arrive before 8:00 a.m., whereas only 9 percent arrived after 9:00 a.m., a clear indication of a preference for earlier working hours. A comparison of starting times of employees on staggered hours and flexible hours is given in Table 6.

*Ottawa*

Canadian government employees in the central area of Ottawa were placed on a combination of staggered and flexible hours in March 1974 (*19*). Nearly all of the 35,000 government employees—almost half of the total number of workers in Ottawa central area—participated in the program. The impacts of the alternative work schedules on the 15-min peak arrivals and departures were similar to those in the Queen's Park area of Toronto. As shown in Figure 19, the morning 15-min arrivals were reduced from about 50 percent of the 6:30 to 9:30 a.m. total before the program to about 25 percent after implementation of variable



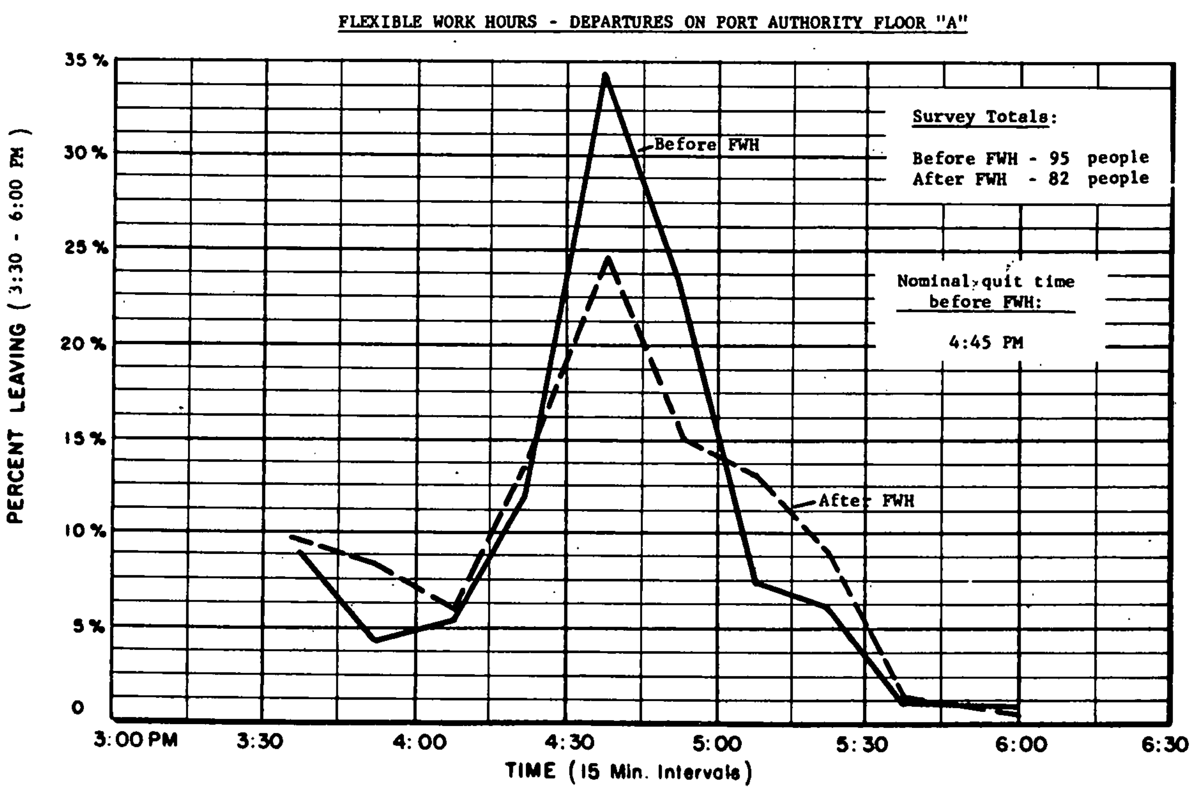




FIGURE 17 Impact of flexible work hours on worker arrival and departure times (*16*).

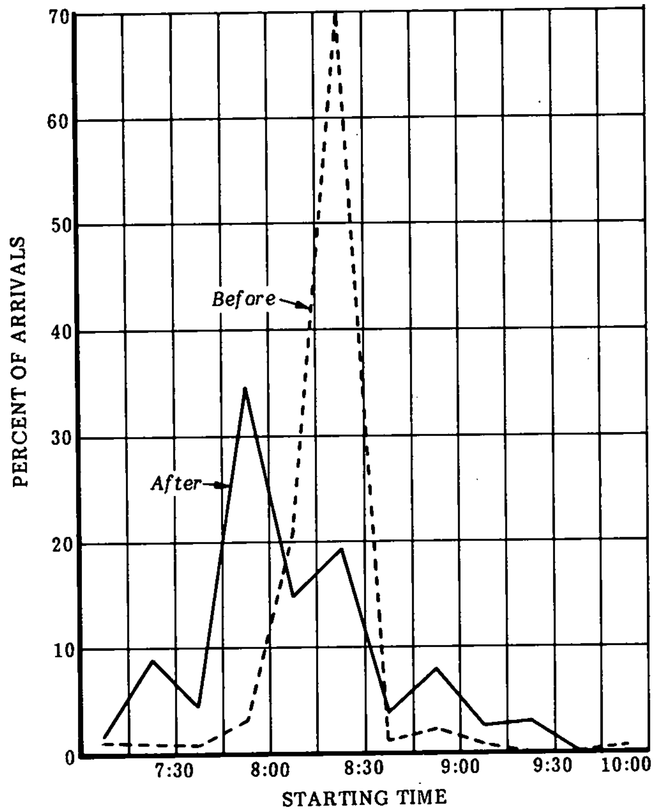



FIGURE 18 Impact of flexible work hours program on arrival times of government employees in Queen's Park (Toronto) (*18*).

work hours. Afternoon peak 15-min departures were reduced even more, from more than 60 percent of the 3:30 to 6:30 p.m. total to about 26 percent.

The standard deviations of 15-min arrivals and departures in the 3-hr morning and afternoon periods were computed, and the results showed that the standard deviations of 15-min volumes fell by approximately 42 percent in the morning peak and by approximately 50 percent in the afternoon peak as a result of the variable work hours program (see Table 7). Peak-hour arrivals and departures as a percentage of the 3-hr peak-period totals in Ottawa were reduced by about 17 percent in the morning and by about 24 percent in the afternoon.

TABLE 6

COMPARISON OF STARTING TIMES OF EMPLOYEES ON STAGGERED HOURS AND FLEXIBLE HOURS, TORONTO-QUEEN'S PARK PROGRAM

| Work Schedule | Before 8:00 a.m. No. | % | 8:01 - 9:00 a.m. No. | % | 9:01 - 10:00 a.m. No. | % |
|---|---|---|---|---|---|---|
| Staggered hours | 1123 | 56.6 | 774 | 39 | 88 | 4.4 |
| Flexible hours | 267 | 39.6 | 349 | 51.7 | 59 | 8.7 |
| Total | 1290 | 52.3 | 1123 | 42.2 | 147 | 5.5 |

*Environmental Protection Agency, Washington, D.C.*

At the Environmental Protection Agency (EPA) headquarters in Washington, D.C., flexible work hours were introduced in September 1976 for approximately 3,000 employees who had been on a nominal 8:00 a.m. to 4:30 p.m. fixed schedule. Evaluation surveys (*20*) performed 9 months later indicated that approximately 50 percent of the employees chose to arrive at work at or before 7:45 a.m., and only one-sixth arrived at 8:15 or later. This provides further evidence that given a choice, workers will tend to shift to earlier work schedules.

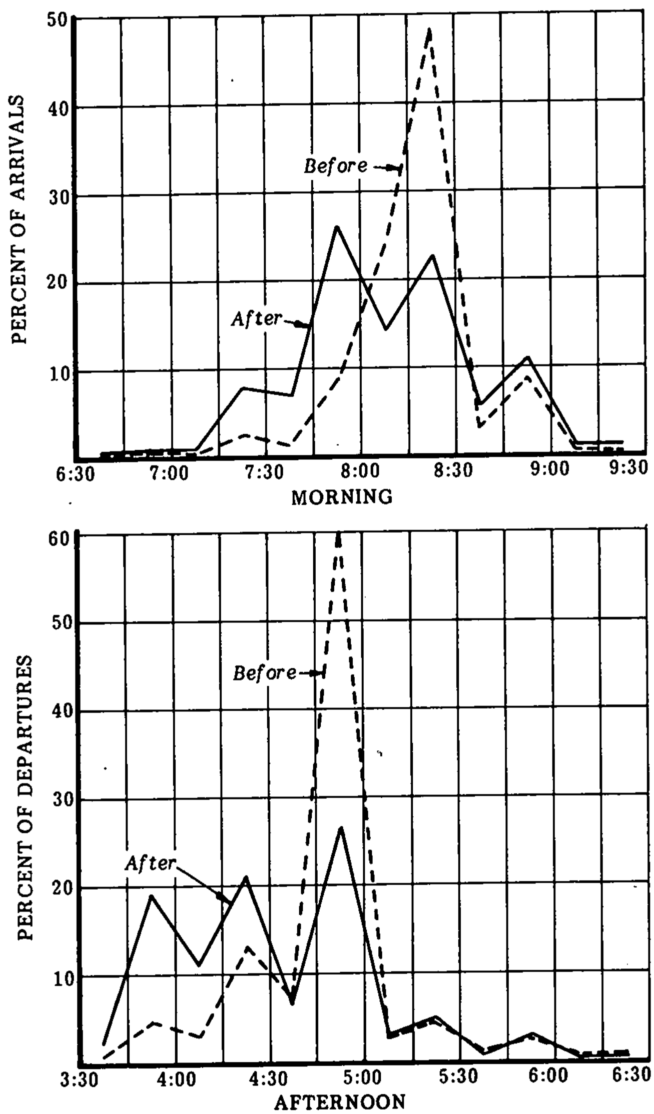



FIGURE 19 Impact of variable work hours on government worker arrival and departure times in Ottawa (*19*).

TABLE 7

CHANGES IN STANDARD DEVIATION AND RATIO OF PEAK HOUR/PEAK PERIOD FOR OTTAWA FEDERAL GOVERNMENT EMPLOYEES (*19*)

| Item | Morning | Evening |
|---|---|---|
| Standard deviation of 15-min volumes | | |
| Before | 156.2% | 183.3% |
| After | 90.1% | 90.7% |
| Percentage reduction | 42.4 | 50.5 |
| Ratio of peak hour to peak period | | |
| Before | 86.2% | 85.3% |
| After | 71.6% | 65.1% |
| Percentage reduction | 16.9 | 23.7 |

*Germany*

The trend toward earlier arrivals under flexitime programs was corroborated by data from Germany (*16*). The Bureau of the Federal Budget in Germany found that 23 percent of their employees on flexible hours arrived at work by 7:00 a.m., the earliest starting time allowed, and 66 percent arrived before 7:30 a.m.

*Summary*

Table 8 summarizes the work schedule changes resulting from the programs in New York, Toronto, and Ottawa. In the two Canadian cities, peak 15-min arrivals and departures were reduced by 50 percent or more; also in Toronto, the peak-hour arrivals were reduced by more than 50 percent. This amount of reduction probably approaches the maximum impact that can be expected from varying work hours. The flattening of the 15-min peak arrivals for Port Authority personnel was not as extreme, probably because the allowable flexible arrival period spanned only 1.5 hr (from 8:00 to 9:30 a.m.), whereas in Toronto and Ottawa, greater work schedule flexibility was provided.

### Time Distribution of Automobile and Transit Traffic

The most obvious direct effects of changes in work schedules are corresponding changes in the peak-period distributions of traffic on highways and public transit. It is important to differentiate between changes in the arrival and departure times of workers and in the distribution of automobile and transit peak demands. Automobile and transit peaks will be affected by the number of workers participating in variable work hours programs and the proximity of a particular highway or transit load point to the employment center.

The flattening of peak work arrivals and departures is weakened by the inclusion in the traffic stream and on the transit system of those travelers who are not participating in flexible work hours programs. This effect tends to increase with distance from the employment center operating on variable work hours, because traffic will be composed of increasingly larger numbers of people traveling to or from other places. Also a significant number of people traveling during peak periods on the highway system, and to a lesser degree on the transit system, are making nonwork trips that are not directly affected by work schedule changes.

As a result of the foregoing factors, the changes in peak distributions observed at highway and transit load points should not be expected to be as large as the changes in work-trip arrivals and departures.

### Peak-Period Transit Demands

In general, peak transit demand is more noticeably affected by work schedule changes than is peak automobile traffic demand. This is because more peak-period transit riders are traveling to or from work.

TABLE 8

SUMMARY OF WORK SCHEDULE CHANGES IN NEW YORK, TORONTO, AND OTTAWA

| | Peak 15 Min as Percentage of Peak Period | | Peak Hour as Percentage of Peak Period | |
|---|---|---|---|---|
| Demonstration Location | AM | PM | AM | PM |
| Employees of the Port Authority of New York and New Jersey[a] | | | | |
| Before | 31[b] | 34[b] | | |
| After | 18 | 25 | | |
| Percentage change | 42 | 26 | | |
| Toronto-Queen's Park (government employees)[c] | | | | |
| Before | 70 | | 90[d] | |
| After | 34 | | 42 | |
| Percentage change | 51 | | 53 | |
| Ottawa (federal employees)[e] | | | | |
| Before | 50 | 60+ | 86.2 | 85.3 |
| After | 25 | 26 | 71.6 | 65.1 |
| Percentage change | 50 | 57 | 16.9 | 23.7 |

[a] For 2.5-hr period.

[b] Change from fixed schedule to flexible hours.

[c] For 3.5-hr period for peak 15-min and 3-hr period for peak hour.

[d] Change from fixed schedule to combination of staggered and flexible hours.

[e] For 3-hr period.

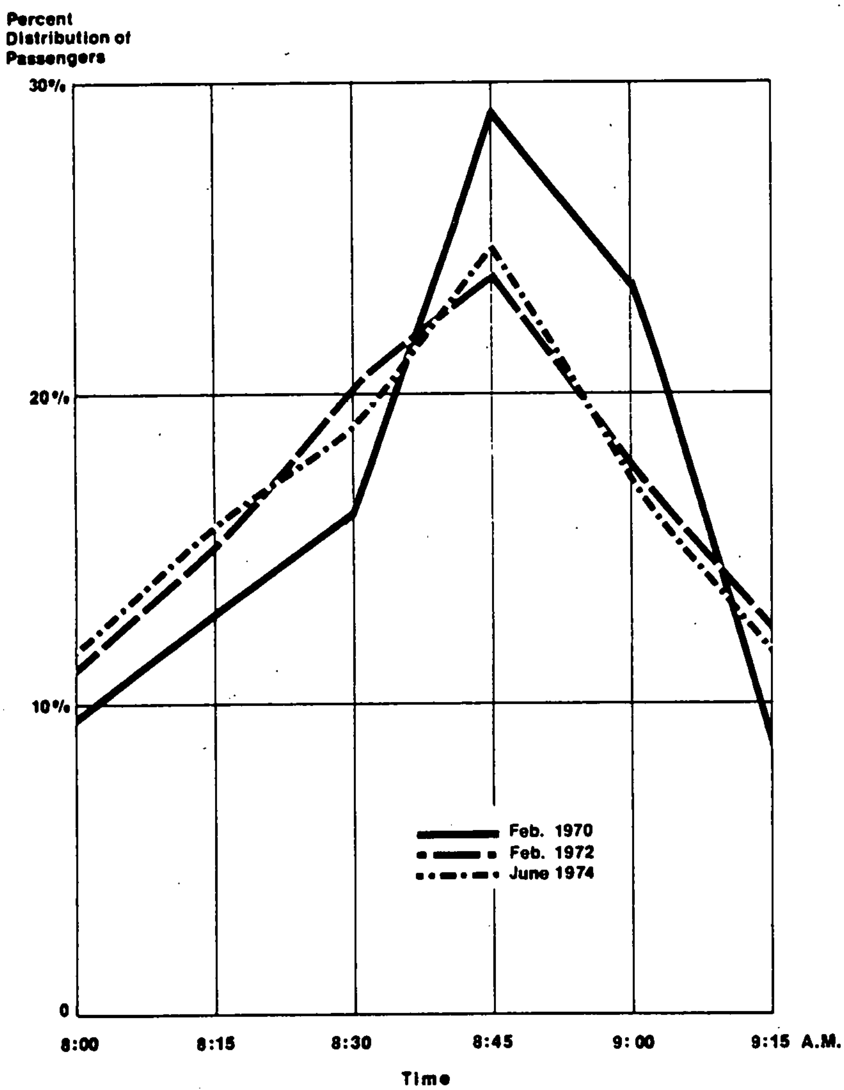



FIGURE 20 Impact of staggered work hours on passenger arrivals at three downtown subway stations in New York (IRT Lexington Ave. Wall St. Station, IRT Seventh Ave. Wall St. Station, and BMT Broad St. Station) (*16*).

