17. Change-of-Mode Parking: A State of the Art. Institute of Traffic Engineers, Arlington, Va., 1971.
18. Locating and Operating Bus Rapid Transit Park-and-Ride Lots: A Synthesis of Experience and Some Preliminary Planning Guidelines. Univ. of Washington, Seattle; Urban Mass Transportation Administration, Aug. 1973.
19. A Guide to Parking Systems Analysis. Final Report prepared by Peat, Marwick, Mitchell and Co., Washington, D. C.; Federal Highway Administration, Oct. 1972.
20. Parking Management Policies and Auto Control Zones. Metropolitan Washington Council of Governments, Washington, D.C., final rept.; Office of the Secretary, U.S. Department of Transportation, Feb. 1976.
21. U. R. Abdus-Samad. Change of Mode Parking Facilities. Purdue Univ., Lafayette, Ind., Feb. 1972.
22. D. L. Christiansen, D. S. Grady, and R. W. Holder. Park and Ride Facilities: Preliminary Planning Guidelines. Texas Transportation Institute, College Station, Rept. 205-2, 1975.
23. W. E. Robertson. National Parking Facility Study. National League of Cities, Washington, D.C., 1972.
24. P. C. Box. Criteria for Regulation on On-Street Parking and Curb Loading Zones. 10th Pan American Highway Congress, Montevideo, 1967.

MANAGING TRANSPORTATION DEMAND BY ALTERNATIVE WORK SCHEDULE TECHNIQUES

Carl S. Selinger
Port Authority of New York and New Jersey

The management of urban transportation demand involves a number of techniques to reduce congestion by altering peak demand patterns. This paper discusses several transportation system management elements and focuses on alternative work schedule techniques such as staggered and flexible work hours and the shortened workweek. Alternative work schedules are deemed to be the most promising approach to managing transportation demand since such techniques are usually highly cost effective, are popularly received, entail nontransportation societal benefits, and can be implemented quickly. The effectiveness and state of practice of various alternative work schedule techniques are discussed, and a recommended approach for studying, implementing, and evaluating such techniques is presented. Brief case studies are given of programs in urban areas.

A primary function of many urban transportation professionals is to determine the demand for transportation and then design and implement systems to serve that demand. The traditional procedure is to analyze the characteristics and quantity of the demand with respect to parameters such as peak-hour flow, trip purpose, directionality, and peaking and to provide a wide variety of facilities to handle the current and forecast demand. Since such facilities usually require high capital and are, in many cases, controversial, increasing emphasis in recent years has been placed on devising ways to alter the demand patterns themselves in order to operate existing systems more efficiently.

TECHNIQUES TO MANAGE DEMAND

A number of techniques are available to alter demand. They vary in their relative effectiveness and ease of implementation. The most common can be classified as alternative work schedules or pricing incentives or disincentives. Each of these is discussed in this paper. Some specific techniques in these areas are contained in the listing of transportation system management (TSM) actions to be considered (1):

Changes in work schedules, fare structures and automobile tolls to reduce peak period travel and to encourage off-peak use of transportation facilities and transit services, such as:
- Staggered Work Hours
- Flexible Work Hours
- Reduced transit fares for off-peak transit users
- Increased peak-hour commuter tolls on bridges and access routes to the city

Alternative Work Schedules

The use of alternative work schedules to manage urban transportation demand is given primary emphasis in this paper. Among the reasons for this are that work schedules are directly correlated with peak-period travel patterns and that a number of feasible concepts can be implemented quickly at little cost, are widely popular, and promise other nontransportation benefits. The fact that the movement away from the rigid 8-h workday is growing in this country behooves the transportation professional to understand and take the lead in directing the acceptance of such concepts so that they are dovetailed with the interests of efficient use of urban transportation systems. In later sections of this paper, a number of alternative work schedule concepts are discussed with respect to their impact on transportation systems and the status of their acceptance. Also discussed is a recommended approach for designing alternative work schedule concepts for an urban area, and a number of case studies of efforts throughout the country are presented.

Pricing Incentives or Disincentives

In a straightforward analogy to the economic theory of demand, the amount of transportation demand varies inversely as the price of the service. Thus, managing demand can be achieved by raising or lowering the price of the service provided. Incentives to use certain public transportation modes or to travel at less-congested off-peak times can take the form of reduced fares or tolls as appropriate. Conversely, disincentives of higher fares or tolls would reduce volumes of certain modes, for example automobiles during the congested peak hour.

Although it is difficult to generalize the wide area of pricing schemes, alternative work schedules are usually more effective than pricing in altering peak transportation demand for work trips. This is because there is a direct impact on such demand when the times that people commute to and from their jobs are changed. In addi-

tion, alternative work schedules are usually more popular and less controversial than pricing schemes and therefore are easier to implement. A common feature of the two concepts though is that the degree of impact on demand increases as the change in work schedule or price increases.

