

Estimating Users and Impacts of a Regional Alternative Work Schedule Program

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This paper presents the findings of a study that estimates (a) the number of firms in the Baltimore metropolitan area that might implement an alternative work schedule program and (b) the reduction of vehicle miles of travel, emission of automobile pollutants, and gasoline consumption that could occur if alternative work schedules were implemented on a large-scale basis in the Baltimore area. The assumptions used to estimate the market for new alternative work schedule users and potential impacts were based on the survey responses of 828 Baltimore area firms and the alternative work schedule experiences of other cities. Employer responses to the regional survey show that nearly 25 percent of the firms are not using alternative work schedules, but it would be possible for them to change their schedule. Based on these responses and the experiences of other areas that have implemented areawide alternative work schedule programs, an estimated 260 firms in the Baltimore metropolitan area that employ 100 or more people could implement a flextime, staggered work hours, or compressed workweek program. As many as 84 000 employees could be involved in these alternative work schedule programs. These employees might reduce the distance that they commute annually by 26 million miles. This, in turn, would reduce the amount of (a) hydrocarbon emissions by 36 Mg, (b) carbon monoxide emissions by 313 Mg, (c) nitrogen oxide emissions by 57 Mg, and (d) gasoline consumption by 1.2 million gal.

Commuters in the Baltimore metropolitan area face the effects of peak-period or rush-hour congestion twice a day, five days a week. Streets and highways are filled with bumper-to-bumper traffic. Buses are crowded beyond capacity. Elevators, corridors, and parking lots are overcrowded. Noise and noxious odors abound. A trip on the Jones Falls Expressway (I-83), the beltway (I-695), or a ride on a local bus during rush hour makes one wonder how the rush hour got its name. Alternative work schedules (AWS) offer potential solutions to some transportation problems related to congestion.

AWS

AWS are options that can be used by employers to change the traditional times when employees report to and leave from work. AWS options may change one or more of the following:

1. Starting time,
2. Quitting time,
3. Number of hours in a day, and
4. Number of days in a week.

The most popular AWS strategies are the compressed workweek (CWW), flexible work hours (FWH), and staggered work hours (SWH).

CWW

Under a CWW system, employees work longer days and shorter weeks. The following are the most widely used forms of CWW:

1. Four-day workweek, 10-h days;
2. Three-day workweek, 12-h days; and
3. Five-four-nine plan, 9-h days; employees work five days one week and four days the next week.

A one-year CWW experiment in the Denver area was recently completed. The project involved more than 7000 employees at 35 federal agencies. Key findings of the Denver experiment (1) were that peak period arrivals and departures were reduced by 25 percent.

Weekly household vehicle miles of travel (VMT) were reduced by 16 percent. Weekend automobile emissions were reduced by 28 percent, and nonwork VMT were also reduced. The study concluded that traffic flow in the central business district (CBD) could be improved if the CWW concept were extended to a larger number of CBD employers.

FWH

Flexible work hours (FWH), or flextime as it is often called, provides employees an opportunity to choose their work hours. The typical FWH system uses two types of time: coretime and flextime. Coretime is when all employees are required to be on the job. Flextime contains preestablished limits (e.g., 7:00 to 9:30 a.m. and 3:00 to 5:30 p.m.) from which employees can select their starting and quitting times.

A flextime experiment conducted at the Social Security Administration's Woodlawn office in Baltimore County (2) found that productivity improved by 21.6 percent. Overtime hours were reduced by 63 percent. The use of annual leave for short absences declined substantially, and 68 percent of employees liked their job better after the flextime experiment began. Social Security Administration management personnel were so happy with the success of the Woodlawn experiment that flextime has been extended to all of their other Baltimore area offices.

SWH

Under a SWH system the starting and stopping times of groups of employees within a firm or groups of firms within a given area are varied to avoid having the entire work force arrive and depart at the same time. The time intervals are fixed and determined by the employer.

One of the early SWH experiments was implemented in New York by the Downtown Lower Manhattan Association and the Port Authority of New York and New Jersey. This SWH program involved 220 000 employees at 400 firms. Some of the key findings of this project (3) were that travel demand was reduced by 26 percent during the peak 10-min period in the morning. Travel demand during the peak 15-min period in the evening was reduced by 25 percent. Eventually, the evening peak demand was flattened to the same level for approximately 45 min. About 22 percent of the work force reported an increase in job effectiveness. This experiment was so successful that it has become a national model for SWH implementation.

Key Results of Regional Employer Survey

Approximately 30 percent of the survey respondents are currently using some type of AWS. Nearly 25 percent of the firms reported that, although they are currently not using an AWS, it would be possible for them to change their current work schedule. The survey results seem to indicate that larger firms are more willing than smaller firms to change their work schedules.