The report of the Port Authority of New York and New Jersey (*16*) indicated that peak concentrations of passengers arriving in the morning at three major lower Manhattan subway stations were substantially reduced as a result of the staggered work hours program initiated during 1970 (see Figure 20). Arrivals in the peak 15-min period fell from 29 to 24 percent of the 8:00 to 9:30 a.m. total, a reduction of about 14 percent. This compares with the 29 percent reduction in the peak for workers arriving at the Port Authority building lobby in lower Manhattan.

In Ottawa (*19*), the number of transit passengers crossing the CBD screenline in the peak 15 min fell 21 percent in the morning and 29 percent in the afternoon after the variable work hours program was instituted. Table 9 presents the hourly distribution of transit riders crossing the Ottawa CBD screenline. The number of peak-hour bus passengers crossing the CBD screenline, as a percentage of the 2.5-hr peak-period total, was reduced by 8.4 percent in the morning (67.9 to 62.2 percent) and by 19.2 percent in the afternoon (62.0 to 50.1 percent). The data indicate that early-morning arrivals (7:00–8:00 a.m.) increased markedly, whereas the postpeak volumes (9:00–9:30 a.m.) did not change significantly. There was also a marked increase in early-departing transit riders in the afternoon.

Data were not collected for the time distribution of total transit system ridership after the variable work hours program was initiated in Toronto. However, as shown in Figure 21, the peak distribution of government employees riding on the Yonge subway line changed drastically when variable hours were initiated in the Queen's Park government center. The peak 15-min transit volume of government employees was cut in half, and the peak shifted to an earlier time period. This should have significantly flattened the overall demand distribution on the subway line.

TABLE 9

IMPACT OF VARIABLE WORK HOURS ON TRANSIT PASSENGERS CROSSING CBD SCREENLINE IN OTTAWA (*19*)

| Period | Passengers February 1974 (Before) No. | Passengers February 1974 (Before) Percentage of Peak Period | Passengers March 1974 (After) No. | Passengers March 1974 (After) Percentage of Peak Period |
|---|---|---|---|---|
| Inbound | | | | |
| 7:00 to 8:00 a.m. | 9,853 | 35.2 | 13,636 | 44.6 |
| 8:00 to 9:00 a.m. | 16,379 | 58.5 | 15,166 | 49.7 |
| 9:00 to 9:30 a.m. | 1,782 | 6.3 | 1,735 | 5.7 |
| Total Peak Period | 28,014 | 100.0 | 30,537 | 100.0 |
| Peak Hour (7:30 to 8:30 a.m.) | 19,014 | 67.9 | 19,008 | 62.2 |
| Outbound | | | | |
| 3:00 to 4:00 p.m. | 3,106 | 11.5 | 4,346 | 15.9 |
| 4:00 to 5:00 p.m. | 9,225 | 34.1 | 12,293 | 44.9 |
| 5:00 to 6:00 p.m. | 14,731 | 54.4 | 10,759 | 39.2 |
| Total Peak Period | 27,062 | 100.0 | 27,398 | 100.0 |
| Peak Hour (4:30 to 5:30 p.m.) | 16,788 | 62.0 | 13,731 | 50.1 |

**Peak-Period Automobile Demand**

The most complete evaluation of the effects of variable work hours on the distribution of peak-period automobile demand is a study performed in Ottawa (*19*). This study is especially important because about half the total CBD work force participated in staggered or flexible hours work schedules—more than in any other program studied.

Peak-period traffic count surveys were made at two screenlines: screenline B, roughly corresponding to the boundaries of the Ottawa central area across which a high percentage of peak-period traffic is bound to or from CBD jobs; and screenline A, representing the Ottawa River across which many regional commuters pass, only part of whom are bound to or from the Ottawa CBD. Vehicle counts were also made at six major parking facilities in or near the CBD that provide a total of more than 6,000 parking spaces.

Figure 22 depicts the time distribution of automobile volumes crossing screenline B into the CBD in the morning and departing in the afternoon. The morning peak 15-min volume was 6 percent lower after flexible hours schedules were initiated and occurred 15 min earlier. It should be noted that the total morning peak-period volume between 7:00 and 9:30 a.m. increased by 10 percent in the time between the before and after surveys in the Ottawa study; thus the peak was flattened more significantly than indicated by the raw 15-min volume values. The peak 15-min volume, stated as a percentage of the 7:00 to 9:30 a.m. total, actually decreased by approximately 15 percent.

The change in peak-period automobile traffic distribution was more significant in the afternoon. The peak 15-min period shifted to 1 hr earlier, and the peak 15-min volume fell 17 percent, even though the 3-hr total increased by 6 percent. This corresponds to a 22 percent decrease in the peak 15-min volume, stated as a percentage of the 3:00 to 6:00 p.m. total volume.

The impact of the variable work hours program on the distribution of automobile volumes at screenline A, which contains a smaller fraction of CBD work trips than screenline B, was less pronounced (see Figure 23). The morning peak 15-min volume decreased by 4 percent despite an increase of 10 percent in total volume between 7:00 and 9:30 a.m. Thus the peak 15 min, stated as a percentage of the 2.5-hr total, decreased by about 13 percent.

In the afternoon peak at screenline A, the peak 15-min volume dropped by 2 percent despite an 8 percent increase in total traffic from 3:00 to 6:00 p.m. Therefore, the peak 15-min volume, stated as a percentage of the 3-hr total, decreased approximately 9 percent.

Traffic counts from six parking facilities in the Ottawa CBD indicated a much more dramatic flattening of the peak-period demand distributions than the screenline counts did, because a very high percentage of the peak-period parking arrivals and departures are work trips. As shown in Figure 24, both the morning and afternoon peak 15-min intervals occurred 0.5 hr earlier. The peak 15-min raw volumes decreased by about 13 percent in the morning and by more than 30 percent in the afternoon. The peak-hour parking arrivals and departures, stated as a percentage of the peak-period totals, decreased by 13.5 percent in the morning (from 62.1 to 53.7 percent) and 21.6 percent in the afternoon (from 57.3 to 44.9 percent).

Figure 25 presents an overall summary of the impacts of the Ottawa variable work hours program on employee arrivals and departures, and on automobile volumes at the CBD and river screenlines. The percentage reductions in peak-hour volumes and in the standard deviations of 15-min volumes are shown. Note that the effects of variable work hours are weakened when "other" traffic is included in the time-of-day distributions.

The evaluation of the staggered work hours program implemented at the 3M Company in St. Paul, Minnesota, reveals that such programs can also produce significant flattening of peak-period traffic demands at large suburban employment centers (*13*). Traffic counts were made at facility entrances and exits and on nearby major arterial highways before and after the implementation of staggered hours. Before the program, most workers at the 8000-employee 3M site started work at 8:00 a.m. A simple staggered hours plan was implemented by which administrative personnel began work 15 min earlier (7:45 a.m. to 4:30 p.m.) and laboratory personnel began work 15 min later (8:15 a.m. to 5:00 p.m.). Substantial growth in employment occurred at the facility in the time between the 1970 survey (before implementation) and the 1972 survey (after implementation).

Table 10 presents the results of the traffic count surveys, showing the peak-hour and peak 15-min volumes as percentages of average daily traffic. At the 3M entrances, the morning peak-hour volumes dropped from 57 percent to 43 percent of average daily traffic (ADT). Peak 15-min volumes decreased from 23 to 15 percent of ADT. Flattening of the afternoon peak-period demands were not as pronounced but were still significant. The results also show that the redistribution of peak traffic on adjacent major highways was significantly less notable than at the 3M entrances and exits as a result of the inclusion of non-3M employee traffic.

Most alternative work schedule programs have been implemented in the CBD; however, the 3M experience demonstrates the potential of these programs in a suburban employment setting.

The study by the Port Authority of New York and New Jersey (*16*) analyzed the impact of the staggered work hours program in Manhattan on the peak-period distributions of automobile traffic demand at the Midtown Tunnel, the Lincoln Tunnel, and the George Washington Bridge.

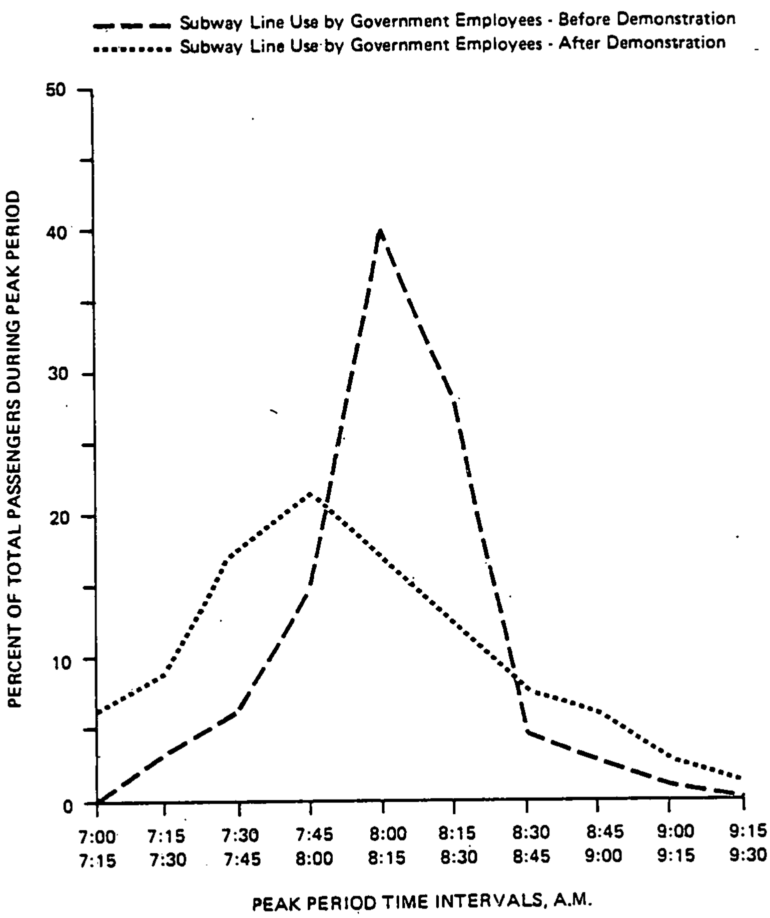



FIGURE 21 Impact of variable work hours program on morning passenger volumes on the Yonge subway in Toronto (*18*).

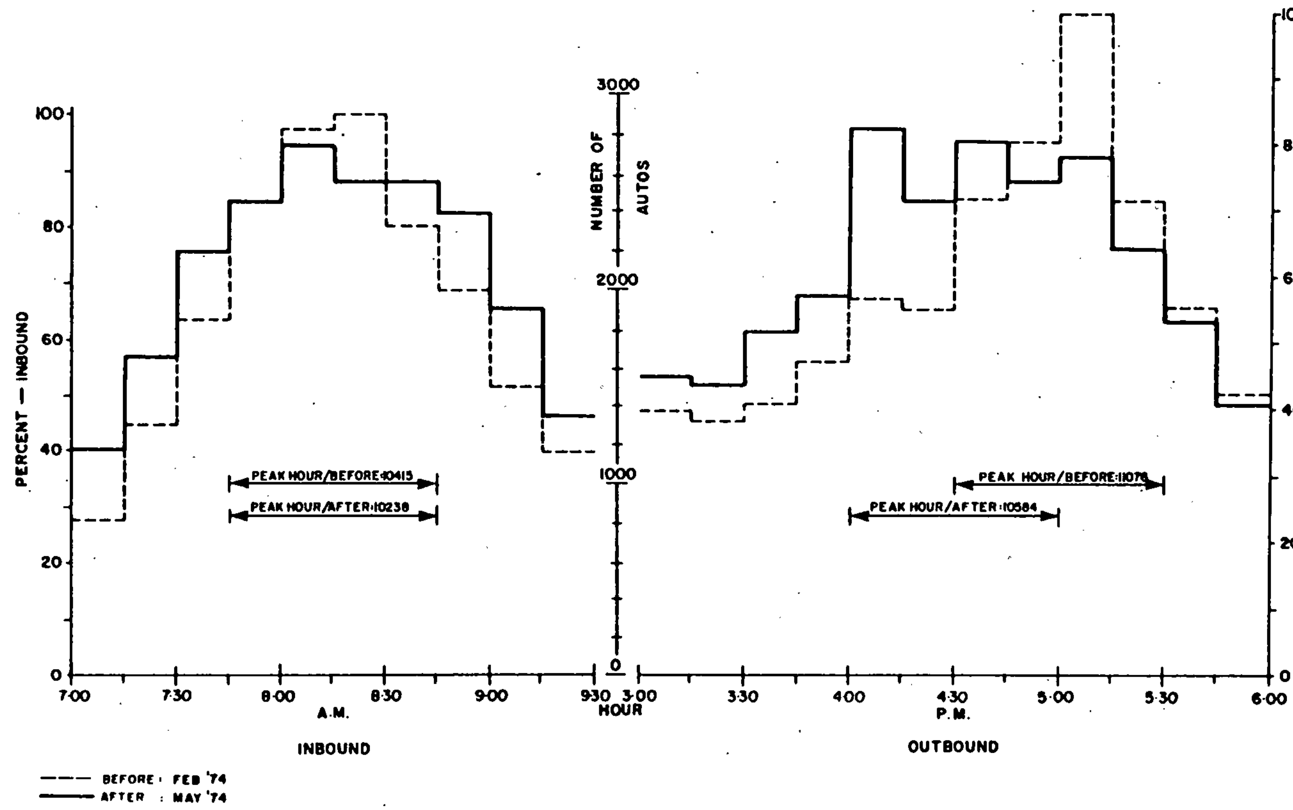



FIGURE 22 Impact of variable work hours on automobile volumes at the Ottawa central area screenline (*19*).

