# Economic Analysis and Potential Cost Savings Associated with Systemwide Transportation System Management Analysis of Winston-Salem Urbanized Area

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**A systemwide transportation system management (TSM) program is based on a comprehensive TSM planning analysis of an urbanized area that develops TSM alternatives to major construction projects. It consists of nine phases, four of which are programmed and applicable for use on the IBM personal computer. Five of the nine phases as they were applied to the urbanized area of Winston-Salem are discussed: (a) elimination of those capacity-deficient corridors or segments that are readily identified as requiring construction or programmed as near-future construction; (b) review and analysis of the preliminary TSM alternatives associated with those remaining corridors or segments to determine whether they are feasible TSM candidates; (c) determination of cost estimates (capital, maintenance, operational) associated with each element of the TSM alternatives, as well as the costs associated with comparable construction alternatives; (d) determination of the benefit-cost (*B/C*) ratio associated with each TSM alternative and comparative construction alternatives (programmed); and (e) determination of annual capital-cost programs for ridesharing (programmed), staggered work hours (programmed), transit mode split (programmed), traffic engineering, and comparative construction alternatives. With this planning tool, agencies are in a better position to maximize the combined effect of TSM, as well as to formulate the necessary policy directives required for implementation. A prospective TSM management program is also discussed, which presents the author's views on how current TSM programs could be improved.**

Since 1985, a local team of transportation managers has been applying a transportation system management (TSM) planning methodology to the urbanized area of Winston-Salem. Their efforts have been based on earlier work and methodology developed by Leggett, which have been documented elsewhere *(1, 2)*.

The urbanized area of Winston-Salem has a population of approximately 147,200 and is located in the western Piedmont region of North Carolina. It is served by an excellent transportation system that facilitates north-south and east-west travel. Although its urban transportation system experiences traffic congestion problems during the peak periods, it is considered to serve the population's travel needs adequately. This urban system has a well-integrated network of streets, some 1,107 mi, which facilitates approximately 5,256,000 daily vehicle miles of travel. It is also supported by excellent transit and ridesharing programs, which carry approximately 11,800 and 15,863 daily person-trips, respectively.

The systemwide TSM analysis consists of the following nine phases, four of which are programmed and applicable for use on the IBM personal computer:

1. Division of urbanized area into districts that radiate from the central business district (CBD) and consist of complementing corridors and their associated employment centers;
2. Collection of existing and future traffic data associated with major collectors and thoroughfares, as well as existing and future employment data;
3. Determination of existing and future capacity-deficient corridors or segments (programmed) *(1)*;
4. Development of preliminary TSM alternatives for capacity-deficient corridors designed to enable facilities to operate at a desired level of service (programmed) *(1, 3, 4)*;
5. Elimination of those capacity-deficient corridors or segments that are readily identified as requiring construction or programmed as near-future construction;
6. Reviewing and analyzing the preliminary TSM alternatives associated with those remaining corridors or segments to determine whether they are feasible TSM candidates;
7. Determination of cost estimates (capital, maintenance, operational) associated with each element of the TSM alternatives, as well as the costs associated with comparable construction alternatives *(2, 4)*;
8. Determination of the benefit-cost (*B/C*) ratio associated with each TSM alternative and comparative construction alternative (Table 1) (programmed) *(2, 4, 5)*; and
9. Determination of annual capital-cost programs (see Table 5) for (a) ridesharing (programmed), (b) staggered-work-hour (programmed), (c) transit-mode-split (programmed), (d) traffic-engineering, and (e) comparative construction alternatives.

The discussion in this paper focuses on the coordinated planning effort used during Phases 5 and 6, the methodology used to develop the cost estimates of Phase 7, the methodology