According to the survey respondents, the peak period of arrivals in the morning extends from 7:00

to 9:00 a.m., and in the evening the peak period of departures extends from 3:30 to 5:00 p.m. The greatest number of arrivals during a 15-min interval in the morning occurs between 8:00 and 8:15 a.m. (Actual on the road peak-period traffic begins earlier and stops later than the peak arrival and departure times referenced in this report.) The evening peak-within-the-peak occurs between 4:00 and 4:15 p.m. Although recommendations for reducing peak travel demand at a particular location must by necessity be site specific, there appears to be a significant potential for flattening the morning peak.

Potential AWS Impacts

Based on the survey results and the experiences of other areas that have implemented areawide AWS programs, as many as 84 000 employees at 260 firms could become new AWS users. Also, as a result of increased opportunities to rideshare, VMT during peak commuting periods could be reduced by as much as 103 000 miles daily or nearly 26 million miles yearly.

The estimated VMT savings could also result annually in the following reductions:

1. 36 Mg of hydrocarbons,
2. 313 Mg of carbon monoxide,
3. 57 Mg of nitrogen oxides, and
4. 1.2 million gal of gasoline.

EMPLOYER SURVEY

A survey of 1785 employers was conducted to assess the potential for implementing AWS in the Baltimore metropolitan area. A primary objective of the survey was to investigate employer attitudes concerning AWS. The survey also sought to (a) assess the potential for implementing employer-based parking management practices and (b) identify general transportation concerns of the business community in the Baltimore area. In addition, the survey sought to identify employee starting and quitting times, employer attitudes toward various AWS strategies, and subareas or corridors where it might be useful to implement an AWS project.

Survey Methodology

Three inventories were used to select the firms that were surveyed:

1. COMPUTERIDE's list of major employers;
2. Mayor's Office of Manpower Resources' report, Industrial Parks of Metropolitan Baltimore; and
3. Regional Planning Council's master establishment file (MEF).

COMPUTERIDE, the regional ridesharing program, has compiled a list of 100 major employers for use in its outreach efforts. Each firm on the list has a minimum of 500 employees. A key contact person (often the president or highest executive officer) has been identified at each of these firms. A letter from the Regional Planning Council's executive director was sent to each of these businesses to request that the firm complete the questionnaire and return it within 10 days in a postage-paid envelope.

Since AWS can be implemented effectively at multiple-employer sites, major industrial parks in the Baltimore region were also surveyed. A major industrial park was defined as a site that (a) is listed in Industrial Parks of Metropolitan Baltimore, (b) is operational in 1978, and (c) contains

a minimum of 10 firms and 1000 employees.

Ten industrial parks were identified that met these criteria:

1. Sinclair Lane Industrial Park (Baltimore City),
2. Baltimore-Washington Science and Industry Center (Anne Arundel County),
3. Parkway Industrial Center (Anne Arundel County),
4. Chesapeake Park, Inc. (Baltimore County),
5. Hunt Valley Business Community (Baltimore County),
6. Meadows Business Park (Baltimore County),
7. Owings Mills Industrial Park (Baltimore County),
8. Security Industrial Park (Baltimore County),
9. Guilford Industrial Park (Howard County), and
10. Oakland Ridge Industrial Center (Howard County).

In addition, the state office complex at Preston and Eutaw Streets was surveyed as a multiple-employer site.

After the 10 industrial parks were selected, Stewart criss-cross directories were used to verify addresses for the survey's mailing. The telephone directory for state agencies was used to verify mailing addresses for agencies located in the Eutaw-Preston Streets office complex. A total of 575 questionnaires were sent to the 11 multiple-employer sites.

MEF was used to identify the final group of survey participants--firms that employ 20 or more persons. The MEF is a tool used by the Regional Planning Council to inventory and monitor the number, type, and location of businesses in the Baltimore metropolitan area. The MEF inventories all firms that have salaried employees and represents the universe of employers in the Baltimore metropolitan area.

The MEF was used to identify a stratified (by jurisdiction) random sample of employers in the Baltimore Region that have more than 20 employees. Twenty employees was established as a minimum category of firm size for two reasons. First, firms of this size account for more than 81 percent of the total regional work force (see table below). Second, alteration of the work schedules at firms with less than 20 employees would probably have a negligible impact on the regional transportation system (unless these firms are located at multiple-employer sites). Also, the smaller the firm, the less likely the chance that the employer would be willing to alter the work schedule.