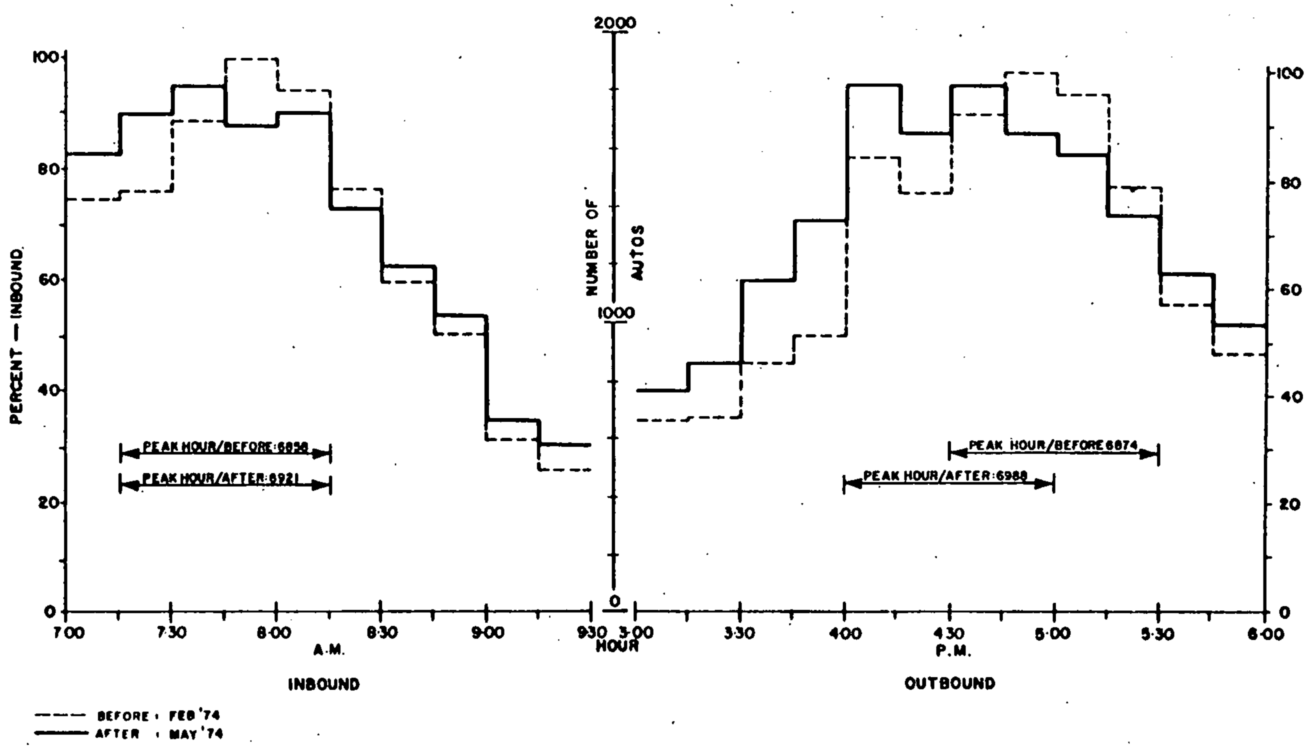



FIGURE 23 Impact of variable work hours on automobile volumes at the Ottawa River screenline (*19*).

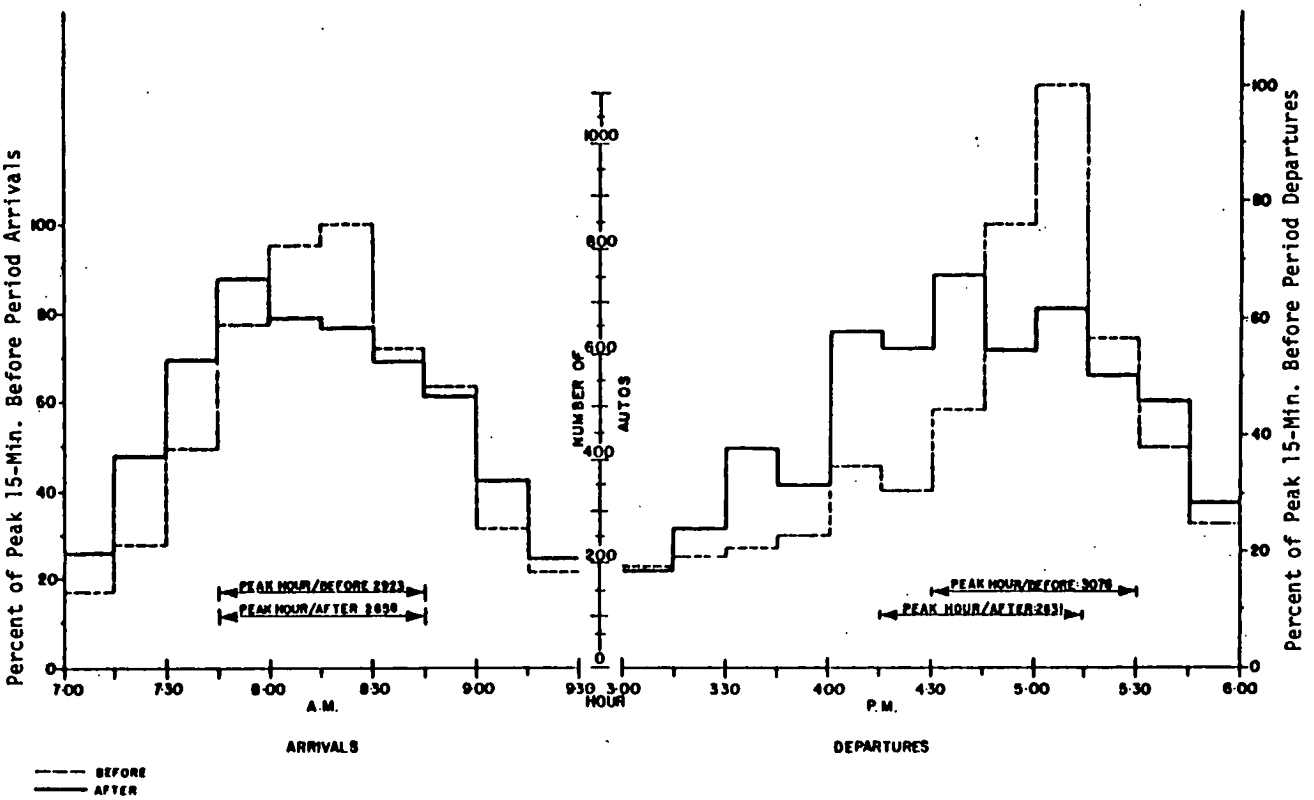



FIGURE 24 Impact of variable work hours on automobile volumes at Ottawa central area parking facilities (*19*).

The findings showed that no significant reshaping of the peak-period traffic loads on these facilities had occurred as a result of the staggered hours program. This was attributed mainly to the fact that the peak traffic periods on these facilities were already very long and flat before variable work hours schedules were implemented. The facilities are loaded to near-capacity levels for almost the entire 3-hr morning and afternoon peak periods. In effect, there is little if any discernible available capacity on the "shoulders" of the peak to attract further shifts in commuting times. It was also explained that only 45 percent of peak-period trips through the Lincoln Tunnel are work trips to midtown Manhattan, and only about 10 percent of those working in Manhattan drive their cars to work. It was not surprising, under these conditions, that no noticeable redistribution of automobile peaking resulted from the Manhattan staggered work hours program.

Although the extremely long and flat automobile traffic peaks on highways leading to and from Manhattan are certainly atypical of most American cities, some very large metropolitan areas show such a pattern on major radial highway corridors serving their CBDs. These long, flat peaks can last as long as 2 hr or more when traffic demand exceeds capacity for the entire period. In such cases, work schedules need to be altered to encompass a very wide range of starting and quitting times in order to produce any significant further flattening of peak automobile traffic concentrations. On many highway sections in these cities, traffic demand equals or exceeds capacity for much shorter time durations, and peaks can be flattened significantly by altering work schedules.

**Highway and Transit Quality of Service**

The purpose of flattening peak-period transportation demands by staggering work hours is to reduce congestion during commuting hours and thereby improve the quality of service for commuters using heavily loaded highways and transit facilities. Improvement in the quality of transportation service can be measured by calculating reductions in work-trip travel times. Service quality is also improved by reducing crowding in transit vehicles and stations, parking facilities, and major office building lobbies and elevators—all of which enhance commuter comfort and convenience and reduce overall commuting time. The following sections highlight the impacts of staggered and flexible hours programs on these key indicators of the quality of transportation service.

*Travel Time*

Perhaps the single most important consequence of variable work hours is shortened commuter travel times. It is surprising, therefore, that relatively little information on travel time has been systematically collected and documented.

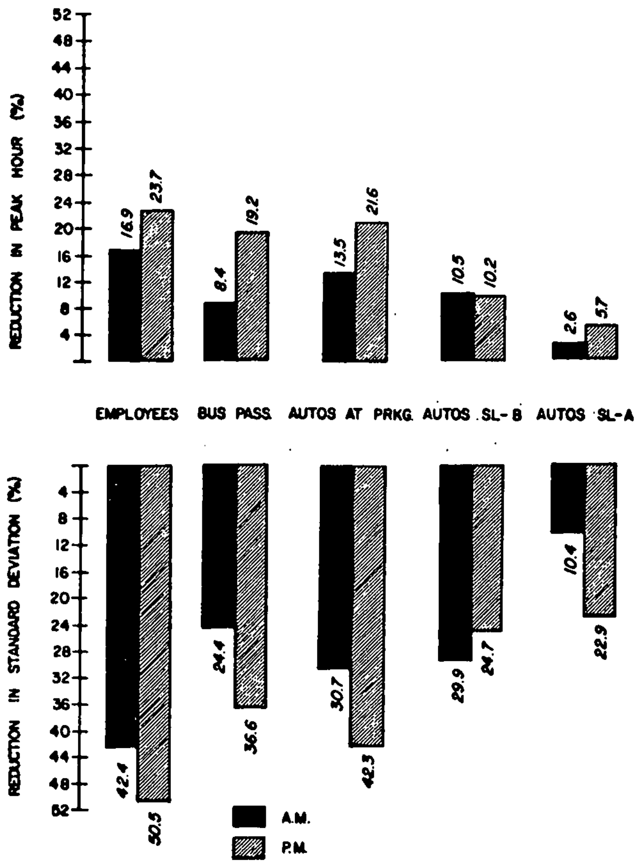



FIGURE 25 Summary of the impacts of the Ottawa variable work hours program (*19*).

TABLE 10

IMPACT OF STAGGERED WORK HOURS PROGRAM (3M COMPANY, ST. PAUL, MINNESOTA) ON PEAK-PERIOD AUTOMOBILE TRAFFIC[a, b]

| | | Percentage of Total Peak-Period Traffic | | | |
|---|---|---|---|---|---|
| | | Morning | | Afternoon | |
| Location | Period | Before (1970) | After (1972) | Before (1970) | After (1972) |
| 3M Entrances and Exits | Peak hour | 57 | 43 | 55 | 48 |
| | Peak 15 min | 23 | 15 | 25 | 20 |
| Nearby Major Highways | Peak hour | 16.5 | 15.3 | 15.7 | 14.0 |
| | Peak 15 min | 5.2 | 5.1 | 5.2 | 4.2 |

[a] Based on data from Owens and Van Wormer (13).

[b] Peak-hour and peak 15-min volumes are shown as percentages of average daily traffic.

Most existing literature is based either on questionnaire surveys, in which participants in variable work hours programs were asked how much their commuting times had been shortened, or on theoretical estimates or indirect approximations of changes in travel time resulting from redistributions of peak-period transportation demand. The findings are generaly considered to be rough indicators of the effects on travel time instead of precise estimates based on empirical measurements.

*Toronto-Queen's Park.* More than 2,000 employees participating in the Toronto-Queen's Park variable work hours demonstration program answered a detailed questionnaire that included queries about travel time (*18*). Approximately 31 percent said that morning and evening travel times had been shortened by an average of 11 min. Only 3.2 percent stated that commuting time was longer in the morning, whereas 8.7 percent reported longer travel times in the evening. The remaining majority responded that travel times were about the same before and after variable work hours programs were implemented. It was finally estimated, based on the above data, that the overall savings in travel time for all respondents averaged about 3 min per trip.

*Manhattan.* In the Port Authority study (16), an analysis was made of train delays encountered by Manhattan commuters on the subway and commuter rail systems during peak periods. Findings from a special study of the subway system indicated a 25 percent increase in the probability of train delay and a 40 percent increase in the average delay time for those starting work at 9:00 a.m. as compared to the average delay time for those shifting to an 8:30 a.m. arrival. For rail commuters, the chance of a train delay for those starting work at 9:00 a.m. was two-thirds greater than for those starting at 8:30; the average delay time was 50 percent greater. The average reduction in delay per person for those shifting from 9:00 to 8:30 a.m. arrivals was estimated at 3.1 min.

*Riverside, California.* The impact on travel time was also estimated for the Riverside, California, staggered work hours program, in which 3,200 people began work earlier or later than 8:00 a.m. (*16*). The average reduction in commuting time was estimated to be 2.5 min per trip for all participating and nonparticipating employees.

*EPA, Washington, D.C.* At the EPA in Washington, D.C., evaluation studies were made after more than 3,000 employees were placed on a flexible hours plan. Employees reported a substantial reduction in daily *round-trip* travel times (see Figure 26). A majority (62 percent) indicated reductions in daily commuting times, whereas only 2 percent said travel times had increased. The approximate average reduction in round-trip travel times was 8 min.

*Freeway Simulation Estimates.* Jones et al. (*2*), in a 1977 study at the University of California at Berkeley, used a freeway simulation model to estimate delay reductions on a heavily loaded 10-mile section of I-80 in the San Fran-

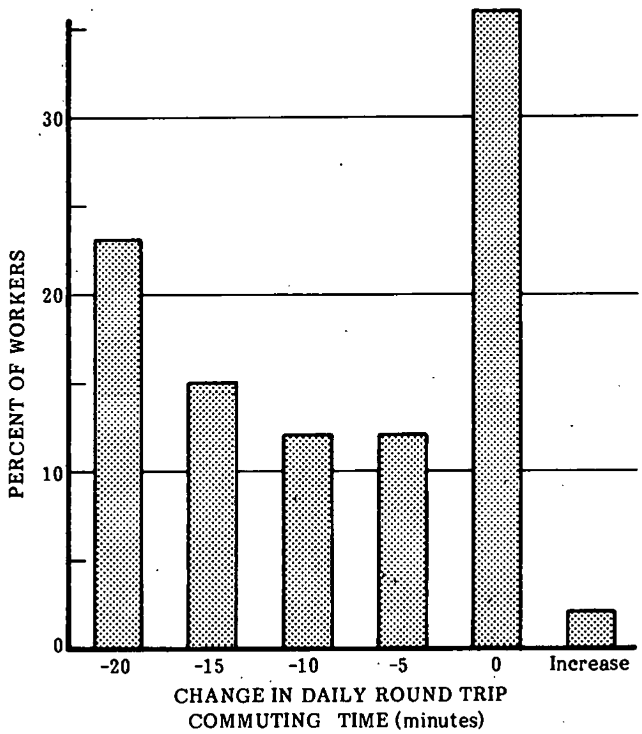



FIGURE 26 Impact of EPA flexible work hours program on travel time (*20*).

cisco area. The redistribution of demand required to flatten the morning peaks sufficiently to eliminate queuing at all the bottlenecks was hypothetically formulated, and the resulting impact on reducing delays was estimated by using the simulation model.

The average reduction in total freeway travel time for all vehicles using the facility between 3:30 and 6:00 p.m. was estimated at 16 percent. This represents the upper-limit potential reduction in travel time for existing conditions on the facility studied, but Jones et al. note that the time shifts in travel demand needed to obtain such a result probably cannot be readily made. They contend, however, that through a combination of variable work hours programs and freeway entrance ramp metering, delay reductions of this magnitude could be achieved.

It is important to stress that the 16 percent reduction in freeway travel time is the average for all vehicles traveling on at least some portion of the 10-mile freeway section analyzed in the study and not only for highway users with hypothetically adjusted working hours. Dividing the estimated total time savings by the number of person trips on at least part of the freeway section results in an average time savings of only 1.2 min per trip. Those who formerly traveled during the height of the peak would, of course, save considerably more time and would also benefit from less delay during those portions of trips made on routes other than the freeway section analyzed.

*Manual Traffic Flow Analysis.* Wagner (*21*) performed a manual traffic flow analysis to estimate the effects on quality of flow (as measured by travel time per mile or its reciprocal, speed) caused by the flattening of peak-period traffic volume distributions. For this analysis, it was assumed that radial freeways and surface arterials approaching the CBD and streets within the CBD are congested during the peak hour and uncongested during the remaining 1.5 hr of the peak period.

It was assumed that some traffic shifts from the congested to uncongested periods as a result of variable work hours (see Figure 27). The resulting flattening of demand causes travel time to improve significantly during the peak hour, when travel time is most sensitive to volume changes. Travel times are only modestly increased as volumes on the shoulders of the peak are increased, because the sensitivity of travel time to volume changes before and after the peak hour is much lower than during the peak hour. The net effect is a reduction in overall average peak-period travel time.

Two variable work hours program scenarios were examined by Wagner. The first was a "maximum" program in which 50 percent of the CBD employees participated (such as was achieved in the Ottawa program), and the second was a more reasonable "target" program in which 20 percent of the CBD employees participated. The shifts of peak-hour volumes to the 1.5-hr shoulders of the peak period were assumed for the two scenarios (Table 11).