Examples of pricing incentives and disincentives are transit fare reductions, toll increases on many automobile facilities (typically at bridges at CBD cordons), transit fare adjustments for special groups or those riding at specific times of the day or days of the week, and restriction of automobile access to the CBD by charging a stiff entry fee.

ALTERNATIVE WORK SCHEDULE CONCEPTS AND THEIR IMPACT ON TRANSPORTATION DEMAND

Based on the standard 5-day, 40-h workweek in the United States, this section compares and analyzes three alternative work scheduling concepts: staggered work hours, flexible work hours, and shortened workweek (usually to 4 days). The discussion defines each of these concepts and views their impacts on urban transportation systems and their current status of acceptance.

Standard Workweek

The standard 5-day, 40-h workweek had evolved by the end of World War II for most of the western business community. The 8-h day may vary because of time given for lunch, which is an important factor since the actual length of the workday, which defines the commuting trip patterns, may extend over a range of 9 to 9 h. In addition, some shortening of the 8-h day may have been won as a fringe benefit. Further, the pattern of predominant starting and quitting times may vary from city to city, and informally staggered schedules exist to a degree among different industries and within some types of firms. Thus, a standard workday refers to a 5-day work schedule about 40 h long. The problem arises, of course, when there is such a great adherence to a single starting and quitting time that it results in severe transportation congestion.

Staggered Work Hours

Staggered work hours involves shifting fixed standard 5-day work schedules to earlier or later time periods without changing the length of the workday. Under staggered hours, employees must still be at work by a specified time and leave at a specified time. The aim of staggered hours is to spread work schedules to relieve transportation congestion and thereby make commuting to and from work more comfortable. On an individual organization level, staggered hours may be established to relieve elevator congestion, to expand the hours of business coverage, and to improve employee attitudes toward their work.

Staggered hours has a significant impact on reducing peak-period congestion on transportation systems and in elevator operations. It should be understood, however, that all three alternative scheduling concepts will, by their very nature of shifting people out of peak commuting times, lead to reducing peak transportation congestion if that congestion is principally caused by concentrated adherence to a 5-day schedule. Generally speaking, the congestion reduction is directly related to the absolute amount of participation, the degree to which the new schedules are spread, and the degree of peaking that existed with the old schedules.

Staggering work hours has been successful in relieving peak-period congestion on transportation systems in Manhattan, Newark, Philadelphia, Toronto, Madison (Wisconsin), and Riverside (California). Within 2 years after the staggered hours program in Lower Manhattan began, passenger counts showed a one-quarter reduction in the peak at three major downtown New York City subway stations and at the World Trade Center Terminal of the Port Authority Trans-Hudson (PATH) transit system. Two years later, in 1974, transportation crowding was also drastically reduced and peaks flattened in Midtown Manhattan at the Grand Central Station of the IRT Flushing Line subway. The amount of congestion reductions with staggered hours is predictable to a degree since the new work schedules are also fixed, and one can determine how many employees are on different schedules and identify their arrival and departure patterns.

Studies of elevator operations in three office buildings, also in Manhattan, showed staggered hours had a beneficial impact on operations. In particular, waiting times for employees were observed to be reduced substantially. An illustration of this service improvement was at one building where a maximum of 673 persons experienced delays in the elevator lobby on a typical weekday before staggered workhours compared with only 278 persons after a major tenant of the building participated in the program.

The degree of effectiveness of staggered hours in relieving elevator crowding depends on whether a company adopts several different schedules or, as in most cases, merely moves all of its 9 to 5 employees to a new single schedule, such as 8:30 a.m. to 4:30 p.m. Using several different staggered hours schedules is desirable if the organization can be persuaded to do so. Another factor determining the amount of congestion reduction on elevators is the spread of work schedules for all employers on a particular bank of elevators. These factors lead to reduced employee tardiness and increased morale and productivity.

Staggered work hours in a large urban area has had no discernible effect on mode use. If there is good public transit, one may be more inclined to continue using it and to travel in less congested time periods. However, the converse would occur if transit service is not satisfactory in time periods just outside the peak, and this therefore requires effecting service adjustments if necessary as part of a successful program. One saving grace here is the relatively small shift of work schedules required in many instances to achieve the congestion reduction desired on transportation systems. In Manhattan, for example, project staff request only a ½-h change, and this does not shift people too far in time away from peak transit services. In Newark, a 15-min change was recommended. There could be problems, however, if larger schedule changes are recommended.

Some thought that staggered hours would encourage some transit riders to switch to automobiles since they could travel after peak congestion periods. This has not been observed, however, and there are several reasons to suggest that it may not be of great concern. These include the generally longer congestion period occurring for highway facilities and other factors such as the cost of gas, the price and availability of parking, and the travel time on congested roads.