Size	Firms		Employees	
	No.	Percent	No.	Percent
<20 Employees	30 875	82.3	166 379	18.8
>20 Employees	6 644	17.7	719 128	81.2
Total	37 519		885 507	

The next task was to determine how many of the 6644 firms that have 20 or more employees should receive questionnaires. By using the formula (4, p. 110-115)

$$n = [Z\sqrt{p^*(1-p^*)}/(\bar{p}-p^*)]^2 \tag{1}$$

where

- n = sample size,
- Z = 1.96 (equals confidence level of 95 percent),
- p* = 0.5, and
- $\bar{p} - p^*$ = 0.05 (equals sampling error of ± 5 percent),

it was found that 385 responses would produce survey results that could be accepted with 95 percent confidence that the sample error would be ±5 percent. The survey response rate was expected to be about 33 percent. This meant that questionnaires should be mailed to 1167 firms to ensure receiving at least 385 responses. After the 1167 firms had been selected, 57 firms were found to be duplicates from the earlier COMPUTERIDE and industrial park lists. These firms were striken from the random sample list and not replaced.

The sample was weighted in favor of the less-populous jurisdictions to ensure an adequate return from these outlying areas. For instance, 3.68 percent of the 6644 firms that have 20 or more employees are located in Harford County. If this actual percentage were used to determine the number of Harford County survey participants, only 43 firms would be selected. About 14 of these firms would be expected to return their questionnaires--not enough to be significant. The following table compares the jurisdictional composition of the actual employer population (those who have 20 or more employees) with the sample population.

Jurisdiction	Actual		Random Sample	
	No.	Percent	No.	Percent
Baltimore City	3039	45.74	330	28.26
Anne Arundel County	872	13.12	153	13.15
Baltimore County	1975	29.72	315	26.97
Carroll County	183	2.75	123	10.54
Harford County	245	3.68	123	10.54
Howard County	330	4.96	123	10.54
Total	6644		1167	

Survey Results

A total of 828 firms responded to the regional parking and alternative work schedule questionnaire. This represents a response rate of nearly 50 percent. The number of responses to the AWS questions (see Table 1) range from 493 (question 14) to 824 (question 1). As mentioned earlier, the responses to any question answered by 385 firms can be accepted with 95 percent confidence that such responses are representative (within 5 percent) of the

Table 1. Responses per question.

Question	No. of Responses	Response Rate (%)
1 ^a	824	99.6
2 ^a	819	99.0
3	822	99.4
3a	590	71.3
4	803	97.1
4a	164	19.8
5	200	24.2
6	739	89.3
6a	194	23.4
7	815	98.5
7a	274	33.1
8	751	90.8
8a	267	32.2
9	808	97.7
9a	78	9.4
9b	80	9.7
10	810	97.9
11	787	95.1
11a	221	26.7
12 ^a	495	59.8
13 ^a	798	96.5
13a ^a	516	62.4
13b ^a	611	73.9
14 ^a	493	59.6
15	159	19.2

^aQuestion relates to alternative work schedules.

entire population. The table below lists the number of responses per jurisdiction.

Jurisdiction	Responses	
	No.	Percent
Baltimore City	221	26.7
Anne Arundel County	96	11.6
Baltimore County	298	36.0
Carroll County	53	6.4
Harford County	53	6.4
Howard County	106	12.8
Total	827	-

The relatively large number of responses from Howard County was the result of a high response rate from two Howard County industrial parks: Guilford Industrial Park and Oakland Ridge Industrial Center.

The 828 survey respondents employ approximately 250 000 employees, nearly 30 percent of the regional work force. Twenty-seven percent of the survey respondents employ fewer than 20 people. Fifty-one percent of the respondents employ between 20 and 199 people; 15 percent have more than 200 and fewer than 1000 workers; and the remaining 7 percent have more than 1000 employees (see Table 2). Of the three firms that employ more than 10 000 people, two are governmental installations and one is a manufacturing concern.

Existing AWS Use and Easiest AWS Strategy to Implement

Nearly 30 percent of the survey respondents are currently using some type of AWS. The table below indicates that the largest percentage of firms that use AWS are located in Baltimore County and Anne Arundel County. Carroll County has the lowest percentage of AWS use.

Jurisdiction	Firms Use AWS		
	No	Yes	Total
Baltimore City	145	70	215
Anne Arundel County	61	29	90
Baltimore County	211	81	292
Carroll County	35	11	46
Harford County	38	13	51
Howard County	75	29	104
Total	565	233	798

When asked to identify the type of AWS that would be easiest for their firm to implement, 54 percent of the survey respondents chose SWH. The CWW was chosen as the easiest to implement by 21.5 percent. Table 3 compares the preferred alternative work option with the respondents' type of business. As would be expected, staggered hours is considered the easiest strategy to implement by manufacturing firms. Firms that engage in finance, insurance, and real estate (F.I.R.E.) consider staggered hours the most difficult strategy to implement. The CWW is considered the easiest strategy to implement by construction firms, but retail firms believe that the CWW would be the most difficult option to implement. FWH are considered the easiest strategy to implement by F.I.R.E. firms. The flexible hours strategy is most difficult to implement by firms engaged in manufacturing.