TABLE 11

CHANGES IN TRAFFIC VOLUMES FOR DIFFERENT LEVELS OF PROGRAM PARTICIPATION

| | Percent Changes in Traffic Volume Levels | | | |
|---|---|---|---|---|
| | 20% Participation | | 50% Participation | |
| | Peak-Hour Volume | Remaining 1.5-Hr Volume | Peak-Hour Volume | Remaining 1.5-Hr Volume |
| Radial freeways and arterials | - 2 | + 1.3 | - 5 | + 3.3 |
| CBD streets | - 4 | + 2.6 | -10 | + 6.6 |

The changes in average travel time and average speeds on three classes of facilities due to hypothetical shifts in peak-hour volumes were then estimated. The results, presented in Table 12, indicate that substantial improvements in quality of service on congested highways can be obtained by a large-scale variable work hours program. In the "maximum" program case, for example, average peak-period travel times were estimated to be reduced by 11 percent on radial freeways, 5 percent on CBD streets, and 2.6 percent on radial surface arterials. The estimated percentage reductions in the peak-hour travel times were twice as great as those for the 2.5-hr peak period.

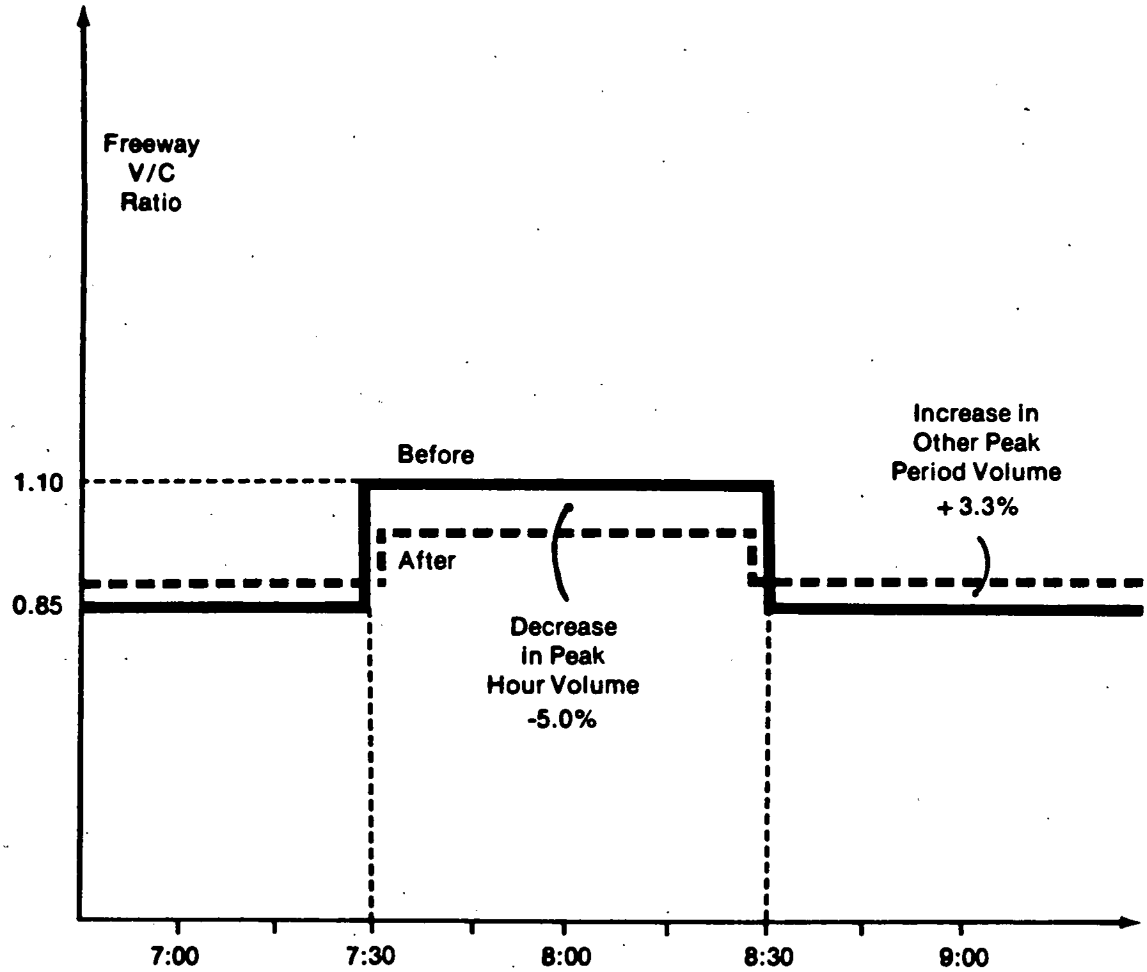
For a "typical" trip in which 15 min is spent on a radial freeway, 5 min on CBD streets, and 5 min on a radial surface arterial, the estimated reduction in average *peak-period* trip time for the 50 percent participation scenario would be

$$15(0.11 + 5(0.05) + 5(0.026) = 2 \text{ min};$$

whereas the reduction in average *peak-hour* trip time for the 50 percent participation scenario would be

$$15(0.20) + 5(0.10) + 5(0.05) = 3.75 \text{ min}.$$

Similar calculations made for the more feasible 20 percent participation scenario result in estimated reductions in average trip time of less than 1 min for the 2.5-hr peak period and 1.5 min for the peak hour. These estimates, like those determined by Jones for the San Francisco freeway case study, represent reductions of overall travel time rates




| | | | | | |
|---|---|---|---|---|---|
| **Before:** | **Peak Hour Volume** | = | **1.1 x C x 1 Hour** | = | **1.100C** |
| | **Other 1.5 Hour Volume** | = | **0.85 x C x 1.5 Hours** | = | **1.275C** |
| | | | | | **2.375C** |
| | **Peak Hour Percent = 46.3%** | | | | |
| **After:** | **Peak Hour Volume** | = | **1.1C - 0.05** | = | **1.045C** |
| | **Other 1.5 Hour Volume** | = | **0.887 x C x 1.5 Hour** | = | **1.330C** |
| | | | | | **2.375C** |
| | **Peak Hour Percent = 44.0%** | | | | |

FIGURE 27 Flattening of demand as a result of the shift in highway traffic from congested to uncongested periods due to the effects of variable work hours schedules (*21*).

TABLE 12

IMPACTS OF VARIABLE WORK HOURS ON PEAK-HOUR AND PEAK-PERIOD TRAVEL TIMES (*21*)

| Facility Type | Percent Reduction in Average Travel Time Per Mile | | | |
|---|---|---|---|---|
| | 20% Participation of CBD Employees | | 50% Participation of CBD Employees | |
| | Peak Hour | 2.5 Hour Peak Period | Peak Hour | 2.5 Hour Peak Period |
| Radial Freeways | -8.0% | -5.0% | -20.0% | -11.0% |
| CBD Streets | -4.0% | -2.4% | -10.0% | -5.0% |
| Congested Radial Arterials | -2.0% | -0.7% | -5.0% | -2.6% |
| Combined Average | -4.7% | -2.7% | -11.7% | -6.2% |

on the highways involved, not just the effects on those participating in variable work hours programs.

Table 13 summarizes the foregoing findings on impacts on travel time. Reductions in travel time range from 2.5 to 8 min per trip for employees in variable work hours programs and from about 1 to 4 min per trip for all commuters using the affected highway segments.

### *Transit System Crowding*

Another key indicator of the quality of transportation service that is affected by variable work hours programs is the degree of crowding experienced by commuters using public transit. As discussed previously, the crowding caused by excessive passenger demand during peak periods results in directly measurable increases in transit travel times, largely because of increased dwell times for passenger loading and unloading at rail transit stations or major bus stops. Crowding in transit vehicles and stations also has a significant bearing on *perceived comfort and convenience of the public transit mode* and therefore has a major influence on the attractiveness of transit.

As stated in the study by the Port Authority of New York and New Jersey (*16*): "In plain terms, of course, people do not like to be crowded. In addition to the physical discomfort associated with heavy crowding, many feel that crowding lessens their sense of personal dignity and evidences a lack of respect. . . . [People dislike being] packed in like sardines [and] are happier about their trips when they have space to move, to read their book or newspaper, and to reduce or eliminate bodily contact."

The ideal situation is to provide a seat for each passenger; however, this is not a practical goal on high-volume rail transit lines in which cars are purposely designed to accommodate large numbers of standees in a reasonably comfortable manner. The interpretation of comfort capacity "will depend on the particular vehicle design, trip length and (type of) transit system" (*16*). Commuters using bus transit, especially long-distance express bus, or commuter rail tend to equate comfort with the availability of adequate seats.

The Port Authority report (*16*) contains the following explicit definitions of transit vehicle capacity:

- Seated capacity: The maximum number of seats during a given time period on transit vehicles. For example, if there are 450 transit vehicles per hour, each with 80 seats, the seated capacity equals $80 \times 450 =$ 36,000 seats per hour.
- Comfort capacity: The maximum number of riders who can be handled "comfortably" on a transit line, taken to mean being able to read a newspaper while standing. For example, 450 transit vehicles per hour $\times$ 180 people riding "comfortably" in each vehicle (80 seated + 100 standing) equals 81,000 passengers per hour.
- Crush capacity: The absolute maximum number of riders who can be handled on a transit line. For example, 450 transit vehicles per hour $\times$ 250 people riding in each vehicle (80 seated + 170 standing) equals 112,500 passengers per hour.

Some limited data indicate that variable work hours can significantly reduce transit vehicle load factors during peaks in addition to enhancing perceived commuter comfort and convenience. The most dramatic effects on transit load factors were found in Ottawa (*19*), where extensive participation in staggered and flexible work hours in the CBD and significantly expanded bus service were implemented. This combination sharply reduced the number of standees on buses in the morning peak period and virtually eliminated them in the afternoon peak (see Table 14). Although both seating capacity and transit ridership increased after variable work hours were implemented, ridership expressed as a percentage of seating capacity had a flatter distribution

TABLE 13

SUMMARY OF IMPACTS ON TRAVEL TIME

| Program | Travel Time Reduction (min) | | Notes |
|---|---|---|---|
| | Peak Period | Peak Hour | |
| Toronto-Queen's Park | 3 | | Impact on participants only |
| Lower Manhattan | | 3.1 | Train delay impact on those changing from 9:00 a.m. to 8:30 a.m. |
| Riverside, California | 2.5 | | Impact on all employees |
| EPA, Washington, D.C. | 8 | | Impact on participants only |
| San Francisco simulation (predictions) | 1.2 | | Impact on all users of 10-mile freeway section |
| Manual analysis (predictions) | | | |
| 50 percent participation | 2 | 3.75 | Impact for "typical" trip of CBD employee |
| 20 percent participation | 0.8 | 1.5 | |

in both the morning and afternoon peak periods in Ottawa.

In New York, observations were made of transit vehicle crowding at a subway station used by Port Authority personnel participating in the staggered work hours experiment. The results, summarized in Table 15, indicate that people on early schedules encountered far less crowding. "In general, the trains become progressively more crowded during the period from 4:15 through 5:15 p.m. Until 4:30 p.m., two-thirds of the trains have empty seats and an average of 15 seats are available per car. By 5:15 p.m., only one train in eight had some available seats, and the number of standees increased greatly" (*16*).

In the same study, riders were asked to make subjective ratings of comfort on one of the subway lines. A significantly greater number of riders on the early work schedule (8:15 a.m.–4:15 p.m.) gave ratings of comfort higher than did employees on the other two schedules, who were traveling near the height of the peak period (see Table 16).

More extensive attitudinal data on travel comfort were collected in the evaluation of the Toronto-Queen's Park variable work hours demonstration program (*18*) in which a majority of participants commuted by public transit. Table 17 summarizes the ratings of travel comfort by all employees responding to the survey question. Nearly half replied that their morning and afternoon commuting trips were more comfortable after variable work schedules had been implemented; fewer than 10 percent said their trips were less comfortable. Changes in perceived comfort were especially noticeable when data were classified by type of work schedule (e.g., staggered hours, flexible hours, or unchanged) and starting time of the respondents. Table 18 shows that 60 to 70 percent of those starting work earlier (7:00 to 8:00 a.m.) or later (9:00 to 10:00 a.m.) than the normal peak hour reported that their trips were more comfortable than before; fewer than 4 percent of these early or late starters reported a less comfortable trip. Even among those who arrived at work during the peak hour (8:00 to 9:00 a.m.), nearly one-third felt their trips were more comfortable, whereas less than 10 percent perceived less comfortable travel. The same data were collected for the afternoon peak commuter trips, and evidence of enhanced comfort was almost as positive as for the morning results.

Severe delay and discomfort are experienced not only on overloaded transit vehicles but also in the process of gaining access to or from the vehicles at crowded stations. Excessive queuing often occurs on escalators and stairways and at fare-collection turnstiles and farecard-dispensing machines. When rail transit platforms or bus stops are overcrowded and transit vehicles are near crush loads, transit passengers cannot all board the first arriving vehicle. Although data on the delays resulting from such phenomena are lacking, it is possible that "transit access" delays during the height of the peak lengthen overall commuting time as much as transit vehicle delay.

TABLE 14

EVENING PEAK OUTBOUND BUS TRANSIT CAPACITY AND UTILIZATION (OTTAWA CBD SCREENLINE) (*19*)

| Time | Percentage Change in Seating Capacity for February to March | Percentage Change in Ridership for February to March | Ridership as a Percentage of Seating Capacity | |
|---|---|---|---|---|
| | | | February | March |
| 3:00 to 3:15 | +53.7 | +41.0 | 39.0 | 35.8 |
| 3:15 to 3:30 | - 7.7 | +10.1 | 39.5 | 47.1 |
| 3:30 to 3:45 | +50.0 | +52.4 | 44.7 | 45.4 |
| 3:45 to 4:00 | +47.2 | +55.2 | 61.1 | 47.5 |
| 4:00 to 4:15 | +16.0 | +91.1 | 56.2 | 92.6 |
| 4:15 to 4:30 | +13.5 | +67.5 | 62.5 | 92.3 |
| 4:30 to 4:45 | +30.6 | +33.2 | 95.3 | 97.2 |
| 4:45 to 5:00 | + 7.5 | - 7.7 | 99.7 | 85.6 |
| 5:00 to 5:15 | 0.0 | -28.9 | 134.0 | 96.4 |
| 5:15 to 5:30 | - 0.8 | -39.0 | 118.0 | 78.3 |
| 5:30 to 5:45 | + 3.6 | -10.1 | 79.0 | 68.5 |
| 5:45 to 6:00 | + 7.0 | - 8.2 | 53.4 | 45.8 |
| 3:00 to 6:00 | +13.0 | + 1.2 | 80.8 | 72.4 |

TABLE 15

CROWDING AT 14TH STREET SUBWAY STATION IN MANHATTAN (*16*)

| Afternoon Time Period | Availability of Seats | | Standees Per Car |
|---|---|---|---|
| | Likelihood | Average No. | |
| 4:16 to 4:30 | 2/3 | 15 | Up to 30 |
| 4:31 to 4:45 | 1/2 | 15 | Up to 30 |
| 4:46 to 5:00 | 1/8 | 11 | Up to 40 |
| 5:01 to 5:15 | 1/8 | 10 | Up to 70 |

*Elevator Congestion*

Another component of travel time that is often overlooked is the time spent waiting for and riding in elevators. In major office buildings where most workers are on fixed schedules, elevator demand often exceeds capacity during peak starting and quitting times, which causes significant delays due to queuing and uncomfortable crowding.

Data collected by the Port Authority of New York and New Jersey (*16*) provide examples of the severity of elevator congestion. After staggered work hours were implemented in the Morgan Guaranty Trust Bank Building in lower Manhattan, the observed peak numbers of passengers waiting for elevator service in the main lobby were sharply reduced (see Figure 28). The number of those delayed at the Morgan Guaranty elevators in the morning was reduced by almost 60 percent from 673 before to 278 persons after staggered work hours were implemented. For those delayed, the average waiting time was cut by 81 sec (or 55 percent) from 145 to 64 sec.