Flexible Work Hours

Flexible work hours, also known as gliding work hours, flextime, and plantime, is a relatively new concept in work-time management; it allows employees a degree of freedom in determining work schedules. Under

flexible hours, employees are permitted to set their own daily starting and quitting times within preestablished limits. They are generally required to be present at work during a fixed or core time and may choose their starting and quitting times in flexible time periods. Thus, they can vary the length of their total working day. An example of a typical flexible work-hour system might allow participating employees to arrive at work anytime between 8 and 9:30 a.m. and depart from work anytime between 4 and 5:30 p.m., with total work hours ranging from 5¾ to 8¾ h (excluding 45 min for lunch). Employees are required to be present during the core hours of 9:30 to 4:30 and must work the required number of weekly hours (36¼).

Several variations of flexible hours are being used by companies. One most often used is called "floating day," which is a bit more restrictive than flexible hours. Employees on a floating day may choose their starting time within a certain flexible period, and this starting time then determines the quitting time based on the length of the workday. For example, employees might have the option to come to work anytime between 7 and 10 a.m., but if they arrive at 8:15 a.m. they are required to work that day until at least 4:15 p.m. (assuming an 8-h workday).

Another variation is called "flexible hours plus four" under which employees can work the total weekly hours requirement in the first 4 days of the week and take the fifth day off. Other options of this include a longer accounting period allowing one to work longer hours in order to build up a reserve and take a day off during the same period. Another basic variation is to allow a flexible lunch period within the flexible day. Workers can then vary the time when they eat lunch as well as the total length of the lunch period. This possibility is often used to reduce cafeteria and elevator congestion at lunch time. In addition, employees may also take longer lunches to run errands or shorter lunch periods to allow them to leave work earlier.

Although staggered hours has proven ability to reduce congestion, it also appears to be able to relieve transportation peaking. This is because commuters, if given a choice, will generally choose to avoid the most congested travel times. In an experiment among staff of the Port Authority of New York and New Jersey, three-quarters of the participants said they adjusted their hours to avoid the most congested traveling periods. Since employees have this choice within limits on flexible hours, it does become, however, more difficult to predict the revised arrival and departure patterns or, indeed, to attempt to design flexible hour systems specifically to reduce congestion at certain spots. However, much insight has been gained from the Port Authority's flexible hours experiment as well as from the experiences of increasing numbers of companies adopting this concept.

The Port Authority experiment showed that arrival patterns on flexible hours on the whole were spread out, and new departure patterns led to reduced afternoon elevator congestion particularly on floors where large units had previously been on a single schedule. This points up another interesting factor: Organizations, like the Port Authority, that were already on staggered work hours usually lead in adopting the flexible system. The shift from staggered to flexible hours is easier to implement since few fixed-schedule organizations are amenable to a flexible hours system at the outset. Flexible hours generally has excellent potential for relieving transportation congestion caused by concentrated arrivals and departures. The concept allows employees to come and go during a broad time span, and that creates a more even flow on all systems. The benefit is usually more pronounced in the afternoon, for arrivals on a single starting time are observed to have a greater time spread than that of departures.

The effect that flexible work hours has on modal switching is also not fully known, although this was examined in the Port Authority's experiment. Given a great degree of schedule flexibility, almost all participants reported they used the same mode of travel as before. Again this must be understood in the context that, before flexible hours, their schedules were mostly staggered away from the height of peak travel periods. But few reported that they shifted from public transit to automobile or car pool, which might have been facilitated with flexible schedules. Some 6 percent did report that they changed mode, but further analysis of the responses to this question indicates that many of them may have meant a revised journey to work by transit rather than, for example, a modal switch from bus to automobile.

Flexible work hours can enhance the formation of car pools when this is the desirable policy and also allows workers to easily adapt to public transit schedules which are more convenient.

Shortened Workweek

The shortened workweek generally involves working the same number of hours but in fewer than 5 days, usually 4 days. The 4-day week in the United States is referred to as the "4-days—40 hours" or "4/40" week, although in some cases the total hours required are somewhat reduced. Under the 4-day week, the extra day off usually is the same for all or most employees, thus allowing the plant or office to close. In a small number of cases, portions of employees have different days off to enable full 5-day business operations.

Three variations of the shorter workweek concept seem to exist: (a) the compressed workweek that consists of the same number of hours worked in fewer and thus longer work days; (b) a reduced workweek that consists of a slight decrease in total weekly hours but still 4 longer days; and (c) a week in which the usual 7 or 8-h day is worked for 4 instead of 5 days. The latter is, understandably, not too popular with management. There seem to be two basic reasons for organizations establishing the new 4-day schedule. One is the attempt to accommodate to employees' life-styles by arranging for another full day of leisure with the understanding that an equal amount of work can be accomplished more efficiently under the new system. Another has been provided by the energy crisis in that a shorter workweek conserves energy. Opponents point out, however, that in colder parts of the nation extended work hours on each end of the regular workday require additional heat. In addition, many modern office buildings cannot shut off heat in parts of the building, and appreciable energy savings can result only if all the heat is completely turned off in the entire building. All tenant organizations in a given building would therefore have to cease operations on either a Monday or a Friday to create a 3-day weekend.