The easiest to implement (used as a proxy for preferred) AWS option responses were also examined in light of whether or not a firm was currently using any of the AWS options. Nearly two-thirds of the firms that are currently using some type of AWS think that staggered hours is the easiest AWS option

Table 2. Responses by employer size.

Jurisdiction	Responses										
	1-19 Employees		20-199 Employees		200-999 Employees		1000-9999 Employees		>10 000 Employees		Total
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	
Baltimore City	35	16	97	44.5	54	24.8	32	14.7	0		218
Anne Arundel County	18	19.4	54	58.1	16	17.2	5	5.3	0		93
Baltimore County	116	39.1	131	44.1	39	13.1	9	3	2	0.7	297
Carroll County	14	26.4	34	64.2	3	5.7	2	3.7	0		53
Harford County	6	11.5	40	76.9	4	7.6	1	2.0	1	2.0	52
Howard County	33	31.1	62	58.5	8	7.5	3	2.9	0		106
Total	222	27.1	418	51.0	124	15.1	52	6.3	3	0.5	819

Table 3. Easiest AWS strategy to implement by type of business.

Type of Business	Compressed Workweek		Staggered Work Hours		Flexible Work Hours		Total
	No.	Percent	No.	Percent	No.	Percent	
Retail	16	21.3	41	54.7	18	24.0	75
Government	14	28.0	23	46.0	13	26.0	50
Service	19	27.9	29	42.6	20	29.4	68
F.I.R.E.	7	20.0	11	31.4	17	48.6	35
Transportation and utilities	3	16.7	14	77.8	1	5.6	18
Construction	14	42.4	16	48.5	3	9.1	33
Manufacturing	25	23.4	73	68.2	9	8.4	107
Wholesale	7	18.9	20	54.1	10	27.0	37
Agriculture	0	0.0	0	0.0	0	0.0	0
Mining	1	100	0	0.0	0	0.0	1
Other	15	21.4	40	57.1	15	21.4	70
Total	121	24.5	267	54.0	106	21.5	494

to implement (see table below).

AWS Option	Preferred by AWS Users	
	No.	Percent
Compressed week	25	13.3
Staggered hours	123	65.7
Flexitime	39	21.0
Total	307	

Nonusers of AWS preferred staggered hours 1.5 times more than their second choice--CWW (see table below).

AWS Option	Preferred by Non-AWS Users	
	No.	Percent
Compressed week	96	31.3
Staggered hours	144	46.9
Flexitime	67	21.8
Total	307	

A comparison of the above tables reveals that the percentage of AWS users that prefer SWH is much higher than the percentage of non-AWS users who prefer staggered hours. The percentage of firms that prefer flexitime is about the same for both AWS users and nonusers. Non-AWS users; however, are more predisposed toward CWW than AWS users.

Reasons For Not Changing Schedules

Question 13b asked the survey respondents to choose those factors that would prevent them from changing work schedules at their firms. The most often selected factors were (a) decreased efficiency and productivity, (b) difficulties in coordination with

other firms, and (c) difficulties in coordination with suppliers.

The list of choices and responses is presented in Table 4. Some of the employer concerns about using AWS could be reduced by a marketing campaign that emphasizes the positive experiences of employers who have implemented an AWS program.

Employee Arrival and Departure Times

As mentioned earlier, a key objective of the survey was to identify when the surveyed work force reports to and leaves from work. The purpose of this objective is to determine the extent to which existing work schedules contribute to peak-period congestion.

Nearly 60 percent (493) of the survey respondents completed the requested information on work schedules. The responses are stratified by jurisdictions and subarea for both total day and peak period. The temporal characteristics described in the following pages are those of approximately 156 500 employees--

Table 4. Reasons why firms cannot change schedules.

Reason	No.	Percent
Difficulties in coordination with other firms	104	17.0
Difficulties in coordination with suppliers	78	12.8
Difficulties in coordination with customers	60	9.8
Difficulty and expense of conversion to another schedule	60	9.8
Decreased efficiency and productivity	120	19.6
Facilities idle for longer periods	19	3.1
Union resistance	42	6.9
Fatigue or negative effects on employees	31	5.1
Other	97	15.9
Total	611	

about 18 percent of the regional work force.

Seventy-one percent of the surveyed work force starts work between 7:00 and 9:00 a.m. Of the remaining work force, 1.2 percent report between 9:01 a.m. and 1:59 p.m., 15.5 percent report between 2:00 and 4:49 p.m., 8.3 percent report between 5:00 p.m. and midnight, and 4.0 percent report between 12:01 and 6:59 a.m. These arrival frequencies are depicted in Figure 1.