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TABLE 1 BENEFIT-COST ANALYSIS: WINSTON-SALEM

| Project | | Do Nothing | | Incremental | | Best Alternative |
|---|---|---|---|---|---|---|
| Dist | Seg | B/C TSM-Null | B/C Cst-Null | B/C TSM-Cst | B/C Cst-TSM | |
| 1 | 1 | 90.6 | 15.5 | 0.0 | -0.8 | TSM |
| 1 | 2 | 194.2 | 98.1 | 0.0 | -9.8 | TSM |
| 2 | 1 | 297.1 | 98.2 | 0.0 | -3.2 | TSM |
| 3 | 1 | 75.8 | 17.5 | 0.0 | -1.0 | TSM |
| 3 | 2 | 86.5 | 5.2 | 0.0 | -0.3 | TSM |
| 3 | 3 | 640.9 | 35.8 | 0.0 | -0.8 | TSM |
| 3 | 4 | 16.2 | 0.0 | 0.0 | 0.0 | TSM |
| 3 | 5 | 268.3 | 80.8 | 0.0 | -3.6 | TSM |
| 4 | 1 | 52.6 | 10.5 | 0.0 | -0.3 | TSM |
| 4 | 2 | 82.5 | 14.6 | 0.0 | -0.5 | TSM |
| 4 | 3 | 199.1 | 30.5 | 0.0 | -0.2 | TSM |
| 4 | 4 | 47.9 | 49.5 | 23.2 | 0.0 | TSM |
| 4 | 5 | 129.2 | 35.0 | 0.0 | -3.2 | TSM |
| 4 | 6 | 100.3 | 57.2 | 0.0 | -4.4 | TSM |
| 4 | 7 | 74.0 | 23.9 | 0.0 | -0.9 | TSM |
| 4 | 8 | 318.9 | 29.4 | 0.0 | -0.2 | TSM |
| 4 | 9 | 117.4 | 14.2 | 0.0 | -0.2 | TSM |
| 5 | 1 | 40.6 | 0.0 | 0.0 | 0.0 | TSM |
| 5 | 2 | 91.8 | 100.8 | 19.8 | 0.0 | TSM |
| 5 | 3 | 435.3 | 1.6 | 0.0 | -0.1 | TSM |
| 5 | 4 | 264.0 | 28.2 | 0.0 | -0.7 | TSM |
| 5 | 5 | 129.2 | 57.4 | 0.0 | -2.5 | TSM |
| 5 | 6 | 565.7 | 73.7 | 0.0 | -0.8 | TSM |
| 5 | 7 | 161.2 | 47.6 | 0.0 | -1.7 | TSM |
| 5 | 8 | 207.2 | 0.0 | 0.0 | 0.0 | TSM |
| 6 | 1 | 210.4 | 93.0 | 0.0 | -3.0 | TSM |
| 6 | 2 | 98.3 | 16.4 | 0.0 | -0.7 | TSM |
| 6 | 3 | 20.9 | 18.5 | 0.0 | -7.9 | TSM |
| 6 | 5 | 902.5 | 0.0 | 0.0 | 0.0 | TSM |
| 6 | 6 | 58.1 | 8.3 | 0.0 | -0.5 | TSM |
| 6 | 7 | 153.1 | 22.9 | 0.0 | -0.6 | TSM |
| 6 | 8 | 198.0 | 20.7 | 0.0 | -0.6 | TSM |
| 6 | 9 | 157.7 | 1.8 | 0.0 | -0.1 | TSM |
| 7 | 1 | 57.9 | 1.9 | 0.0 | -0.1 | TSM |
| 7 | 2 | 105.3 | 8.4 | 0.0 | -0.2 | TSM |
| 7 | 3 | 155.6 | 0.9 | 0.0 | 0.0 | TSM |
| 7 | 4 | 50.8 | 4.2 | 0.0 | -0.1 | TSM |
| 7 | 5 | 19.6 | 10.4 | 0.0 | -0.2 | TSM |
| 7 | 6 | 183.3 | 66.7 | 0.0 | -0.3 | TSM |
| 7 | 7 | 88.9 | 6.9 | 0.0 | -0.3 | TSM |
| 8 | 1 | 194.9 | 110.9 | 0.0 | -1.4 | TSM |
| 8 | 2 | 477.1 | 64.6 | 0.0 | -0.3 | TSM |
| 8 | 3 | 110.3 | 31.8 | 0.0 | -0.7 | TSM |

Note: Under Do Nothing, when B/C (Cst-Null)=0.0 indicates construction was not considered as an alternative and only B/C (TSM-Null) was evaluated.

: Under Incremental, a 0.0 indicates this alternative was not evaluated because its comparable alternative under Do Nothing produced a greater B/C ratio which makes it the defender.

used to determine the *B/C* ratios of Phase 8, the methodology used to determine the annual capital-cost estimates of Phase 9, and the prospective TSM management process.

The comprehensive TSM analysis has been designed to determine TSM alternatives that can be used to defer or replace construction alternatives. Once the urbanized area has been divided into districts, the analysis proceeds with the determination of existing (1983 = base year) and forecast (2000 = design year) transportation demands for the area's major collectors and thoroughfares, as well as the existing effects of TSM on such corridors (i.e., ridesharing; staggered work hours, if known; and transit mode split).

For each of the major collectors and thoroughfares, the local thoroughfare plan was used to determine

- Vehicle capacity at level-of-service E during the base year:

$$EVC = \sum_{S=1}^{n} [(\text{segment's distance}_s/\text{total distance}) \times (\text{segment's capacity}_s)] \text{ or most restricting capacity}$$

- Existing average daily traffic (*ADT*) volume during the base year:

$$EADT = \sum_{S=1}^{n} [(\text{segment's distance}_s/\text{total distance}) \times (\text{segment's } ADT_s)] \text{ or segment's highest ADT}$$

- Existing peak-hour directional flow factor (*PHDF*).
- Existing peak-hour traffic volume factor during the base year (*PHF*).
- Forecast ADT for the design-year volume ($ADT_{di}$).