The 4-day week is generally implemented in an organization chiefly to increase morale or productivity or both, but it also has significant implications in reducing transportation congestion. The 4/40 or 4/38 workweek requires the employee to work 9 or 10 h a day, and thus the starting and quitting times are pushed beyond the normal traveling periods. For example, an 8 a.m. to 6 p.m. schedule allows employees to avoid the most crowded travel times and also serves to reduce peak congestion.

If widespread adoption of the 4-day week takes place, however, one long-range implication for peaking of

transportation facilities is that the bands of starting and quitting times for the longer workday would be much narrower. This might lead back to severe peaking in many urban areas, only at earlier and later times with little acceptable margins for change. These effects are especially contingent on whether one has a 3-day or a 4-day schedule and also whether the days off are staggered or whether, as is more common, all employees are off on Friday or Monday.

Depending on the way it is organized, the 4-day workweek may or may not ease any elevator congestion existing in a building. If a staggered day-off schedule is set up for employees on the 4-day week, it could relieve elevator congestion since there would be about 20 percent fewer people working on any given day. If everyone in the same elevator bank works the same 4 days, however, then elevators might still be congested around the nominally scheduled starting and quitting times.

The 4-day week has implications for modal use, although the extent is not known exactly. Where automobile commuting predominates there may be little impact, although car-pool arrangements would be nearly impossible among people mixed between 4-day and regular workweek schedules. In an urban area with heavy transit usage, people adopting the 4-day week would find significantly fewer and less convenient transit services available at the earlier morning and later evening start and quit times. There would then be a tendency to switch to the automobile because roads may be less crowded. A shift from transit may also occur because of reduced fare costs with two less work trips per week (unless a monthly commutation system is used).

Status of Alternative Work Schedules

It is clear that a certain degree of change is at hand for the standard 5-day, 40-h workweek. Alternative schedules are being increasingly used because of the pressures of traffic congestion, energy shortages, additional fringe benefits, and increased part-time employment. Transportation professionals must be aware of these trends since they have such impact on transportation system planning, design, and operation.

The first organized efforts to stagger work hours were made as early as the 1920s, and the attractiveness of the idea has grown in urban areas with greater need for improving public transportation services, higher employment densities, and longer journey-to-work trips. In New York City, for example, because of its high employment density, large working population, and geographical location of the central business district on an island, a number of attempts have been made to implement staggered hours. As early as 1926, the commissioner of the Department of Health established a committee with the aim of preventing "the transmission of respiratory infections which are so common where overcrowding exists."

Work-hour staggering also aroused considerable interest during World War II. The Transportation and Communications Departments of the U.S. Department of Commerce published two pamphlets on work-hour staggering in 1941 and 1942 and, although there are reports that staggered work-hour plans were introduced in a number of large cities, including Washington, D.C., these efforts appear not to have been documented to any large extent. After the war, work schedules generally reverted to prewar habits except for Washington, D.C., as discussed later.

In recent times, staggered hours is becoming more accepted as a low-cost and effective method of reducing congestion on transportation systems and is a suggested strategy in the package of transportation system management elements. In a 1974 international survey by the Port Authority of the state of the practice of staggered work hours, 16 percent of the 131 U.S. cities responding reported that they had used some form of staggered hours to relieve transportation congestion. A higher percentage of foreign cities, 30 percent of those responding, noted experience with staggered hours.

Flexible work hours is also receiving increasing attention and has been implemented by many U.S. companies. It is regarded primarily as an employee benefit to improve morale and reduce turnover, tardiness, and absenteeism. Many companies also use it to reduce congestion by their employees in traveling to and from work. Many of these benefits were realized when the flexible work-hour system was initiated in 1967 by the Messerschmidt Headquarters at Ottobrunn, West Germany. The new hours not only relieved traffic congestion but also had positive effects on employee morale. Flexible hours quickly became popular throughout West Germany, then in many other European countries, and more recently in Canada. This new concept is just beginning to be explored by U.S. companies and the federal government. Again, from the international survey, while only eight responding U.S. cities, or 10 percent, reported experience with flexible hours, 17 foreign cities, or 65 percent of the respondents, reported experience with flexible hour systems.

The status and acceptance of the shortened or 4-day workweek has become increasingly accepted in the United States since 1970, although with considerable controversy. The American Management Association (AMA) in 1972 reported between 700 and 1000 U.S. firms were using the 4-day week with most retaining the 40-h week. A recent newspaper article stated that about 10 000 concerns with a million employees are on some type of 4-day schedule. As noted in the AMA report, in most instances the idea was introduced by management of small manufacturing firms in order to provide a fringe benefit not found in larger competitors. Of the firms surveyed, 85 percent were in the manufacturing sector and the remainder predominantly in service and retail industries. Recently more and more white collar experiments have been made with the 4-day week in spite of the fact that serious questions have arisen regarding fatigue and long-term productivity under the 4-day week.

DESIGNING ALTERNATIVE WORK SCHEDULES FOR AN URBAN AREA

This section presents a framework for designing alternative work schedule programs and a number of brief case studies of North American cities.