Sixty-seven percent of arrivals during the 2-h morning peak period and 47 percent of all arrivals occur between 8:00 and 9:00 a.m. Thirty-three percent of the peak-period arrivals occur between 7:00 and 7:59 a.m. The greatest number of arrivals during a 15-min period occurs between 8:00 and 8:15 a.m., when 34.3 percent of peak-hour arrivals and 24 percent of all arrivals take place. Only 2.6 percent of peak-period arrivals occur between 8:46 and 9:00 a.m. The nine-to-five schedule is clearly not the predominant shift among the survey respondents. Figure 2 depicts the morning peak-period arrivals.

Approximately 65 percent of the surveyed work force depart from work between 3:30 and 5:00 p.m. The remainder of the work force leaves between 5:01 and 6:30 p.m. (1.8 percent), 6:31 p.m. and midnight (13.9 percent), 12:01 a.m. and 2:59 p.m. (12.7 percent), and 3:00 and 3:29 p.m. (6.4 percent). The work force departure frequencies are found in Figure 3.

Approximately 70 percent of departures during the 1.5-h evening peak period and 34 percent of all

departures occur between 3:30 and 4:30 p.m. Thirty percent of the evening peak-period departures occur between 4:31 and 5:30 p.m. According to the survey results, the greatest number of employee departures during a 15-min period occur between 4:00 and 4:15 p.m., when 29.2 percent of peak-hour departures and 20 percent of all departures take place. Only 2.2 percent of peak-period departures occur between 5:01 and 5:30 p.m., and only 3.3 percent of peak-period departures take place between 4:31 and 4:45 p.m. Figure 4 depicts the peak-period departures in the evening.

A comparison of Figures 2 and 4 reveals the following information:

1. The evening peak period lasts for 1.5 h (3:30-5:00 p.m.); however, the morning peak period lasts for 2 h (7:00-9:00 a.m.);
2. A large shoulder exists at the end of both peak periods and at the beginning of the morning peak period;
3. The peak 30-min interval in the evening occurs between 4:30 and 5:00 p.m., when 34.2 percent of all employees leave work; and
4. A significant number of employees (approximately 24 300) have to report to work during the evening peak period.

The reported starting and stopping times for a jurisdiction or subarea often varied significantly from the regional averages. For example, although

Figure 1. Frequency of employee arrival times.

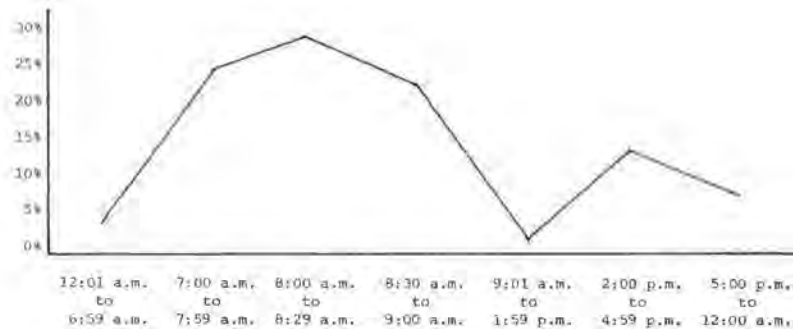


Figure 2. Morning peak-period arrival times.

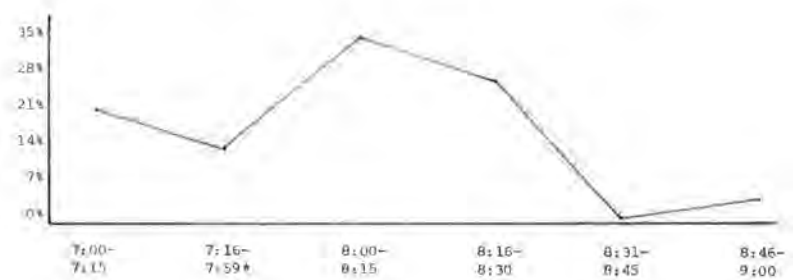


Figure 3. Frequency of employee departure times.

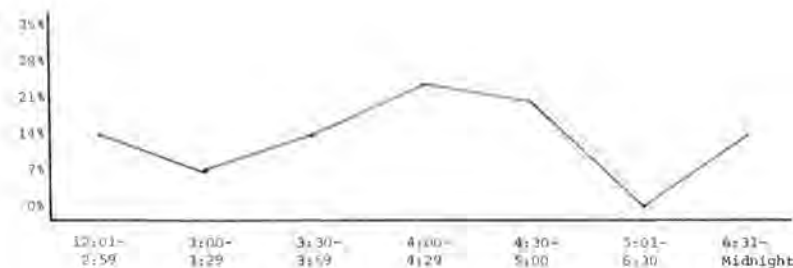


Figure 4. Evening peak-period departure times.