Elevator transit time was not reported, but it is certain to be longest when the elevators are loaded to capacity. Consequently, the sum of waiting time and transit time was

TABLE 16

SUBJECTIVE COMFORT RATINGS BY PORT AUTHORITY PERSONNEL USING SUBWAY (*16*)

| Work Schedule | Comfort Rating (Percent) | | |
|---|---|---|---|
| | Poor | Fair | Good |
| 8:15 to 4:15 | 47 | 26 | 27 |
| 8:45 to 4:45 | 50 | 29 | 21 |
| 9:15 to 5:15 | 54 | 30 | 15 |

TABLE 17

RELATIVE CHANGES IN TRAVEL COMFORT AMONG ALL PARTICIPANTS IN THE TORONTO-QUEEN'S PARK VARIABLE WORK HOURS PROGRAM (*18*)

| Travel Comfort | People Responding (Percent) AM | PM |
|---|---|---|
| More comfortable | 47 | 43 |
| The same | 48 | 47 |
| Less comfortable | 5 | 9 |

probably decreased by an average of approximately 2 min. The distribution of delay times shown in Figure 29 indicates that the maximum waiting time was reduced from 6 to 2 min.

These findings suggest that for those employed in large office buildings, the decrease in commuting time caused by reduction in elevator delay may be nearly as great as that due to reductions in transit access delay and transit vehicle delay. The combined effects of these reductions in delay can shorten total commuter travel time by as much as 5 to 10 min, a significant change in total trip time.

### *Parking-Facility Congestion*

Commuters using automobiles can be affected by congestion within parking facilities as well as on the road network. Delay and inconvenience arising from congestion in parking facilities can be particularly acute in large, multilevel parking structures in the CBD, at other high employment centers, or in large surface parking lots in suburban work places. Commuter delay time can be caused by several factors.

- Heavy parking arrivals can cause queuing at the entry points and on ramps or circulation paths within the parking facility.
- The commuter can spend a good deal of time circling the parking structure before finding an available parking space.
- Delays occur when a driver is waiting for other vehicles to maneuver into parking spaces, especially in structures with narrow driveways and stalls.
- As large surface lots fill up, the only available spaces may be some distance from the office building entrances; thus walking times between the parked car and the building might be 2 or 3 min or even longer.
- Steeply concentrated work departures can result in long

TABLE 18

COMPARISON OF MORNING TRAVEL COMFORT FOR EMPLOYEES ON STAGGERED AND FLEXIBLE HOURS PROGRAMS AND ON UNCHANGED SCHEDULES (*18*)

| Commence Work at | More Comfortable | Less Comfortable | Same | Total |
|---|---|---|---|---|
| **STAGGERED HOURS** | | | | |
| 7:00-8:00 a.m. | 674 (61.6%) | 39 (3.6%) | 381 (34.8%) | 1094 (100%) |
| 8:01-9:00 a.m. | 226 (30.3%) | 60 (8.0%) | 461 (61.7%) | 747 (100%) |
| 9:01-10:00 a.m. | 64 (72.7%) | 3 (3.4%) | 21 (23.9%) | 88 (100%) |
| **FLEXIBLE HOURS** | | | | |
| 7:00-8:00 a.m. | 138 (60.0%) | – | 92 (40.0%) | 230 (100%) |
| 8.01-9:00 a.m. | 101 (32.9%) | 18 (5.9%) | 188 (61.2%) | 307 (100%) |
| 9:01-10:00 a.m. | 38 (70.4%) | 1 (1.9%) | 15 (27.7%) | 54 (100%) |
| **UNCHANGED SCHEDULES** | | | | |
| 7:00-8:00 a.m. | 10 (30.3%) | 1 (3.0%) | 22 (66.7%) | 33 (100%) |
| 8:01-9:00 a.m. | 18 (11.2%) | 16 (9.9%) | 127 (78.9%) | 161 (100%) |
| 9:01-10:00 a.m. | 1 (100%) | – | – | 1 (100%) |

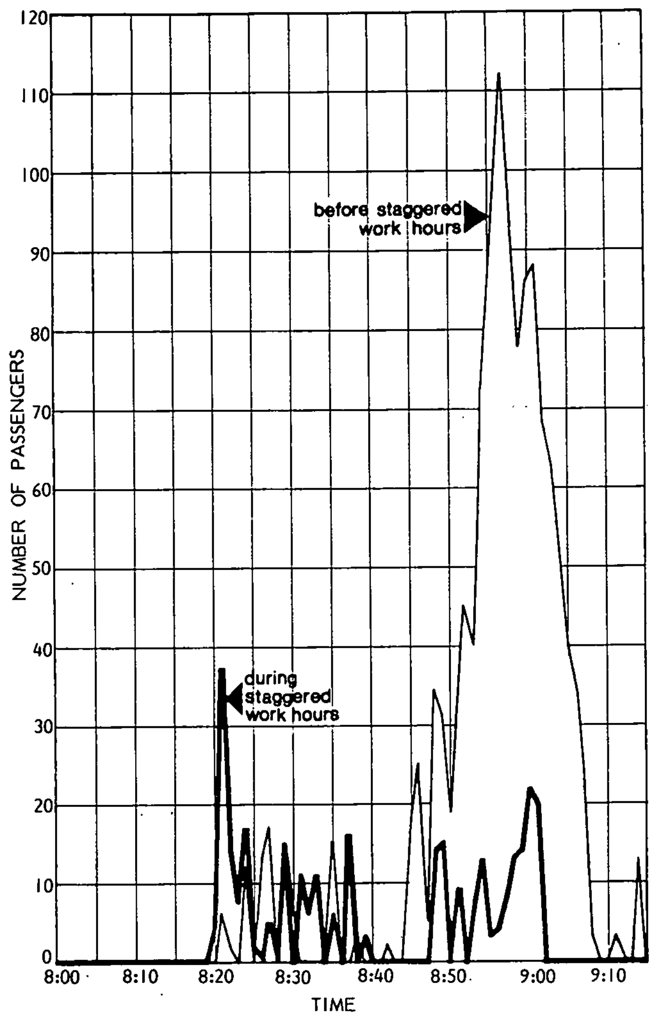



FIGURE 28 Number of passengers waiting for elevator service before and after implementation of staggered work hours program at Morgan Guaranty Trust Bank (*16*).

queues and delays at parking facility exits, which usually tend to be more severe than parking entrance queuing in the morning.

- If parking capacity is limited and commuter parking spills over into neighboring on- and off-street spaces, the search for a parking space in the morning may be time-consuming.

No quantitative data on the effects of variable work hours on these various parking-related causes of delay were discovered. It seems reasonable to hypothesize, however, that for some commuters the potential of variable work hours to reduce the parking-related delay may be at least as large as the potential of these programs to reduce delays on the road. The greatest reductions in parking-related delays can be gained by commuters who switch to earlier than normal work schedules because they have access to the choicest parking spaces. Conversely, where parking capacity is overburdened, later-arriving employees can experience great difficulty in finding convenient parking. Parking problems are believed to be a major factor in influencing commuters who participate in flexible hours programs to shift to earlier rather than to later schedules.

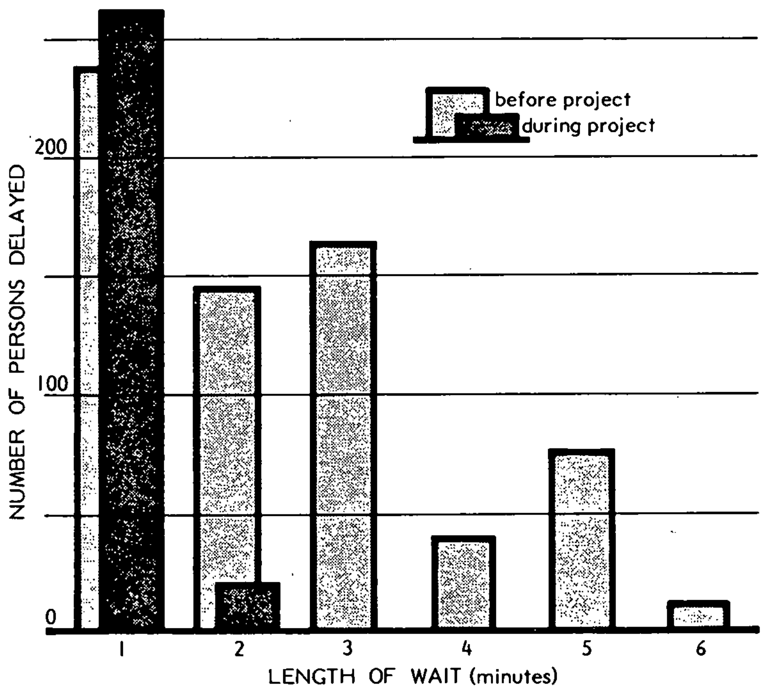



FIGURE 29 Waiting times for elevator service before and after implementation of staggered work hours program at Morgan Guaranty Trust Bank (*16*).

### Choice of Travel Mode

Relatively little is known about the effects of staggered and flexible work hours on the choice of travel modes by participants. A variety of conflicting hypotheses on the effects of variable work hours on the choice by commuters to drive alone, carpool, or use public transit has been offered, but there is insufficient evidence to show that significant mode shifts are caused by implementing alternative work schedules.

Some frequently stated hypotheses about the impacts of variable work hours programs on choice of transportation mode are presented in Table 19. All of these hypotheses may have some substance, but what is most noteworthy is the conflict between hypotheses—different factors tend to have the opposite influence on the choice of particular modes. It is not surprising, therefore, that the available empirical evidence shows little if any net change in the balance of mode shares that can be clearly attributed to work schedule changes.

Summarized below are the actual findings of empirical studies on the effects of variable work hours on choice of travel mode by commuters.

Selinger (*22*) reported that negligible changes in the transit/auto mode shares occurred as a result of the staggered work hours program in Manhattan. He attributed the lack of significant change to the fact that most of the work schedules were changed by only 0.5 hr and that transit service was nearly as frequent at the new times as during the height of the peak, and also that the transit share of Manhattan workers is close to 90 percent. Selinger warns, however, that transit service availability can be a problem if larger schedule changes are made and recommends that modifications in transit services be implemented in such cases to avoid losing transit patronage. He studied the impact of flexible hours programs on choice of transportation mode and found that few commuters reported shifts from using public transit to carpooling or driving alone.

In Ottawa (*19*), within 1 month of implementing staggered and flexible work hours in February 1974, the public transit share of work trips increased by approximately 3 percent in the morning peak and was virtually unchanged in the afternoon peak. This was attributed to two factors: the introduction of expanded express bus service during the evaluation period and the occurrence of the energy "crisis" at the time of the initiation of the variable work hours. It was concluded that the evidence could "not support a conclusion that the introduction of the variable work hours has had any influence on the modal split relationships."

In the Toronto-Queen's Park evaluation (*18*), it was found that carpooling increased from 15 percent of the

TABLE 19

POSITIVE AND NEGATIVE HYPOTHESES ON EFFECTS OF ALTERNATIVE WORK SCHEDULES ON TRAVEL MODE CHOICE

| Negative Hypotheses | Positive Hypotheses |
|---|---|
| Fixed work schedules are the "glue" that holds carpools together. The more commuters having common working hours, the higher the probability of making compatible carpool arrangements. | Flexible work hours will enhance the formation of carpools, because workers can tailor their schedules to match those of compatible partners. |
| Flexible work hours may lead to high day-to-day variability of some individual work schedules, effectively eliminating the efficiency of carpooling for such persons. | Reduced delay and increased comfort on transit systems from flattened peak period transit demands will encourage more people to use public transit. |
| Staggered work hours in which individuals have little or no choice of schedules may break up existing carpools and constrain the formation of new ones, because fewer potential partners will have compatible schedules. | For employees on rigid work schedules, the mismatch of transit schedules and work starting times, coupled with day-to-day variability of transit schedules, causes many transit users to arrive at work early (and in effect be at the work place longer than necessary) to avoid being a few minutes late. Flexible work hours eliminate this problem and make transit use relatively more attractive by allowing people to match their work schedules with transit schedules. |
| Reduced highway traffic congestion from flattening of peak period demands through variable work schedules will encourage more people to commute by automobile. | |
| Transit service may be less available or less frequent on the "shoulders" of the peak for some commuter trips; thus the relative attractiveness of transit use for persons who shift to earlier or later than normal schedules would decrease. | |

TABLE 20

CHANGES IN COMMUTING TRAVEL MODES AT EPA HEADQUARTERS IN WASHINGTON, D.C. (*20*)

| Mode | Percentage of People Using Modes | | Change |
|---|---|---|---|
| | Before Flexible Hours (Sample size = 1721) | After Flexible Hours (Sample size = 1540) | |
| Driving alone | 19.5 | 15.4 | -4.1 |
| Carpool | 56.2 | 62.1 | +5.9 |
| Bus | 16.3 | 13.8 | -2.5 |
| Motorcycle | 0.9 | 1.1 | +0.2 |
| Bike/walk | 5.4 | 5.7 | +0.3 |
| Train | 0.5 | 0.5 | 0 |
| Other | 1.2 | 1.4 | +0.2 |

participating employees before the program in 1973 to 17 percent after variable work hours were introduced in 1974. Only about 1.5 percent of survey respondents abandoned carpools, but more than twice as many joined carpools after implementation of the program. As in Ottawa, however, these findings were confounded by the coincidence of program initiation and the energy crisis.

At the EPA in Washington, D.C. (*20*), the 1976 implementation of flexible work hours appeared to cause a minor shift of commuters who had previously driven alone or used transit into carpooling (Table 20). Although an increase of approximately 6 percent in the use of carpools and a reduction of about 4 percent in driving alone were the largest changes found, this study does not provide firm conclusions on impacts on mode choice.

Another large-scale flexible work hours experiment involving 2,600 U.S. Geological Survey employees in Reston, Virginia (a suburb of Washington, D.C.), produced negligible changes in commuting modes (*23*). After flexible hours were implemented, 28 employees left carpools and 31 joined carpools. Only nine employees who formerly rode the bus changed to driving alone or carpooling. Such small changes are more likely to be the result of normal turnover among the three modes rather than the effect of flexible work hours.

Jones et al. (*2*) reported the results of a flexible work hours program, implemented in 1974, for 1,300 employees of the California Department of Water Resources in downtown Sacramento. Only 11 percent of the employees surveyed in 1977 reported a change in their usual travel modes during the 3 years after flexitime was introduced. The individual freedom permitted by flexitime seems "to have allowed some regular drivers to use carpools and buses on an irregular but more frequent basis" (see Table 21).

Although these responses appear to be encouraging, it must be remembered that a vast majority of the employees of the Department of Water Resources reported no change in regular or routine commuting habits. Among the 11 percent who did report changes, the shifts into buses and carpools far outweighed the shifts back to driving alone. The results, however, are confounded by the fact that the flexible work hours were implemented during a period when bus service was being improved and carpooling was being promoted in Sacramento, toward the end of the oil embargo, and in a downtown area with an increasingly short supply

TABLE 21

FREQUENCY OF CHANGES IN TRAVEL MODE BY REGULAR[a] DRIVERS UPON IMPLEMENTATION OF FLEXITIME (CALIFORNIA DOT) (2)

| Change | Percentage of Regular Drivers |
|---|---|
| Carpool more frequently | 12 |
| Carpool less frequently | 1 |
| Use bus more frequently | 14 |
| Use bus less frequently | 2 |
| Drive their cars more frequently | 4 |
| Drive their cars less frequently | 11 |

[a] Regular drivers are those who normally drive to work but occasionally use other travel modes for commuting.

TABLE 22

PERCENTAGE OF EMPLOYEES WORKING EACH DAY ON ALTERNATIVE 4-DAY WORK SCHEDULES (*24*)

| Alternative 4-Day Work Schedule | Percent of Participating Employees Working Each Day | | | | | | | Average Percent Reduction |
|---|---|---|---|---|---|---|---|---|
| | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Average Workday | |
| 1. Equally rotated Monday-Friday | 80 | 80 | 80 | 80 | 80 | | 80 | 20 |
| 2. Equally rotated Monday-Saturday | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 33 |
| 3. 1/2 Monday-Thursday, 1/2 Tuesday-Friday | 50 | 100 | 100 | 100 | 50 | | 80 | 20 |
| 4. 1/2 Monday-Thursday, 1/2 Wednesday-Saturday | 50 | 50 | 100 | 100 | 50 | 50 | 67 | 33 |
| 5. 1/3 Monday-Thursday, 1/3 Tuesday-Friday, 1/3 Wednesday-Saturday | 33 | 67 | 100 | 100 | 67 | 33 | 67 | 33 |

of commuter parking. All of these factors could influence choice of mode more than the implementation of flexible work hours.