Recommended Approach

Since a program to implement alternative work schedules to reduce urban transportation congestion usually involves voluntary participation, the program design is a critical factor in its ultimate success or failure. Unfortunately, however, there are no design procedures that can ensure a successful program.

The overall design strategy of a variable hours program should be to adjust work schedule patterns in such a way that transportation demand is smoothed. This results in more efficient operations, less congestion and delay, and higher use of equipment and facilities. Designing a program includes several basic steps: defining the problem clearly, identifying potential alternate work scheduling methods, evaluating each of these methods by predicting their effectiveness, and deciding on the basic method of approach and implementation. The following are some questions that must be answered.

1. What should be the overall approach of a staggered-hour program for a particular CBD? An answer involves examining available information on transportation, current employment, and work schedules and planning surveys to obtain any additional necessary information.
2. What objectives should be set, and what are the most effective options to be considered? Will the program be directed to a particular transportation mode, geographic location, or peak time (morning or evening) or the entire CBD itself? Which work schedule approaches will be practical and effective in the particular city?
3. How can one predict the effects of a particular work schedule program in a given city? How are the results to be evaluated, what level of participation should be attempted, and how can one anticipate the potential problems of each alternative?
4. How does one "sell" the work schedule program to employers? What strategies would be used? What benefits would be of enough incentive to adjust work schedules? What are the negative aspects to avoid?

Three approaches to designing an alternative work-hour program have been developed: A comprehensive plan and evaluation process that identifies the transportation problems and then estimates the effectiveness of alternative work schedules in alleviating them and two directed plans that are aimed at alleviating specific transportation problems. In the latter, the initial results guide the gradual evolution of the overall program.

The various survey and analysis techniques developed in this paper to identify transportation problems and to aid in the design of a staggered hours program are discussed below in more detail in conjunction with the comprehensive plan. These same methodologies can also be applied on a more limited basis if either of the directed plans are selected.

Comprehensive Plan

The following are the steps in a comprehensive plan for the design of a variable work-hours program.

1. Survey conditions on transportation modes. The first step is to determine the levels of service currently being provided on transportation modes serving the CBD. Where possible, existing data should be used to determine values of demand and service patterns and peaking characteristics, although it may be necessary to conduct some additional surveys.
2. Evaluate current levels of service on transportation modes. Once the surveys have been analyzed, current levels of service on various transportation modes should be reviewed. These include the levels of transit systems, congestion and flow rates on roadways, bus speeds, and conditions on pedestrian facilities. If current levels of service are unsatisfactory during short time durations or if projected service levels indicate future problems, then a feasibility study of alternative work schedule programs should be pursued.
3. Determine the expected need for additional transit facilities. The need for additional transit facilities should be determined. These include those facilities currently being planned or those indicated by deficiencies in the current or projected future levels of service. If new facilities are forecast, then variable hours should be investigated as a means to spread the demand in order to obviate the need for new facilities or to reduce their scope.
4. Conduct a work schedule survey within the CBD. The foundation of the design of a variable hours program is a survey of the starting and quitting times of employees within the CBD. This survey should include as many as possible of the organizations that generate substantial peak-period traffic.
5. Compare projected arrival and departure patterns to those observed on transportation modes. The projected arrival and departure patterns, based on the work schedule survey results, should be compared to demand patterns observed on transportation modes having unsatisfactory levels of service during parts of the peak period. The potential effectiveness of alternative work schedules to improve levels of service is based on (a) the degree of peaking in patterns of arrival to and departure from work, (b) the degree of correlation of these patterns to actual arrival and departure patterns observed on transportation modes, and (c) survey results or estimates of the proportion of journey-to-work trips on transit and roadway systems during peak periods (these are the only trips affected by work schedule adjustments).
6. Develop variable hours alternatives. Alternative work schedule proposals should be developed based on the results of organizational and employee attitude surveys toward changes in work schedules and on the projected impact of the various work-hour schemes in reducing peaking.
7. Project the potential impact of a variable hours program. The design of recommended variable hours alternatives should be based on their acceptability to employers and employees and on the potential impact in improving current or future levels of service. The methods to determine this impact are similar to those discussed in step 2. This procedure may be carried out for several sets of work schedule alternatives to determine which will result in the greatest benefits.
8. Implement the variable hours program. The program should be expeditiously implemented once the recommended approach has been chosen. This involves the broad-based support of business and civic groups and transportation agencies in an energetic promotional and selling effort. Follow-up attitudinal and transportation surveys should be conducted as participation increases, and the results should be compared to similar surveys conducted before the program started. The changes in arrival and departure patterns, transportation demand, crowding, and congestion should be compared to those predicted, and necessary modifications in the program should be made to achieve the benefits originally sought.

Directed Plans

Two directed plans for designing a variable work-hour program are aimed at specific transportation facilities or specific neighborhoods rather than at the entire central business district. The objective of either one is to reduce the time, cost, and effort required to design the program by concentrating efforts on specific transportation problems. A brief description of the two directed plans follows.