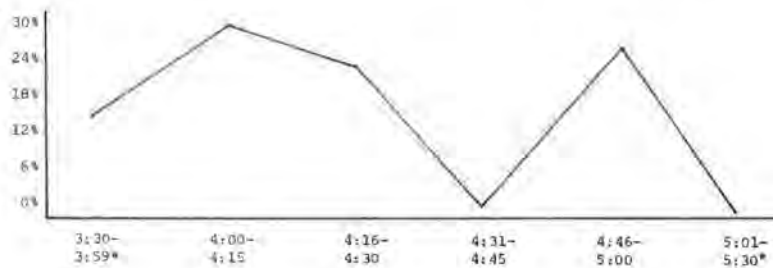


Table 5. Comparison of jurisdictional arrival and departure times.

Time	Baltimore City (%)	Anne Arundel County (%)	Baltimore County (%)	Carroll County (%)	Harford County (%)	Howard County (%)
Arrival						
12:01-6:59 a.m.	6.9	1.8	2.0	2.2	5.3	0.9
7:00-7:59 a.m.	20.5	23.9	24.9	17.0	24.8	38.3
8:00-8:29 a.m.	23.2	23.9	26.1	39.6	49.2	8.3
8:30-9:00 a.m.	23.6	31.6	15.6	10.2	10.1	39.9
9:01 a.m.-1:59 p.m.	1.8	0.7	0.7	1.0	1.0	1.4
2:00-4:59 p.m.	15.9	13.1	18.3	19.7	6.9	9.0
5:00 p.m.-midnight	8.1	5.0	12.4	10.3	2.6	2.2
Departure						
12:01 a.m.-2:59 p.m.	17.2	5.5	12.9	12.6	8.5	4.2
3:00-3:29 p.m.	6.9	6.8	6.2	1.6	16.5	2.4
3:30-3:59 p.m.	13.2	11.8	5.0	14.8	8.3	26.6
4:00-4:29 p.m.	9.6	19.7	35.9	27.4	10.4	9.9
4:30-4:59 p.m.	22.9	13.8	12.0	20.5	40.7	6.8
5:00-5:30 p.m.	18.6	28.4	8.8	3.6	8.7	41.0
5:31-6:30 p.m.	0.1	0.1	0.3	0.4	0.1	1.6
6:31 p.m.-midnight	11.5	13.9	18.9	19.0	6.7	7.6

Table 6. Ability to implement AWS by employer size.

No. of Employees	No		Yes		Total
	No.	Percent	No.	Percent	
1-19	117	76	37	24	154
20-199	217	82.2	47	17.8	264
200-999	44	58.6	29	41.4	70
1000-9999	7	46.7	8	53.3	15
10 000	0		0		0
Total	392	75.9	121	24.1	503

regionally 4 percent of all employees started work between 12:01 and 6:59 a.m., less than 1 percent started during this time period in Howard County and nearly 7 percent started work during this time period in Baltimore City (see Table 5). In the region, between 7:00 and 7:59 a.m., 24 percent started work; however, nearly 40 percent of the Howard County work force started work during this time period. Between 8:00 and 8:29 a.m., 25 percent started work; about 50 percent of the Harford County work force started during this period, as opposed to only 8 percent in Howard County.

Regionally, 20 percent of the work force leaves work between 4:00 and 4:29 p.m. Thirty-six percent of employees in Baltimore County leave work during this period as opposed to 10 percent of employees in Baltimore City. Between 5:00 and 5:30 p.m., 18 percent leave work; however, 41 percent of the Howard County and 4 percent of the Carroll County work force leave during this time period. Between 12:01 a.m. and 2:59 p.m., 13 percent leave work; but only 4 and 5.5 percent leave during this time period in Howard and Anne Arundel Counties, respectively. Between 4:30 and 5:00 p.m., 34 percent leave work; however, nearly 60 percent of the Metrocenter employees leave during this time period. Nearly 12 percent of all employees in the region leave work

between 3:30 and 3:59 p.m.; only 2.4 percent of Towson area employees leave work during this time.

Potential AWS Use

Of the firms that do not currently use AWS, nearly 25 percent can change their shift times (see table below).

Jurisdiction	Able to Implement AWS		
	No	Yes	Total
Baltimore City	97	39	126
Anne Arundel County	34	16	50
Baltimore County	148	41	189
Carroll County	27	4	31
Harford County	31	4	35
Howard County	56	18	74
Total	383	122	505

Although the results are inconclusive, larger firms might be more willing to change their work schedules than smaller firms (see Table 6). Forty-three percent of the firms that employ 200 or more persons say that it is possible to change their work schedules; only 24 percent of the firms that employ less than 200 people indicate that they can change their schedules.