Jones suggests that "flexitime is a marginal factor in carpool formation, but . . . it does seem to relax a scheduling constraint that allows other factors such as cost and parking availability to play themselves out more forcefully than they might in the absence of flextime. What is significant here, is that while flextime does not appear to be a powerful incentive for carpooling, its marginal effect does seem to be *positive*. . . . Thus it appears that rigid work hours are not the 'glue' that hold carpools together and, in fact, are more likely to be a factor which frustrates the formation [of] . . . carpools." Jones contends that flexible work hours definitely have some positive impact on mass transit ridership because they appear to eliminate the need for "schedule buffering among transit riders—i.e., having to arrive 10 minutes early to avoid being five minutes late . . . it appears that flextime can diminish the (transit) user (time) cost and improve the *user-obtainable* level of transit performance relative to the automobile."

The scarcity of data prevents drawing firm conclusions about the effects of variable work hours on the choice of transportation mode by commuters, but it appears that (a) flexible work hours probably have more significant positive than negative effects on both transit ridership and carpool use and (b) staggered work hours increase the risk of reducing transit use and ridesharing. Reduced use of transit and carpools can be avoided if alternative work schedules are carefully implemented in order to avoid shifting commuters outside the periods of availability of good transit service and setting arbitrarily rigid schedules that break up existing carpools and hamper formation of new ones.

## COMPRESSED WORKWEEKS

Until recently, alternative work schedule programs have focused on staggered and flexible work hours. Implementation of compressed workweeks has mainly been carried out independently by employers instead of as part of a coordinated urban area scheme. Consequently, there is a lack of empirical data of the impacts of these work schedules on transportation. The discussion of possible impacts is, therefore, based largely on the results of theoretical analyses.

As noted in Chapter 2, there are numerous variations of compressed workweek schedules, including variations in the number of workdays per week (e.g., 4-day week, 3-day week, the 5-4/9 plan) and in the days of the week that are taken off (e.g., always Friday, Friday or Monday, equal rotation throughout the 5 weekdays, etc.). Greatest attention has been focused on the 4-day workweek alternative; thus most of the following discussion of potential impacts is devoted to this schedule.

### Number of Daily Work Trips

Regardless of the particular compressed workweek schedule being considered, the primary thrust is to reduce the number of daily work trips. For example, the 4-day workweek reduces the average daily number of work trips for those participating by 20 percent, the 5-4/9 plan by 10 percent (9 days are worked every 2 weeks instead of 10), and the 3-day workweek by 40 percent. The impact on the transportation system varies for different days of the week as a function of which days are taken off. The overall impact also depends on what fraction of persons in the work force change to a compressed workweek.

Desimone (*24*) analyzed five alternative forms of the 4-day workweeks. Table 22 gives the percentage of participating workers traveling on each day of the week for each alternative, along with the resulting average percentage reduction in daily work trips. Note that regardless of the alternative, the *average* percentage reduction in work trips is 20 percent when work is confined from Monday through Friday (alternatives 1 and 3), but is 33 percent when some workers are scheduled to work on Saturday (alternatives 2, 4, and 5). Note also the dramatic difference between equal rotation of days off across all weekdays (alternative 1) as compared to confining days off only to Monday or Friday (alternative 3). The equal rotation is more effective from a traffic flow viewpoint because there is a uniform 20 percent reduction in work trips every day of the week. In alternative 3 there is no work-trip reduction on Tuesday, Wednesday, or Thursday.

The 5-4/9 plan is closely related to the 4-day workweek. If it is assumed that in any given week exactly half of the 5-4/9 participants will take 1 day off, then the average percentage reductions in work trips are half of those shown in Table 22 for the 4-day week. Three-day workweeks are most commonly found in 24 hr per day, 7 days per week operations (e.g., data processing centers, hospitals, police and fire departments, etc.).

It is important to note that the above discussion and Table 22 relate only to those employees who have switched to compressed workweeks. A proper analysis of the impacts on work-trip traffic must also take into account those employees whose work schedules are unchanged. The *overall* areawide work-trip proportion reduction is computed as follows:

$$PR_A = P_p \cdot PR_p,$$

where:

$PR_A$ = the proportion reduction in areawide daily work trips, i.e., percent reduction/100;
$PR_p$ = the proportion reduction in average daily work trips among participating commuters; and
$P_p$ = the proportion of commuters converted to shortened workweeks.

Calculations of impacts on the average areawide daily number of work trips are presented in Table 23 for different levels of employee participation in 4-day workweeks. Naturally, the nonparticipants dilute the impacts on areawide work trips, but, nevertheless, the impacts are substantial even if only 10 percent of the work force convert to compressed workweeks.

Nollen and Martin (*25*) report that as of 1976, only 2.1 percent of all full-time workers were on compressed workweeks. Growth in the use of compressed workweek schedules was very rapid from 1971 to 1976, but participation appeared to taper off in the subsequent years. The renewal of concern with energy problems beginning in 1979 appears to have restimulated interest in compressed workweeks as an energy conservation measure. It is unknown, however, what a realistic compressed workweek target participation level might be in "normal" times or how much higher the target could be in the event of a severe energy emergency.

### Vehicle Miles of Travel

Compressed workweek schedules do not have as great an effect on reducing vehicle miles of travel (VMT) as they do on reducing the number of daily work trips because:

- Work-trip VMT is typically only 35 to 40 percent of total VMT.
- Shifts in commuters' modes of travel may be induced.
- Nonwork travel mileage on days off may increase significantly.

If a simple case is assumed in which no mode shifts or no extra nonwork travel occur, the overall VMT reduction

TABLE 23

REDUCTION IN AREAWIDE AVERAGE DAILY WORK TRIPS AS A FUNCTION OF PERCENTAGE OF EMPLOYEES ON 4-DAY SCHEDULES AND TYPE OF SCHEDULING (*21*)

| Alternative 4-Day Work Schedule | Average Percent Reduction in Work Trips by Participants | Percent Reduction in Areawide Average Daily Work Trips for Different Percents of Areawide Employees Participating in 4-Day Weeks | | | |
|---|---|---|---|---|---|
| | | 10% Participation | 20% Participation | 30% Participation | 40% Participation |
| Equally rotated Monday-Friday or 1/2 Monday-Thursday, 1/2 Tuesday-Friday | 20 | 2.0 | 4.0 | 6.0 | 8.0 |
| Equally rotated Monday-Saturday or 1/2 Monday-Thursday, 1/2 Tuesday-Saturday or 1/3 Monday-Thursday, 1/3 Tuesday-Friday, 1/3 Wednesday-Saturday | 33 | 3.3 | 6.6 | 10.0 | 13.3 |

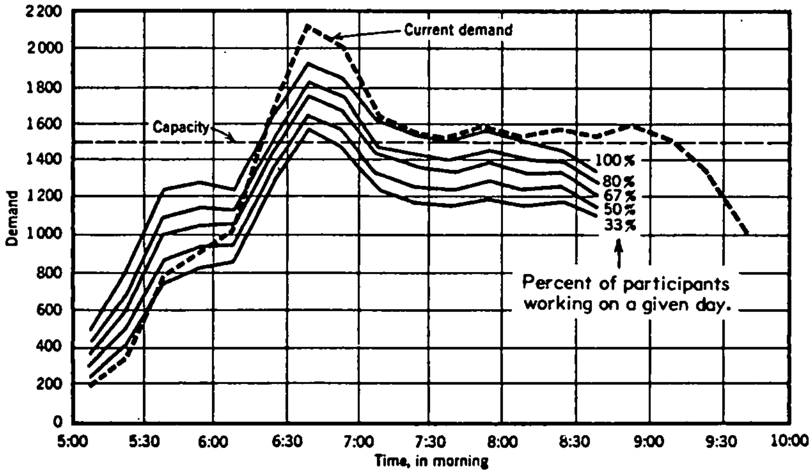



FIGURE 30 Redistribution of peak-period demand given participation of 35 percent of workers in 4-day/40-hr workweek (*24*).

would approximate 35 to 40 percent of the reduction in work trips. For example, if 10 percent of the work force converted to 4-day workweeks, overall daily VMT would be reduced by approximately 0.6 to 0.7 percent (assuming no Saturday workers). However, as Wagner (*21*) points out:

> All forms of 4-day work schedules would tend to deter the formation of carpools and dissolve existing carpools. The reduction in average daily work trip VMT would thus be less than the reduction in average daily work trips. However, since average vehicle occupancy levels for work trips are relatively low, there are limits to the potential dilution of 4-day work week impacts due to reduction in carpooling among the 4-day workers. For example, even in the extreme case of a drop in average occupancy of from 1.2 to 1.1 persons per car among the 4-day workers (or an 8 percent increase in VMT per PMT). . . .

Taking the mode shift factor into account, therefore, would cut the *overall* VMT reduction potential. Work-trip VMT reductions would be about 8 percent less than those shown in Table 23 if a marked mode shift out of carpools were to occur among 4-day workweek participants. For example, if 10 percent of the work force converted to 4-day workweeks, average daily work-trip VMT would be reduced by approximately 1.8 percent (assuming no Saturday workers) instead of by 2 percent as shown in Table 23.

The final and perhaps most complex factor to consider is the possibility of increased nonwork travel. Wagner (*21*) states:

> Work trip reductions in VMT, however, may largely be offset by increases in non-work travel during days off. To the extent that much of this extra travel might be recreational trips made on long weekends, the total daily VMT within urban areas could still be reduced somewhat even though aggregate VMT for urban and non-urban travel combined might be unchanged or even increased.
>
> It appears reasonable to assume, on balance, that overall changes in VMT resulting from 4-day work week schedules would be negligible. However, further research is needed to test this hypothesis.

**Time Distribution of Peak Traffic**

A secondary but important impact of compressed workweeks on transportation is the flattening of the peak resulting from employees (who work more than 8 hr per day) starting work earlier and/or quitting work later than those on regular work schedules. In analyzing 4-day/40-hr workweeks (i.e., 10-hr days), Desimone (*24*) assumed that all participants would begin work exactly 1 hr earlier and quit 1 hr later than before. Under this assumption, the new distribution of total worker arrivals and departures can be easily calculated for varying levels of 4-day workweek participation. The net effect would usually be a significant flattening of the peak as shown in the example in Figure 30.

Desimone's approach is limited to a simplified case of 4-day/40-hr workweeks. Time shifts by individual commuters may be more complex, as observed by Tannir and Hartgen (*26*) who claim that although participation in compressed workweek schedules would cause many workers to shift to earlier times, some by as much as 2 hr, others might actually shift to later commuting hours. When applied to a large state government suburban employment site, their more complex time shift analysis yielded an estimate of 28 percent reduction in peak-period arrivals. The effect of compressed workweek schedules on flattening the morning peak, as estimated by Tannir and Hartgen, is similar to the observed effect of large-scale flexible work hours programs. Hence, the use of compressed workweek programs improves peak-period flow conditions in two ways: (a) by reducing average daily work trips, and (b) by flattening the peak on any given work day.

### Quality of Transportation Service

Several theoretical estimates have been made of the impact of compressed workweeks on quality of transportation service. These analyses have all related to the quality of highway service. It is important to reiterate that the magnitude of the areawide impact is strongly correlated with the percentage of the work force that can be converted to compressed workweek schedules.

Wagner (*21*) applied a simple concept of travel time elasticity to estimate the order of magnitude of the impacts of compressed workweeks on travel time. He claims that areawide peak-period travel time elasticity is approximately 1.0 for medium-large metropolitan areas (i.e., a 1 percent reduction in peak-period VMT produces a 1 percent reduction in average travel time per mile). Thus, in the previous example in which participation of 10 percent of the work force in 4-day workweeks resulted in an areawide work-trip VMT reduction of 1.8 percent, the same percentage reduction in peak-period travel times would occur. This simple estimate does not account for the effects of peak flattening.

Desimone (*24*) analyzed the effect of 4-day workweeks on traffic demand at a major freeway bottleneck. He tested a case in which 35 percent of the work force converted to compressed workweek schedules; this was shown to result in both work-trip reduction and peak flattening (see Figure 30). Several different 4-day work scheduling alternatives were examined. Computations were made of the number of daily 15-min periods during which demand exceeds capacity and of the cumulative daily excess of demand over capacity. The results, summarized in Table 24, show significant reduction in bottleneck congestion.

A considerably more refined analysis approach by Tannir and Hartgen (*26*) used a 24-hr networkwide traffic assignment and level of service test for a 4-day workweek program at one large (10,000 employee) government installation in Albany, New York. The results, summarized in Table 25, indicate that average speeds increased by 1.3 percent in the immediate locale of the employment site and by 0.5 percent for the total network. Tannir and Hartgen interpret these as insignificant impacts, but considering that the impacts are averaged for full 24-hr day and that work schedule changes at only one large site were tested, the results appear to show that compressed workweeks can have a significant effect on quality of flow.

### Discussion

Although the examples discussed above are limited to highway traffic flow, it is expected that the quality of transit service in general would also be improved by compressed

TABLE 24

EFFECTS OF ALTERNATIVE 4-DAY WORKWEEK SCHEMES ON FREEWAY BOTTLENECK CONGESTION (35 PERCENT OF WORK FORCE PARTICIPATING IN 4-DAY SCHEDULES) (*24*)

| Work Schedule Alternative | Day of Week | Percent of Participants Working on Given Day | No. of 15-Min Periods Overloaded | Excess Demand Over Capacity (Vehicles) | Percent Reduction in Overload |
|---|---|---|---|---|---|
| Standard 5-day | M-F | 100 | 12 | 1,815 | -- |
| 4-Day, Equally Rotated Mon-Fri | M-F | 80 | 3 | 577 | 68 |
| 4-Day, Equally Rotated Mon-Sat | M-S | 67 | 2 | 414 | 77 |
| 4-Day, 1/2 Mon-Thur | M & F | 50 | 2 | 234 | 87 |
| 1/2 Tue-Fri | T,W,Th | 100 | 8 | 1,181 | 35 |
| | Average Day | 80 | 6 | 802 | 56 |
| 4-Day, 1/2 Mon-Thur | M,T,F,S | 50 | 2 | 234 | 87 |
| 1/2 Wed-Sat | W,Th | 100 | 8 | 1,181 | 35 |
| | Average Day | 67 | 4 | 550 | 70 |
| 4-Day, 1/3 Mon-Thur | M & S | 33 | 1 | 69 | 96 |
| 1/3 Tues-Fri | T & F | 67 | 2 | 414 | 77 |
| 1/3 Wed-Sat | W & Th | 100 | 8 | 1,181 | 35 |
| | Average Day | 67 | 4 | 555 | 69 |

TABLE 25

ESTIMATED DAILY IMPACTS OF 4-DAY WORKWEEK IN ALBANY, NEW YORK, USING CAPACITY-RESTRAINED TRAFFIC ASSIGNMENT TECHNIQUES *(26)*[a]

| | Total System | | | District 38 (Locale of Test Site) | | |
|---|---|---|---|---|---|---|
| Condition | Vehicle Kilometers of Capacity | Vehicle Kilometers of Travel | Speed (km/h) | Vehicle Kilometers of Capacity | Vehicle Kilometers of Travel | Speed (km/h) |
| Null | 6,285,300 | 1,539,200 | 29.84 | 339,700 | 69,000 | 25.00 |
| Test | 6,277,700 | 1,536,500 | 30.00 | 334,500 | 67,700 | 25.32 |
| Change | - 7,600 | - 2,700 | + 0.16 | - 5,200 | - 1,300 | + 0.32 |
| Percent Change | - 0.1 | - 0.2 | + 0.5 | - 1.5 | - 1.9 | + 1.3 |

[a] Assumes 65 percent participation in a 4-day workweek at one large (10,000-employee) site in a non-CBD area of Albany.

workweeks. However, some possible negative effects should be noted.