1. Physical facilities. The design of the variable hours program is directed or aimed at a specific congested transportation facility or mode rather than at an entire central business district.
2. Neighborhood or special group. The variable hours program evolves initially from a relatively small experiment in a specific neighborhood or industry and evolves on a step-by-step basis until the desired reduction in peak demand for transportation facilities is achieved.

Case Studies

The following are brief case studies of recent or ongoing efforts to adopt alternative work schedules in North American cities. Most encourage the use of only staggered work hours, but several also urge consideration of flexible work hours and label the overall concept as variable work hours.

Manhattan

On April 1, 1970, the Downtown-Lower Manhattan Association in cooperation with the Port Authority of New York and New Jersey initiated a staggered hours program to relieve the severe transportation congestion in the Lower Manhattan business district during the peak hours by persuading business and government to switch away from the predominant 9-to-5 work schedule. In 1972, the program was expanded to include Midtown Manhattan, where it is sponsored by the Midtown Task Force on Staggered Work Hours, a group comprising 26 civic and trade associations and public agencies.

Currently more than 220 000 men and women in more than 400 organizations are participating by staggering their work hours, mainly adopting an 8:30 a.m. to 4:30 p.m. schedule. All levels of government and transportation operators are actively supporting the project. Service or schedule improvements have been made by the metropolitan Transit Authority, PATH, ConRail (Erie-Lackawanna, Jersey Central, and Penn Central railroads), and Transport of New Jersey. Staggered work hours has reduced peaking in the three busiest Downtown Manhattan subway stations by 26 percent in the peak 10 min. Critical peaking at PATH's World Trade Center Terminal relieved about 25 percent in the peak 15 min between 5 and 5:15 p.m.; traffic increased in the more lightly traveled period from 4:30 to 4:45 p.m. by 57 percent. Elevator operations improved in buildings in which staggered hours are in effect.

The overall reaction to staggered hours was positive; attitude surveys indicate that about 85 percent of the men and women sampled had a favorable overall reaction to staggered hours and about 50 percent said their trips to and from work were improved under the new schedules. About 22 percent of the participants report increased effectiveness at work, and only 4 percent report a decrease. Supervisors generally reported an increase in punctuality.

The program in Manhattan continues to urge increased adoption of staggered work hours and to evaluate its impact on transportation systems. Since 1973, it has been aided by technical study funding from the Urban Mass Transportation Administration.

Newark, New Jersey

The staggered hours program began in Newark during the 1973 energy crisis to persuade public and private organizations to change from the predominant 8:30 to 4:30 work schedule. To date, a dozen organizations employing more than 1000 people have shifted their work hours.

During the winter of 1973, the Greater Newark Chamber of Commerce requested the Port Authority to commence a feasibility study of staggered hours in downtown Newark. A work schedule survey conducted in the spring of 1974 found that more than 40 percent of the organizations started work at 8:30 a.m. and quit at 4:30 p.m. and about 20 percent worked from 8 a.m. to 4 p.m.

Transportation surveys were conducted in the spring of 1975 by the city of Newark, Transport of New Jersey, and the Port Authority to determine peak-period transportation patterns on buses, the city subway, and automobiles. The results showed that transportation congestion was correlated with the 8:30 to 4:30 work hours. All companies were urged to shift at least 15 min earlier or later than those times.

Beginning in the spring of 1976, a dozen organizations implemented staggered work hours on an experimental basis, mainly shifting starting 15 min earlier. Several months after the implementation of the new schedules, a work-hours survey was conducted among four of the participating firms to determine the impact of staggered hours on employees. The conclusions in almost every case were positive; 75 percent of the participants expressed a favorable reaction to staggered work hours, and only about 11 percent expressed the desire to return to their old schedule. It was also found that 66 percent said their commuting trip was better than on the previous hours, and only 7 percent reported it was somewhat worse.

Philadelphia

In 1970, the Delaware Valley Regional Planning Commission (DVRPC) received funding from the U.S. Department of Transportation for a study that included a staggered work hours program to lessen the peak-hour congestion on center city transit facilities. Efforts to introduce staggered work hours to Philadelphia began in 1970 as several large Philadelphia firms, aroused by newspaper articles, adopted such plans on their own initiative. About the same time, the major downtown department stores changed their hours to open and close ½ h later than previously. This had dual effects of encouraging people to shop later (thereby making use of transportation facilities at a less critical time) and of having store employees make their trips home at a later, less critical time.

In 1971, a brochure entitled "How to Lose Wait During Rush Hour" was released as the first large effort to implement the concept. Thirty-five of the largest firms in Philadelphia were given this and other materials at a meeeting sponsored by the Greater Philadelphia Chamber of Commerce in June 1971. Efforts to increase the number of persons on staggered work hours continued with a reduced emphasis until late in the summer of 1972. At that time, DVRPC and the Greater Philadelphia Chamber of Commerce cooperated in applying to the federal government for funds for expanded staggered work hours efforts.