ESTIMATING REGIONAL TRAVEL, AIR QUALITY, AND ENERGY IMPACTS

Based on the results of the survey of regional employers, approximately 25 percent of the employer population, or about 9400 firms in the Baltimore metropolitan area, might be able to implement an AWS program. However, this estimate probably overstates the amount of AWS activity that reasonably can be expected to occur because this estimate assumes that approximately 7750 firms that employ fewer than 20 people will change their work schedules. Many of these smaller firms are not likely to change their

Table 7. Estimated regional AWS impacts at firms that have 100 or more employees.

Item	Level A ^a	Level B ^b	Level C ^c
Estimated actual market for AWS			
Firms	155	233	264
Employees	61 861	92 791	106 163
Estimated new AWS users	43 303	69 593	84 130
Automobile driver trips before AWS ^d	31 741	51 011	61 667
Automobile passenger trips before AWS ^e	6149	9883	11 946
Transit trips before AWS ^f	5413	8699	10 517
Automobile driver trips after AWS ^g			
With 3 percent reduction in automobile driver trips	30 442	48 924	59 143
With 9 percent reduction in automobile driver trips	27 844	44 748	54 096
Automobile passenger trips after AWS ^h			
With 3 percent reduction in automobile passenger trips	6842	10 996	13 293
With 9 percent reduction in automobile passenger trips	8220	13 223	15 985
Transit trips after AWS ⁱ			
With 3 percent reduction in transit trips	6019	9673	11 694
With 9 percent reduction in transit trips	7231	11 622	14 049
Estimated daily peak VMT reduction			
With 3 percent reduction in automobile driver trips	17 666	28 383	34 326
With 9 percent reduction in automobile driver trips	53 000	85 177	102 966
Estimated daily reduction of pollutants (Mg)			
HC			
With 3 percent reduction in automobile driver trips	0.026	0.039	0.047
With 9 percent reduction in automobile driver trips	0.074	0.118	0.143
CO			
With 3 percent reduction in automobile driver trips	0.215	0.345	0.417
With 9 percent reduction in automobile driver trips	0.645	1.04	1.25
NOX			
With 3 percent reduction in automobile driver trips	0.040	0.062	0.075
With 9 percent reduction in automobile driver trips	0.117	0.187	0.227
Estimated daily gasoline savings (gal)			
With 3 percent reduction in automobile driver trips	837	1345	1627
With 9 percent reduction in automobile driver trips	2512	4037	4880

Note: The number of firms in the area that employ more than 100 people is 1235. The number of employees of these firms is 494 884. If we assume that the estimated potential for AWS is 25 percent, then 310 firms that employ 123 721 people have the potential for AWS.

^aLevel A assumes a 50 percent rate of employer participation and 70 percent of their employees participate.

^bLevel B assumes a 75 percent rate of employer participation and 75 percent of their employees participate.

^cLevel C assumes an 85 percent rate of employer participation and 85 percent of their employees participate.

^dCalculation is based on 73.3 percent of all trips being automobile driver trips.

^eCalculation is based on 14.2 percent of all trips being automobile passenger trips.

^fCalculation is based on 12.5 percent of all trips being transit trips.

^gCalculation is based on 76.3 percent of all trips being automobile driver trips.

^hCalculation is based on 15.8 percent of all trips being automobile passenger trips.

ⁱCalculation is based on 13.9 percent of all trips being transit trips.

work schedules without some type of assistance, encouragement, or incentive from an AWS promotional campaign. Also unlikely is that a promotional campaign would receive enough funds to conduct an outreach program aimed at 9400 employers, of which nearly 8000 employ fewer than 20 people.

Potential Trip Reductions

A more realistic approach to estimating the number of establishments that might implement an AWS program is to examine the AWS potential at firms that employ 100 or more people. It is financially realistic to assume that an outreach program could be designed to reach this segment of the employer market. The estimated impacts from implementing a regional AWS program at firms that have 100 or more employees have been calculated in Table 7.

In the Baltimore region, 1235 firms employ more than 100 people. These firms have a combined work force of nearly 0.5 million people. Approximately 30 percent of these firms (370) currently have some type of AWS, and approximately 45 percent (555) cannot use AWS due to scheduling difficulties. The remaining 25 percent (310) represent the maximum number of employers who could be persuaded to implement an AWS project. Let us assume that the percentage of employees likely to be affected by a regional AWS program will be the same as the number of firms (i.e., 25 percent, or 123 721 employees).

Even with an extremely aggressive AWS outreach effort, it is unlikely that all of the employers that are candidate firms for implementing an AWS project will do so. For this reason, three different levels of employer participation of less than 100 percent were assumed. The first level (level A) of estimated employer participation assumes that 50 percent of those employers eligible to implement an AWS program will do so. The second and third levels are more optimistic and assume that between 75 and 85 percent, respectively, of the employers who can implement an AWS program will do so. Under these assumptions, the estimated number of firms in the Baltimore metropolitan area that might implement a new AWS program ranges from approximately 150 to

Table 8. Change in automobile driver trips at selected AWS sites.