First, total transit patronage is decreased by compressed workweeks which, while reducing crowding, also reduces revenues. The transit fleet size and operating costs might be decreased somewhat to offset the reduced revenue.

Second, some employees on compressed workweek schedules may travel so early in the morning and so late in the afternoon that transit service availability might be a problem, especially in less transit-intensive corridors. As a result, these commuters may abandon mass transit, or the transit agency may have to add or modify service, which increases transit operating costs. Moreover, commuter trips will more often be made in hours of darkness, which may serve as a disincentive to transit patronage. It is difficult to generalize about the effects of compressed workweeks on transit costs, ridership, and quality of service. The impacts will depend on the unique nature of the compressed workweek scheme implemented and on the unique characteristics of the transit system in the affected corridors. Careful planning is essential to avoid undesirable impacts.

On balance, compressed workweeks tend to have beneficial impacts on transportation. Peak-period work trips and work-trip VMT can be significantly reduced and peak-period congestion relieved if reasonably significant penetration of the work force is achieved. In "normal" times, nonwork travel on days off may negate the impacts on reduction of overall VMT and energy conservation. However, in the event of a severe energy shortfall, compressed workweeks offer a significant way to reduce essential travel; in such a situation nonwork travel would also tend to decrease.

CHAPTER FIVE

# IMPLEMENTATION GUIDELINES

The general approach to and key factors influencing the implementation of an urban area alternative work schedule program is discussed in this chapter. For more detailed discussion, the reader is encouraged to consult the *Staggered Work Hours Manual* prepared by the Port Authority of New York and New Jersey (*17*), which presents an overall methodology for designing, implementing, and evaluating a staggered work hours program in an urban area. Although the Port Authority document focuses specifically on staggered work hours, its general approach is valid for programs encompassing all forms of alternative work schedules.

Two reports published by the American Management Associations provide further guidance on the implementation of compressed workweeks (*25*) and flexible work hours (*27*). These documents are of special value in understanding the problems and opportunities presented by alternative work schedules for different types of employers and employees.

## URBAN AREA NEEDS AND POLICIES

Before proceeding with any programmatic steps to encourage implementation of alternative work schedules in a specific urban area, the first consideration must be whether such a program is really needed in that particular area. Two issues should be considered:

- Is peak-period congestion a serious recurring problem in this area?
- Is the congestion clearly attributable to distinct, steep peaks in commuting schedules that could be modified by work schedule alterations?

Clearly, a program will receive little backing from either transportation policymakers or employers unless it is perceived as a vital element in the alleviation of serious peak-period congestion problems.

In some urban areas, transportation policy may be heavily slanted toward traditional means of expanding the capacity of the highway system. If congestion is not very severe, and if highway improvements are physically and financially feasible, then the need for a major alternative work schedule program may be small. More commonly, however, urban area and state transportation agencies, faced with escalating costs and tight budgets, have emerging policies that stress transportation system management programs, including actions aimed at restraining and reshaping travel demand, as essential complements to improvements in highway and transit facilities.

The advocates of government programs to encourage alternative work schedules must be sensitive to the transportation needs and policies of the particular urban area under consideration. If high-level support for a program is weak, it may be prudent to begin with small pilot projects for a small number of private or public sector employers who have an especially strong interest in alternative work schedules. Successful experience can then be used as a basis for a plan for continuing program growth.

## PROGRAM ORGANIZATION

A prerequisite to an effective program is the establishment of a viable program organization including: (a) assigning lead agency responsibility; (b) obtaining commitments for participative cooperation from other agencies and organizations; (c) appointing program manager and staff members; and (d) allocating a program budget.

### Lead Agency

In urban area programs implemented to date, metropolitan planning organizations (MPOs) have most often been assigned (or have assumed) lead responsibility. Often the taking of a leadership role by the MPO has been the result of a leadership vacuum, combined with the fact that an alternative work schedule program frequently crosses jurisdictional boundaries. At the risk of invalid generalization (because their characteristics are highly variable), MPOs seldom have a strong orientation to program or project implementation and operation, as their personnel and budgets are often stretched thin in meeting transportation planning, coordination, and documentation requirements. Even with these disadvantages, some MPOs can function effectively as the lead agency, especially if arrangements can be made for financial and technical support from state and local highway, traffic, and transit agencies.

A more desirable approach to program organization may be to assign to the MPO the role of coordinator—to have the MPO take the lead in gaining support from the various participating organizations and administering the coordination process. In this approach, an operating agency with broad powers and budgetary autonomy in transportation matters would be the lead agency for implementing the program. Whether this would be a state or city transportation agency, a regional transit authority, or some other body depends on the unique characteristics of each urban area.

There is a strong correlation between the organizational and staffing requirements of an alternative work schedule program and a ridesharing program. Both involve close and continuing interaction with employers as well as mass promotion and public information activities. Thus serious consideration should be given to assigning principal responsibility for both these programs with the same agency.

### Cooperation Between Private and Public Sectors

It is highly desirable to plan the program from the start as a coordinated team effort between the public and private sectors. Frequently, private organizations, such as Chambers of Commerce, trade associations, or selected large companies, can be brought into the program and given substantive roles in a joint program with the lead government agency.

There has been little involvement of labor leaders in the overall program planning and implementation of alternative work schedules. Organized labor frequently takes positions resistant to the alteration of work schedules, and management often is fearful of yielding any more of its prerogatives in managing internal operations. Because of the complexities of the traditional adversarial relationships between labor unions and management, there does not appear to be a single best approach to cooperative participation. In some urban areas with particularly strong labor unions, union participation at the areawide program policy level may be highly desirable. In other circumstances, however, it may be more beneficial for individual employers to decide on the most productive mechanism for coordination with labor unions. A breakdown in communication or cooperation between organized labor and management on work scheduling matters is almost certain to lessen significantly a program's chance for success.

### Program Manager

Another critical factor affecting the success of an alternative work schedule program is the selection of a program manager. It is difficut to set explicit criteria for selecting a program manager that will ensure success. A carpool evaluation report prepared for the Federal Highway Administration (*28*) provided the following guidelines for selecting a program manager, which should be equally applicable for the selection of an alternative work schedule program manager:

- Demonstrated capability in the implementation management of complex, interdisciplinary projects.
- Experience in dealing effectively with the public, in general, and with influential members of the private sector.
- Sufficient stature within the implementing organization to command a presence with top management officials and to be entrusted with adequate discretionary authority for flexible and efficient project management. In short, the ability to cut through red tape quickly, when necessary to get things done.
- Prior experience in dealing with the technical complexities of multimodal and multijurisdictional activities and a well developed network of personal interrelationships with professional peers in other public agencies whose cooperation or participation is needed.

The program manager should be supported by staff members skilled in marketing, public information, transportation planning, traffic operations analysis, and (ideally) personnel administration. In a small urban area project, or in a pilot program for a larger area, it may be necessary to embody all these skills in the project manager plus one professional staff member. In larger undertakings, full-time involvement of specialists in each of these disciplines may be appropriate.

Program costs will be heavily influenced by the size and character of the program staff. Costs of professional and supporting labor services typically will account for at least two-thirds of the total program budget.

As noted previously, alternative work scheduling and ridesharing programs have all the ingredients for an effective coordinated approach. A well-conceived joint program approach should result in budgetary savings as well as more effective performance.

## PROGRAM IMPLEMENTATION STEPS

Once the decision has been made to proceed with a coordinated program to encourage alternative work schedules, and program organization, staffing, and budgets have been committed, the following series of implementation steps are suggested:

1. Identify high-priority employment locations.
2. Obtain management support for feasibility studies.
3. Conduct work schedule and transportation surveys of employers.
4. Design work rescheduling plans for employers.
5. Obtain management decisions to implement.
6. Provide implementation assistance.
7. Evaluate impacts.
8. Refine and extend the program.

### Identify High-Priority Locations

Not all employment locations in an urban area will have demonstrated need for alternative work schedules as a means of relieving peak-period congestion. Moreover, for greater success in the long run, a staged incremental approach that builds progressively on successful experiences is viewed as a desirable strategy. An important step, therefore, is the identification of employment locations to be assigned high priority for implementation of modified work schedules. Criteria for implementation include:

- The size of a particular employment concentration (number of employees).
- The seriousness of congestion problems due to peaking.
- The potential willingness of employers to participate (especially if a few major employers account for a substantial share of total employees).

Most urban area CBDs are prime candidates because of the amount of employment contained therein and the severity of congestion. CBDs typically have a large number and diverse array of employers, which complicates implementation. Opportunities in non-CBD locations should not be overlooked. Although congestion may not be as severe or lengthy in the peak periods, there may be opportunities to cause a significant change in traffic demand patterns by implementation of alternative work schedules by a few major employers.

#### Obtain Management Support for Feasibility Studies

After high-priority locations are identified, the agency encouraging and coordinating work rescheduling must initiate a planning and design process with the cooperation and support of potential participants. It is essential to gain the support of top management to permit detailed feasibility studies of alternative work schedules.

This step is the first substantive direct involvement with employers. Considerable attention should be given to reaching top executives of each targeted organization. Meeting either individually or in groups with key management figures has been effective in obtaining initial cooperation. The Port Authority of New York and New Jersey, in its *Staggered Work Hours Manual* (*17*), stresses the need for a dual approach, which includes marketing contacts with individual organizations as well as a general promotion of the concept among private and public sector employers.

Suggested activities for promotion include: (a) enlisting the participation of business, government, and civic leaders as "spearheads" of a promotional campaign; (b) mass mailings of promotional materials; (c) mass media publicity; and (d) special promotional events. Professional expertise in advertising and public relations is needed to design and carry out an effective promotional program. Large organizations that agree to participate as major sponsors of alternative work schedule programs may be able to assist in this activity. It is vital to recognize from the outset that an effective program will require professional advertising and public relations skills on a continuing basis.

In gaining the commitment of cooperation from individual employers, it is especially important to have each organization assign a key headquarters staff person for the purpose of in-house coordination.

#### Conduct Work Schedule and Transportation Surveys of Employers

After obtaining the cooperation of individual employers, the next step is to conduct surveys of existing work schedules and transportation conditions at the employment sites. These surveys serve as the basis for specific work rescheduling recommendations.

In the *Staggered Work Hours Manual* (*17*), it is suggested that the data obtained from each employer include "the total number of employees at each site, the number of employees on each specified work schedule," as well as additional data on employee residential distribution and commuting modes of travel. It is important to recognize that "official" work hours and actual employee arrivals and departures do not necessarily coincide. Therefore it is useful to supplement employer questionnaire data with employee arrival counts by 15-min intervals. Measurements of the degree of congestion (e.g., traffic delay, queue lengths, transit overloading, etc.) at critical points in the network and at employment site entrances and exits are valuable both as design and marketing tools and as baseline data for subsequent evaluations.

#### Design Work Rescheduling Plans for Employers

If work rescheduling appears feasible and desirable, as determined by the preceding two steps, the next step is to proceed with the design of explicit work rescheduling recommendations. This must be a collaborative procedure, involving active participation of in-house coordinators who understand the internal operational constraints of their organizations.

The essence of the design process is systematically finding answers to the following three questions (*17*):

- How much of a work schedule change is needed to shift people out of the peak hour?
- Which work starting and quitting times are currently least utilized?
- What kind of work schedule changes would both employers and employees (and labor unions if involved) be willing (and able) to make?

The plan should first determine which type of work rescheduling (i.e., staggered hours, some form of flexible hours, or one of the compressed workweek alternatives) is best suited to an individual organization and then work out the specific rescheduling details. In some larger organizations, it may be appropriate for individual departments, which have different operational needs and constraints, to pursue differing forms of work rescheduling. For example, the production, administration, and customer service units of a given organization may have radically different work schedule requirements. The key, both across and within organizations, is to tailor the available alternatives to the varying needs, desires, and constraints; no single, simple plan can provide a universal solution.

#### Obtain Management Decisions to Implement Work Rescheduling

Specific recommendations to modify work schedules should then be taken to the top management of each organization for a firm go/no-go decision to implement. A positive decision by management should be accompanied by immediate assignment of the internal staff and other resources needed to execute the revisions in work schedules. Some employers may choose a "wait and see" posture at this stage, preferring to let other organizations take the initiative and the initial "risks." In such cases, a plan and schedule for periodic follow-up meetings should be devised to aid in obtaining a commitment from these employers.

Many organizations may prefer to implement a pilot program within selected units and reserve judgment on larger-scale implementation; the approach to a program must accommodate such internal decisions on implementation. The coordinating agency must be aware from the beginning that implementation is an evolutionary process, which involves much more than just a simple, single decision.

#### Provide Implementation Assistance

Each organization will then proceed with its own internal steps to execute a changeover in work schedules. The coordinating agency can assist in many ways, especially by the provision of an implementation support package consisting of guidelines, model employee communications packages (posters, fliers, memos, slide shows, etc.), explanations of alternative timekeeping systems, and internal evaluation feedback mechanisms. The goal is to make implementation easier, less expensive, and more efficient for the employer by providing a prepackaged set of tools instead of having each organization create its own package. In this regard, technical assistance to support work rescheduling is quite similar to assisting employers with ridesharing and transit encouragement programs. Thus the effectiveness of the coordinating agency may be significantly enhanced if ridesharing/transit activities and work rescheduling assistance are fully integrated.

#### Evaluate Impacts

After the first major phase of implementation has been achieved, systematic efforts to measure and evaluate program impacts should be made by the participating employers and the coordinating agency. The evaluations by employers can be expedited and made more valuable if the coordinating agency provides some standardization of evaluation survey tools. The impacts on transportation are the primary responsibility of the coordinating agency (or their designated transportation research group or consultant). The evaluation of the impacts of work hours rescheduling on transportation should, to the greatest extent possible, include all the aspects discussed in Chapter 4, including changes in:

- Time distributions of automobile and transit traffic demand.
- Quality of traffic and transit service (travel time, delay, crowding).
- Shifts in choice of commuting mode (driving alone, ridesharing, or transit).
- Employee perceptions and attitudes about the impacts on commuter travel.

Objective evaluation data are essential in determining the worthiness of a work rescheduling program and in refining approaches to program continuation and expansion.

#### Refine and Extend the Program

As has been discussed, the implementation of a work rescheduling program in an urban area requires a staged incremental approach. After each stage, the technical procedures and processes used in the program can be refined to encourage and assist employers. The program can be expanded by both extension to new employment locations and recruitment of additional participating organizations at the same location.

### LAWS AFFECTING ALTERNATIVE WORK SCHEDULES

There are numerous federal laws concerning working hours and overtime pay requirements that had (until 1978) a constraining effect on the use of flexible hours and compressed workweek schedules. These laws apply specifically to federal employees, employees of U.S. government contractors under certain conditions, and those engaged in interstate commerce.

Brief descriptions of relevant statutes, excerpted from Nollen and Martin (*27*), are presented below.

> 1. *The Walsh-Healy Public Contracts Act* (41 U.S.C. 35) sets basic labor standards for employees working on U.S. Government contracts to manufacture or furnish more than $10,000 worth of goods. Its overtime provisions require payment at time-and-a-half for hours worked in excess of forty per week or eight per day. The latter provision may be troublesome for users of flexitime and compressed workweeks.
>
> 2. *The Contract Work Hours and Safety Standards Act* (40 U.S.C. 328) applies to U.S. Government construction contracts exceeding $2,000, service contracts exceeding $2,500, and supply contracts exceeding $2,500 but less than $10,000. It, too, specifies payment at time-and-a-half after eight hours per day.
>
> 3. The amended *Fair Labor Standards Act of 1938* (as amended by P.L. 93-259, April 18, 1974), covers all employees in interstate commerce and public administration. It requires payment of overtime at time-and-a-half after 40 hours per week. There are some statutory exemptions from overtime, however—for example, farm workers, railroad and airline workers, and interstate truck drivers.
>
> 4. *The Federal Pay Act* (U.S. Code, Title 5) establishes a basic 40-hour workweek for full-time U.S. Government employees and provides payment at time-and-a-half for hours worked in excess of eight per day. Unless an agency would be seriously handicapped in carrying out its function or costs would be substantially increased, tours of duty must be scheduled not less than one week in advance—and, whenever possible, on five consecutive days of equal length Monday through Friday. Breaks of more than one hour may not be scheduled on a basic workday. These provisions limit the use of flexitime and preclude the use of compressed workweeks.