In the fall of 1972, a staggered work-hours committee was established under the auspices of the Chamber of Commerce to promote the concept. The first stage in the project was to determine present starting and quitting times within the CBD, the exact nature of the peaking problems, and the types of work-hour staggering that might alleviate them. In late 1972, the Chamber of Commerce conducted a survey of employers to determine numbers, locations, and hours of downtown employees. Other preparatory work included data collection and analysis, review of past efforts, and establishment of a master file of relevant material.

The group was joined in the winter of 1973 by an organization called Alliance of Business, Academe, and Commerce in the United States (ABACUS), which for a time provided valuable business contacts and other assistance. Early in 1973, breakfast meetings were held with top executives of the major banks and insurance companies in Philadelphia. The concept was presented to this group, and its cooperation and participation in the program were requested. Consulting teams were established to work with individual companies. Throughout the program strong efforts were made to obtain

media cooperation in publicizing the program and to alert the public to its benefits.

During and after the period of intense publicity and promotional efforts, surveys and direct contact were used to determine the type and extent of employer participation. Peak-hour loading at the transit stations was monitored to note effects on traffic patterns as a result of the staggered hours programs.

Approximately 160 firms were contacted during the course of the program. Efforts were concentrated on firms with more than 250 employees. Forty-seven firms are known to have participated in the program, involving 42 630 employees on either staggered, flexible, or 4-day work schedules. This level is two-thirds of the goal set by the Staggered Work Hours Committee.

Toronto

The Metropolitan Toronto Council approved the establishment of the Variable Work Hours Project on January 29, 1974, to encourage a wider adoption of variable work hours within Metropolitan Toronto in order to relieve peak-period congestion on the transportation system. The project focused on the downtown area containing about 260 000 employees, which is about one-quarter of Metropolitan Toronto's total employment. A steering committee comprising 15 senior representatives of business and government and a project staff were established to implement and coordinate the project. Each member of the Steering Committee represented one of the following sectors of the business community: banks, education, general insurance, government, hospitals, investments, life insurance, retail, transportation, trust companies, utilities, and communications; there were two members at large.

In May 1974, a report was issued indicating the degree of success attained in encouraging companies in downtown Toronto to adopt variable work hours. At that time a cursory assessment was made of the potential for change to variable work hours within the major industry groups that represent 121 000 employees. No information had been collected or contact made with the member-at-large industries, which represent 42 000 employees. Since February 1974, the project staff through the Steering Committee has worked with companies in downtown Toronto to encourage the adoption of variable work hours. Basically two types of programs were recommended: staggered and flexible hours.

During the months August to October 1974, an extensive survey was conducted among the 490 companies contacted as a result of the project to determine the change in work scheduling that had taken place to that time. Those 490 companies representing 163 000 employees or 63 percent of the 260 000 downtown workers were contacted through the Steering Committee, and 111 representing 68 000 employees have adopted variable work hours and an additional 66 companies representing 29 000 employees are considering variable work hours. At this writing, the project is no longer active.

Riverside, California

In recent years, traffic congestion in the central Riverside area has occurred daily during the morning and evening peak periods because of the 8 a.m. to 5 p.m. workday, causing thousands of people to go the same place at the same time.

A staggered work-hours project was proposed in April 1972 as a means to reduce the peak-period congestion. The city of Riverside and the California Department of Transportation agreed to participate cooperatively in this staggered work hours program. The city was to be the coordinating agency and the city traffic engineer the director. The freeway operations personnel of the department were to assist by preparing questionnaires, correspondence, and surveys and conducting before-and-after congestion and delay studies. The project was scheduled for implementation in April 1973.

Questionnaires requesting pertinent work schedule information were sent to businesses and governmental agencies in August 1972. Replies to questionnaires were received from more than 60 employers of 9500 people, 6300 of whom worked in the downtown area. Of these, 3450 people stated they would voluntarily change work hours if requested. In addition, Riverside City College indicated that it would be possible to stagger morning classes. There were approximately 2000 students and faculty with 8 a.m. classes.

The initial implementation effort was concentrated on the businesses and agencies whose personnel volunteered to cooperate. The survey responses revealed that 1850 of the voluntary group did not begin work or end work during the peak periods. Employers of the remaining 1600 persons were contacted and requested to stagger their schedules. Starting times were shifted mainly to 7:30, 7:45, and 8:15 a.m. The shift ending times were controlled by the starting time and length of lunch hour.

Approximately 900 employees actually changed hours on the April 2 target date. Since then another 300 people have changed, making the total 1200. Of these, 300 are from private businesses, 420 from city agencies, and 480 from county agencies. Riverside City College changed most 8 a.m. classes to 7:45 for the fall semester. As previously stated, this involved 2000 persons. There are an additional 2300 persons whose schedules could be adjusted, and further contact with these employers is warranted to obtain maximum participation in the program. Implementation of public agencies in the staggered work hours program is near maximum. At this writing, the program is inactive.

Madison, Wisconsin

Although the rush-hour traffic in Madison was not deemed critical when compared to that in major metropolitan areas, it was regarded as unsatisfactory particularly for trips at 4:30 p.m. Congestion is more severe during the afternoon peak than the morning peak because more people are making social, recreational, personal business, and shopping trips then.