The local ridesharing and transit programs provided the following TSM elements for each of the designated corridors:

- Peak-hour vehicle occupancy rate during the base year ($VOR_{bi}$).
- Peak-hour percent transit mode split during the base year ($TMS_{bi}$).
- Peak-hour percent staggered work hours during the base year ($SWH_{bi}$) (this was not evaluated for Winston-Salem).

Of the 180+ corridors or segments evaluated in Winston-Salem, 100 proved to have an existing or future capacity problem. However, only 43 of these were determined to be feasible TSM candidates, whereas the remaining 57 problem areas were judged definitely to require a construction solution.

## COORDINATED TSM PLANNING PROCESS

During this phase of the study, the management-level transportation professionals responsible for each of the TSM elements (i.e., the transportation planner, ridesharing coordinator, transit director, and traffic engineering manager) collectively reviewed and evaluated the potential for the preliminary TSM alternatives associated with each of the 100 capacity-deficient corridors or segments. Each alternative consisted of at least one and in most cases a combination of the following TSM options:

- Vehicle occupancy rate (*VOR*)
- Staggered work hours (*SWH*)
- Transit mode split (*TMS*)
- Traffic engineering (*TE*)

These alternatives were developed from a computer model on the basis of operational characteristics of a particular corridor or segment [i.e., base-year capacity ($EVC_{bi}$), estimated ADT volumes during base year and design year ($EADT_{bi}$ and $EADT_{di}$), vehicle occupancy rate during base year ($VOR_{bi}$), and transit mode split during base year ($TMS_{bi}$)].

For a given corridor, the designated magnitude of each TSM alternative (i.e., which one is designated to accommodate the percent of peak-hour person or vehicle trip demand in excess of the facilities' peak-hour vehicle capacity at level-of-service D) is directly associated with the existing effects of TSM. For example, if the corridor or segment has no transit, transit is not considered as an option, and if it has lower-than-average participation from ridesharing and staggered work hours, these options are weighted accordingly. Therefore, corridors of this nature place greater emphasis on traffic engineering, which makes them easy to eliminate when the traffic-engineering option requires extensive construction.

This element of the planning process is considered a valuable planning tool. The professionals are provided with a potential alternative based on a corridor's operational characteristics without having to perform the cumbersome calculations associated with TSM evaluations. For each alternative, the number of additional person-trips required to be accommodated was given for the non-traffic-engineering options, and the number of vehicles was given for traffic-engineering options. With these values the professionals had the necessary components to evaluate the potential for their programs to effectively manage a particular traffic congestion problem.

Criteria used by each of the non-traffic-engineering professionals to determine whether their individual program could accommodate the additional number of person-trips associated with each option were based on the concentration of employment centers, past employee-employer participation, nature of employment base, available land resources for park-and-ride facilities, and available transit service within the particular area of interest.

For each of the traffic-engineering options, traffic engineers evaluated the ability of the existing corridor or segment to accommodate additional vehicles on the basis of improving intersection geometrics, re-marking existing pavement, improving signal optimization, minor widening of shoulders, and making reversible lanes to enhance the existing roadway capacity.

This coordinated planning process consisted of approximately five meetings. Initially the group eliminated the following types of projects: those projects programmed and budgeted as immediate Transportation Improvement Program (TIP) construction needs that were scheduled to be built in the near future, those that could not be mitigated by TSM because of severe capacity problems or their nonsupporting TSM criteria, and those being complemented by ongoing or near-future construction projects.

On completion of the elimination process, the professionals examined the details of each TSM option and the associated operational characteristics of each corridor or segment to determine the feasibility of the TSM alternative. As with the foregoing case, a number of these projects were also dropped and designated as construction projects.

Throughout the evaluation of each preliminary TSM option, the various options were altered, if necessary, to produce a TSM package more applicable to a particular corridor or segment. For example, if an individual indicated that his program could not adequately accommodate the required persons or vehicles, an informal dialogue would begin. One person might remind the transit manager of a transit route that could be extended to the particular project area. The transit manager might respond by acknowledging the fact that the particular route extension was possible and that the idea had great potential. Therefore, the demand of one or all of the other TSM options would be reduced to make the TSM alternative feasible. This type of dialogue would continue throughout the meeting and produce an invaluable exchange of ideas.