City	Change in Automobile Driver Trips (%)	Type of AWS
Boston	-6.4	Flexible
Cambridge	-3	Flexible
Denver	-2.2	4-day week
Richmond, VA	+1	Flexible
Sacramento	-20	Flexible
San Francisco	-2.4	Flexible
Seattle	-9.6	Flexible
Toronto	-2	Staggered

Table 9. Estimated annual reduction of pollutants and gasoline use.

Level	3 Percent Reduction in Automobile Driver Trips				9 Percent Reduction in Automobile Driver Trips			
	HC (Mg)	CO (Mg)	NOX (Mg)	Gasoline (gal)	HC (Mg)	CO (Mg)	NOX (Mg)	Gasoline (gal)
A	6.5	53.7	10	209 250	18.5	161	29	628 000
B	9.7	86.2	15.5	336 250	30	260	47	1 009 250
C	11.7	104.2	18.7	406 760	36	313	57	1 220 000

275. The number of affected employees could range from 62 000 to 105 000 (see Table 7).

Firms that implement AWS often do not allow their entire work force to adopt an AWS. In fact, only about half of the firms that implement AWS put their entire work force on the new schedule. For this reason, the analysis assumes three different levels of employee participation at firms that implement AWS programs. Each of the three levels assumes that half of the firms put their entire work force on AWS, while the remaining firms put between 40 and 60 percent of their work force on AWS. As a result, level A assumes that a total of 70 percent of the affected work force is allowed to participate in an AWS program. Levels B and C assume that a total of 75 and 85 percent, respectively, of the affected work force will be allowed to participate in their employers' AWS programs. Under these assumptions, the total number of employees whose work trips might be affected by implementation of an AWS program is approximately 43 300 for level A; 69 600 for level B; and 84 100 for level C.

Estimating AWS Impacts

The transportation system management, energy, and air quality improvement benefits of AWS are derived from estimated reductions in automobile driver trips. Reductions in automobile driver trips can occur regardless of the type of AWS program implemented. However, these reductions are generally more pronounced when a FWH program is implemented. For this reason, the impact analysis assumes that the predominant AWS strategy is some type of FWH program. Data from feasibility studies, pilot studies, and long-term projects indicate that persons on FWH programs tend to reduce automobile use. The reductions in automobile driver trips range from 2 to 20 percent (see Table 8).

Based on the experiences of AWS users in other areas, the implementation of an AWS strategy in conjunction with a ridesharing and transit marketing effort could reduce automobile driver trips of participating employees by at least 3 percent and perhaps by as much as 9 percent (1,5-11).

The next step of the impact analysis uses the estimated automobile driver reductions to adjust the modal shares by subtracting the estimated reductions from the existing percentage of automobile driver trips. The reductions are then added to the automobile passenger and transit mode shares (see Table 7). The range of regional automobile driver work trip reductions is 1300-7600. The estimated 1300 trip reductions assumes a minimum level of participation by employers (level A) and a 3 percent reduction in automobile driver trips. At a 9 percent level of reduction, almost 4000 level A automobile driver trips could be saved. At level B, 21 000 automobile driver trips would be saved at the 3 percent level of reduction and 6300 could be saved at the 9 percent level. At level C, an estimated 7600 work trip reductions assumes a 9 percent reduction in automobile driver trips; at 3 percent the reduction is almost 2500 trips.

The estimated daily VMT is derived by multiplying the trip reductions in Table 7 by the average (two-day) work trip length of 13.6 miles. The estimated peak VMT savings could be as low as 18 000 or as high as 103 000 daily (see Table 7). These VMT savings could reduce the region's hydrocarbon emissions burden by as much as 36 Mg annually (see Table 9) and save more than 1.2 million gal of gasoline.

CONCLUSIONS

Between 155 and 264 firms in the Baltimore metropol-

itan area that employ 100 or more people could implement a flextime, staggered work hours, or compressed workweek program. (This estimated market is between 13 and 21 percent of the employers who have a work force of 100 or more.) The number of work-related automobile trips could be reduced by as few as 1300 or as many as 7600 if employers implemented AWS on a wide-scale basis in the Baltimore area.

The estimated travel, air quality, and energy impacts that could result from implementation of a regional AWS program are not of mammoth proportions. However, the estimated impacts would be beneficial to the region and could assist the area in meeting its travel, air quality, and energy objectives. In addition, AWS generally has a positive impact on ridesharing and transit use and its benefits would probably be increased if it were implemented as a package along with other transportation system management measures.

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