Recognizing the need for reliable data of employee travel patterns to support the feasibility of a staggered work hour program, early in 1971 the state, county, city, and University of Wisconsin jointly agreed to cooperate in conducting a travel behavior survey of government employees. In 1972, they implemented a staggered hours program involving some 5000 governmental employees in Madison's central business district. Madison planned no initial involvement of the private sector in Wisconsin. Of 17 000 downtown employees, 5000 work for state, city, or county agencies and this group would initially be involved on a recommended work schedule of 7:30 a.m. to 4 p.m.

Chicago

During the fuel crisis in the winter of 1973-74, a consortium of Chicago-area business groups studied the possibility of using staggered working hours as a means to increase the use and productivity of existing transit plant and equipment. The Transit Carriers Coordinating Council (TCCC), the Chicago Association of Commerce

and Industry, the Chicago Central Area Committee, and the Greater North Michigan Avenue were members of the consortium.

TCCC instigated the study, since it was clear that any staggered work-hour plan would have a heavy impact on transit carriers. The main conclusion of its report was that, although staggering of work hours could be handled by the carriers, a large-scale program would cause problems. The most serious drawback to extending the rush hour was the conflict created between commuter trains and freight trains, many of which use the same tracks.

Washington, D.C.

Washington, D.C., has no formal staggered work-hours program, yet 200 000 employees, representing about half of the federal employment in the District of Columbia, are on staggered starting and quitting times. The staggering of hours began during World War II, when it was decided not to have all federal employees arriving and leaving Washington at the same time and thus clogging all the streetcars. The General Services Administration coordinates the staggered system used by the federal government and oversees the spreading of quitting times between 3:30 and 5:30 p.m.

Atlanta

The planning of Atlanta's staggered hours plan was completed in 1970 under the sponsorship of the State Highway Department of Georgia, the city of Atlanta, the countries of Fulton and DeKalb, and the Atlanta Chamber of Commerce. The plan was implemented by the Metropolitan Area Rapid Transit Authority in cooperation with UMTA as part of the Urban Corridor Demonstration Program.

The recommended staggered hours plan for Atlanta involved work-hour changes for employees of a major retail firm and three public agencies, affecting approximately 3000 in the private firm and 8000 in governmental agencies. Although the study criteria allowed as much as a 45-min earlier or later work shift, the optimum plan as recommended envisioned 30-min shifts for the four participants.

The plan called for one public agency to start and quit 30 min earlier, two public agencies to start and quit 30 min later, and the private firm to start 30 min later and quit 15 min later. This variation of work hours for the private firm corresponded to new store hours of opening at 10 a.m. and closing at 6 p.m. On a 15-min basis the plan would reduce peak traffic volumes at the CBD cordon about 5 percent in the morning peak period and almost 6 percent in the afternoon peak.

Unfortunately, the plan was never implemented because the public agencies resisted shifting to later hours. Further efforts to modify the work schedule recommendations were also unsuccessful.

SUMMARY

This paper outlines several TSM techniques to adjust demand patterns to reduce transportation congestion. The focus is on a number of alternative work schedule concepts as being more effective than pricing incentives or disincentives.

Although the potential effectiveness of alternative work hours has been known for a long time, some explanation is needed of the relatively few coordinated efforts that have been undertaken in major cities to date. Several of the case study cities showed a failure to achieve a successful program.

The following reasons (listed in no particular order) can be given:

1. Limited technical knowledge as to the planning, design, and implementation of a variable work hours program;
2. Little desire on the part of government and business institution to undertake, finance, or manage such a program;
3. A reticence, especially by government agencies, in undertaking the considerable "selling" effort to persuade voluntary participation in the program; and
4. Until recently, a limited impetus to seriously consider anything but capital-oriented transportation projects.

Fortunately, it appears that two trends will collectively make alternative work schedule programs more acceptable in urban transportation planning and engineering. The first trend involves the move toward and now the requirement of low-capital programs to solve transportation problems.

This second trend involves the changing work habits throughout the United States and similar change in other western countries. Whether spurred by nontransportation factors or by the several variable work-hour programs in existence, alternative work-hour schemes are increasing steadily. The challenge to the transportation professional is to take advantage of and even direct these trends to complement or enhance the efficient use of urban transportation systems. This is all the more important because some alternatives that employees might adopt could have an extremely unfavorable impact on urban transportation systems.

REFERENCE

1. Federal Register, Vol. 40, No. 181, Sept. 17, 1975, p. 42979.

ACTIONS TO REDUCE VEHICLE USE IN CONGESTED AREAS

John Crain, Larry Glazer, Tom Higgins, and David Koffman
Crain and Associates
Dale Ross
Daro Associates

Federal TSM guidelines are used as a basis for four broad groups of measures for reducing vehicle use in congested areas. Within each group, examples of specific measures now in use or planned for implementation are presented. These are classified according to their important opera-