The following is another relevant statute, as described by Mussel (29):

> *The Federal Employees Flexible and Compressed Work Schedules Act of 1978* (P.L. 95-390). This law authorized Federal agencies to experiment over a period of three years with alternatives to the standard work week.

It suspends certain overtime and premium pay provisions of prior statutes to permit experimentation with flexible and compressed work schedules for Federal employees. The Office of Personnel Management is required to evaluate the effects of the work hours experiment and report findings and recommendations to Congress in 1982. Currently, over 100,000 Federal employees are engaged in the alternative work schedules experiments.

## ACCEPTANCE BY EMPLOYEES, MANAGEMENT, AND UNION OFFICIALS

In general, employees have had positive reactions to alternative work schedules—especially to flexible work hours. Management has been a positive force in that employers have, in most cases, taken the initiative for implementing alternative schedules. In many circumstances, however, management has been wary of problems that arise out of changing "standard" work schedules. Labor unions have often taken a negative or resistant position to alternative work schedules and have been strongly opposed to compressed workweeks.

### Employees

There are many reasons why employees find alternative work schedules attractive. Included among the reasons most often cited by employees are the following:

- Greater dignity and autonomy in the work place.
- Opportunity to integrate the scheduling of work and home responsibilities more smoothly.
- Ability to adapt commuting modes and schedules to more easily arrange ridesharing, for example, or to *avoid the most congested traffic periods.*
- Greater flexibility in scheduling necessary or desirable nonwork activities (e.g., medical appointments, shopping, pursuit of hobbies, continuing education, community affairs, etc.).
- Substantial minimization of the problems of and penalties for tardiness (except for being late or absent during core hours).

The most obvious benefit of compressed workweeks is the extra day off, which is often viewed as an opportunity to expand recreational or personal development interests. This effect is viewed as less beneficial by employees if the compressed workweek scheme involves rotation of days off throughout the week (instead of having the same day off each week). Employees also have concerns about problems related to longer working days, such as fatigue, commuting problems (e.g., mismatch with transit schedules or ridesharing arrangements), and disruption of family responsibilities.

### Management

As has been noted, the impetus for modifying work schedules has come largely from employers. Organizations in Europe, in particular, have taken a strong role in adopting flexible work schedules as a way to improve both the quality of work life and worker productivity. Employers in the United States have not been as quick to adopt alternative work schedules; however, there was a rapid rate of increase in the use of these schedules in the 1970s.

Nollen and Martin (*27*) report that management cites employee welfare as among the most important motivations for implementing flexible work schedules. They list the following reasons (in roughly descending order of importance) for using flexible hours:

- To improve employee morale, satisfaction, motivation, attitudes.
- To increase employee freedom of choice, flexibility; accommodate their other responsibilities; improve the quality of life both on and off the job; provide equity between professional and other employees; comply with employees who wanted it.
- To reduce absenteeism, personal time off, sick leave, tardiness, long breaks, and turnover.
- To increase productivity and efficiency; facilitate production scheduling.
- To improve services to customers; stay open more hours; increase telephone contact across time zones.

By no means are employers universally positive about the benefits of flexible work hours. The Nollen and Martin (*27*) surveys of management uncovered the following problems encountered or concerns expressed:

- Management or supervision problems, scheduling more difficult.
- Scheduling more difficult, supervisors work longer, have less flexibility.
- Supervisory resistance, fear of loss of control.
- Coverage—too few workers at some places at some times.
- Abuse by workers—cheating on time worked, failure to work in absence of supervisor.
- Timekeeping—employees resent timekeeping device or manual recording difficult.
- Flexitime model unsuited—core time too short or too long, lunch periods too flexible.
- Communications, coordination problems.
- (Unfair to some) excluded employees.
- Carpools disrupted.

In regard to compressed workweek schedules, management cites advantages similar to those mentioned for flexible hours: improved morale, reduced absenteeism and tardiness, easier recruiting, reduced turnover, etc. In some manufacturing businesses, substantial increases in productivity have been gained by reducing the number of process start-ups and shutdowns relative to the number of production hours. Advantages in scheduling are also often realized in around-the-clock operations such as police, fire, hospitals, data processing, and the like.

Two principal concerns of management with compressed workweeks are significant: (a) the fear of increased worker fatigue and associated loss of productivity and, possibly, of job safety; and (b) difficulty in implementation because of overtime laws and/or union work rules.

### Labor Union Officials

Although workers are generally positive about alternative work schedules, their enthusiasm is definitely not shared by labor union officials. Owen (*30*) states: "As a striking example, during recent hearings on a bill to permit widespread experimentation with flexible hours systems for federal employees, the principal opposing witness . . . was the president of the American Federation of Government Employees. . . ." Nollen and Martin (*27*) identify several reasons for resistance by unions to staggered and flexible work scheduling:

- Arbitrary manner in which the schedules will be set.
- Reduced opportunity to earn overtime pay.
- Undercutting of shift differentials and weekend premiums.
- Unfair methods for distributing (or not distributing) productivity gains.
- Equity in granting compensation for personal "necessity" absences during the day.
- Problems with clearing and setting times for union meetings.
- Unacceptable methods of timekeeping.

Many of these same reasons are cited by unions in opposition to compressed workweeks. The principal objection of labor unions to compressed workweeks concerns the lengthening of the workday without overtime pay and at the risk of fatigue and occupational safety. Unions feel that the 8-hr day is one of their biggest historic achievements and view the compressed workweek as a direct attack on that hard-won victory.

Union opposition to compressed workweeks on the basis of occupational safety was summarized by Rudolph Osward, an AFL-CIO staff economist (*31*):

> Probably more important than the economies of the situation is that the 10-hour day will multiply, rather than simply add to, the number and magnitude of work place-related safety and health problems. Prolonged, unalleviated exposure of workers to hazardous substances, adverse temperature, limited motion, noise and artificial light, leads to increased fatigue and increased levels of toxic substances in the body. As fatigue and exposure levels increase, the ability to function safely on the job without permanent impairment of health decreases.

This statement illustrates the intensity of the feelings of some labor union officials concerning altered work schedules. However, some of the union resistance may stem in part from unions often having been left out of the planning of alternatives. As Owen (*30*) points out:

> Negative union response . . . will more easily develop if the employer introduces the system without involving the union in its design and implementation. Close labor-management cooperation cannot only help to head off a union suspicion that flextime is purely a management-oriented policy but also assure prompt resolution of some specific problems of the union organization under the new system. . . . In addition, labor representatives can also bring to light, and help to resolve amicably, specific problems that might otherwise lead to conflict.

In summary, implementation of alternative work schedules is not always easy. Agencies involved in areawide coordination and encouragement of alternative schedules must recognize that organizations must be treated individually. No single approach to work rescheduling is universally the best. Early involvement of top management, labor officials, and other spokespersons for employees is essential to avoid and minimize problems in implementation.

CHAPTER SIX

# CONCLUSIONS AND RECOMMENDATIONS

## APPROACHES TO THE PEAK-PERIOD TRANSPORTATION PROBLEM

There is a growing consensus that a balanced approach to transportation system management is needed in which greater emphasis is devoted to making more efficient and economic use of existing highway and transit facilities. A key feature of this approach is the notion that travel demand need not be taken as a given, but can and desirably should, to some degree, be managed. A significant factor in this approach to transportation system management is changing the time distribution of commuter travel demand in order to alleviate peak-period congestion.

The two principal thrusts of alternative work schedules are: (a) to flatten the daily morning and afternoon travel demand peaks by shifting more commuters to the "shoulders" of the peak where traffic concentrations are lower; and (b) to reduce overall demand for commuter travel by introducing compressed workweeks, which reduce the number of days on which employees must travel to work. Compressed workweeks also tend to flatten the commuting peak on any given day because of the lengthened workday and correspondingly earlier starting times and later quitting times of participants.

The majority of employees have work schedules that are imposed by their employers instead of freely chosen. Hence, employers must bear a large share of the responsibility of implementing a program of alternative work schedules. Government can play an important role, however, as a planner, coordinator, and technical supporter in encouraging and facilitating work rescheduling.

In the past, considerable use has been made of staggered work hours programs in which regular starting and quitting times are assigned by the employer—with little or no choice by the employee. Most employment zones in an urban area will exhibit some degree of work hour staggering (if not within individual organizations, then among organizations).

The use of flexible work hours has been increasing in the United States, growing from practically no participation in such programs in 1970 to participation of 12 percent or more of all employees in the late 1970s. A wide variety of flexible work hours programs is practiced, which mainly differ with respect to the degree of daily and weekly scheduling flexibility left to the choice of the worker.

Interest in the possible use of compressed workweeks in the U.S. increased in the early 1970s, leveled or even declined in the mid-1970s, and was revived somewhat in the late 1970s due at least in part to energy concerns. Approximately 2 percent of the U.S. nonagricultural work force is currently participating in some form of compressed workweek schedule. Numerous forms of compressed workweek schedules are practiced, which vary with respect to number of workdays per week per individual, the number of hours worked per day, and the manner in which workers are assigned to different days of the week.

## TIME-OF-DAY DISTRIBUTIONS OF WORK AND TRAVEL

In one study (*11*), eight cities of widely varying size and type were found to have similar hourly distributions of travel demand. Although aggregate time distributions of travel are usually similar between cities, there are great differences among locations in a given city. Generally, the larger and more diverse an employment zone (subarea) within a city, the flatter the peak-period distribution of travel demand; the converse has also been noted. For example, many isolated employment zones that are dominated by a single employer exhibit very steep traffic peaks.

Morning peak periods tend to be steeper than afternoon peak periods because a higher percentage of travelers in the morning are commuters. Consequently, it is feasible to reduce morning peak congestion through rescheduling programs that shift traffic to the shoulders of the peak. The problem of afternoon peak-period congestion is more difficult to resolve because the afternoon peak-hour traffic is usually greater than that in the morning, and also the peak-period distribution is flatter (i.e., the afternoon shoulders are also higher).

Urban area mass transit systems experience peak-hour percentages that are much greater—sometimes by 2 to 3 times—than highway traffic peak-hour percentages. For example, on transit lines that primarily serve commuters traveling to and from major employment concentrations, such as the CBD, the morning and afternoon peak-hour volumes approximate one-third or more of the daily total directional passenger volumes. On an areawide basis, mass transit systems have peak-hour volumes from 15 to 20 percent of the daily total passenger volumes.

## IMPACTS ON TRANSPORTATION

Implementation of staggered and flexible work hours has a significant flattening impact on the time distribution of worker arrivals and departures. For example, in the Canadian variable work hours programs in Toronto and Ottawa, the peak 15-min arrivals and departures, as a percentage of peak-period totals, were approximately cut in half. The extent of the impact of variable work hours on worker arrivals and departures is heavily dependent on the character of work hours patterns in an organization or employment zone before program implementation.

When given a choice, workers usually shift to earlier schedules. However, the responses of individuals to the rescheduling of work hours are influenced by many variables such as workplace attitudes (e.g., supervisors often view the "early bird" favorably), parking availability, transit availability, and family responsibilities as well as by personal preference.

The impact of work rescheduling on the peak-period distribution of automobile and transit traffic is less dramatic than the impact on worker arrival and departure distributions. Impacts on automobile and transit traffic are weakened by the travel of commuters not participating in work rescheduling programs and by nonwork traffic in the network. Moreover, the impact on traffic and transit demand patterns becomes progressively more weakened as the distance from the employment location operating on variable work hours increases.

Peak-period transit demand distributions are usually affected more significantly by work rescheduling than are automobile traffic demands, because a higher percentage of transit riders are commuters.

Data from several empirical and theoretical studies (*2, 16, 17, 19, 20*) indicate that the effect of alternative work schedules on the reduction of travel time ranges from 2.5 to 8 min per trip for participants and from about 1 to 4 min per trip for all commuters on affected highways or transit lines.

Overcrowding on transit vehicles and at transit stations can be significantly alleviated by comprehensive work rescheduling programs, as proven in New York, Toronto, and Ottawa. As perceived by participants in alternative work schedules, reduction in overcrowding results in substantial improvements in the comfort and convenience of transit facilities.

Although quantitative data are sparse, it is hypothesized that reductions in travel time at transit stations, parking facilities, and elevators may contribute as much to the reduction in overall home-to-job travel time as does reduced line haul travel time.

The scarcity of data prevents the drawing of firm conclusions about the effects of alternative work schedules on mode choice. However, the following general conclusions have been drawn:

- Flexible work hours tend to have more positive than negative impacts on both transit ridership and private ridesharing.
- If not carefully implemented, staggered work hours may cause a reduction in transit use and ridesharing.
- Compressed workweeks can have a significant negative effect on ridesharing arrangements and could also reduce the use of transit if long working hours cause employees to commute during periods of poor availability of transit service. Compressed workweeks reduce overall transit patronage because the number of commuter trips per week or per pay period is reduced.

The beneficial effects of compressed workweeks on transportation include significant reductions in average daily peak-period work trips and work-trip VMT, as well as a flattening of the peak-period demand distribution. Subsequent reductions in commuter travel time and improvements in comfort and convenience are possible if significant participation of the work force is achieved. Extra travel on days off from work may negate the impacts on commuter VMT and energy conservation; however, in an energy crisis, nonwork travel would decrease.

## IMPLEMENTATION GUIDELINES

The evidence from previously implemented work rescheduling programs in both private industry and government indicates that measurable and worthwhile transportation benefits can be gained. Many organizations pursue alternative work schedules on their own initiative, most often for reasons unrelated to transportation. However, government agency involvement in the encouragement and coordination of work rescheduling and the provision of technical assistance to participating employers can expand, facilitate, and increase the effectiveness of these programs.

Not all urban areas are logical candidates for comprehensive, coordinated work rescheduling programs. An essential prerequisite is the existence of serious, recurring congestion that could be alleviated by shifting transportation demands to less congested or congestion-free periods.

If high-level commitments to a comprehensive work rescheduling program cannot be obtained from public officials and private-sector leaders, a successful program will be difficult to achieve. In such cases, a small-scale pilot program, possibly involving a major government agency office, may be the best first step.

Because there is a strong correlation between the organizational and functional requirements of a work rescheduling program and those of a ridesharing program, consideration should be given to assigning lead responsibility for both these programs to the same agency. Both programs require close and continuing interaction with participating employers and employees, as well as initiation of mass media promotion and public information activities.

In urban areas in which labor union membership is a significant factor, union participation in the planning and execution of a work rescheduling program is essential. In some urban areas, it may be desirable to obtain union participation at the *areawide* policy and coordination level. In other cases, it may be more appropriate to ask large individual employers to decide on the best way to involve union representation in their programs.

An areawide coordinated work rescheduling program requires a multidisciplined staff with such specialties as public information, marketing, and personnel administration, which may not be readily available in a traditional transportation agency. The use of such specialists, if only on a part-time or consulting basis, in addition to experts in transportation planning and operations, will contribute to the success of a program.

Implementation of a work rescheduling program should be directed to those urban area locations where subarea and access corridor congestion is severe and can be alleviated by alternative work schedules. Once such locations have been identified and priorities have been set, the approach to work rescheduling must be systematically planned in cooperation with employers, and must consider the unique characteristics of the site's transportation problems and the current and feasible alternative work schedules of the participating employers.

Systematic evaluation of the impacts of work rescheduling programs is important. Evaluation permits an objective assessment of program benefits relative to costs and helps to guide refinements in subsequent program efforts.

The chances for long-term success of a work rescheduling program are greatest if a staged incremental approach is used. Each successive step should be given priority based on needs and estimated impacts, and the effectiveness of technical and institutional procedures can be progressively strengthened based on earlier experience. A program should be instituted with the understanding that a period of several years will be necessary to obtain a full level of urban areawide implementation.

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