This multimodal planning process enabled the professionals to maximize the combined effects of their programs, thereby enabling them to identify a greater number of projects that might be significantly affected by TSM.

## BENEFIT-COST ANALYSIS AND PROJECT COST DETERMINATION

In order to assess the economic benefits associated with the 43 TSM projects, each TSM alternative and a comparative construction alternative were subjected to an economic analysis by using the traditional benefit-cost ratio (*B/C*) method *(5)*. This method determines the ratio of benefits to costs after each project or alternative has been discounted with respect to its expected life at a minimal attractive rate of return [i.e., all projects or alternatives were discounted to an equivalent uniform annual cost (EUAC) on the basis of their expected life, which was judged to be the difference between the design year and the year the problem occurs plus 1, and a minimal attractive rate of return of 10 percent]. In other words, both TSM and construction alternatives were designed to accommodate the capacity problem from the year of inception through the design year 2000. Projects with *B/C* ratios greater than 1.0 are considered economically attractive and those with *B/C* ratios less than 1.0 are considered not to be economically efficient.

When projects with different benefits and costs are compared, it is necessary to conduct an incremental benefit-cost analysis. First the *B/C* ratio for each project alternative is compared with the null alternative. If the *B/C* ratios of both alternatives are greater than 1.0, incremental benefit-cost analysis is used to determine which alternative is more economically advantageous. The process is a repeat of the direct *B/C* ratio approach, with the exception of replacing the null alternative with the alternative (TSM or construction) that has the highest *B/C* ratio. This alternative then becomes the "defender" and the benefits and costs of the other alternative are compared with those of the defender. If the *B/C* ratio in this comparison is less than 1.0, the costs associated with the defender produce a greater rate of return; however, if the *B/C* ratio is greater than 1.0, the costs associated with the other alternative produce a greater rate of return. To illustrate the procedure of the incremental benefit-cost analysis, an actual project has been evaluated as follows (Table 2).

The basis alternative (null) is taken as the defender:

$$B/C = \frac{R_{\text{null}} - R_{\text{TSM}}}{(C_{\text{TSM}} + M_{\text{TSM}}) - M_{\text{null}}}$$

$$= \frac{(12{,}590{,}765 - 9{,}680{,}800)}{(15{,}253 + 6{,}453) - 2{,}700}$$

$$= \frac{2{,}909{,}965}{19{,}006}$$

$$= 153.1$$

$$B/C = \frac{R_{\text{null}}\ R_{\text{const}}}{(C_{\text{const}} + R_{\text{const}}) - M_{\text{null}}}$$

$$= \frac{(12{,}590{,}765 - 9{,}741{,}766)}{(121{,}930 + 5{,}401) - 2{,}700}$$

$$= \frac{2{,}848{,}999}{124{,}631}$$

$$= 22.9$$

Because both the TSM and construction alternatives produce *B/C* ratios greater than 1, which implies that they are economically advantageous at the same minimum attractive rate of return, it is necessary to conduct an incremental benefit-cost analysis to determine which investment should be pursued. The TSM alternative has a greater *B/C* ratio than the construction alternative, so it is regarded as the defender against the construction alternative in the incremental benefit-cost analysis, as follows:

$$B/C = \frac{\text{incremental benefits}}{\text{incremental costs}}$$

$$\frac{R_{\text{null}} - R_{\text{const}}}{(C_{\text{const}} + M_{\text{const}}) - (C_{\text{TSM}} + M_{\text{TSM}})}$$

$$\frac{9{,}680{,}800 - 9{,}741{,}776}{(121{,}930 + 5{,}401) - (15{,}253 + 6{,}453)}$$

$$= \frac{-60{,}976}{105{,}625}$$

$$= -0.6$$

As can be seen, the construction alternative produces a negative *B/C* ratio when compared with the TSM alternative, suggesting that the TSM alternative is the more attractive investment. In both cases, the TSM costs are less than the construction costs. In other words, the total of implementation and maintenance costs as well as the user costs incurred by the TSM alternative is less, implying that the TSM alternative provides greater benefits for less cost.

The results of this analysis (Table 1) identify each project by a particular district and segment number. For each of the TSM alternatives, with the exception of the two projects designated 4, 4 and 5, 2, the investment costs and the road user costs were less than those costs associated with the comparative construction alternative. In most cases, as reflected by the *B/C* ratios, these costs were considerably less because their improvements do not extend beyond the peak hours, as do the construction improvements.

In the case of Projects 4, 4 and 5, 2, the TSM investments over the life of the projects were greater than the construction investments. But estimated TSM user costs were less as a result of the reduced number of vehicles to be operating on the facility by the design year, which explains why the construction alternatives proved to be less cost-efficient in the incremental analysis. In other words, the TSM investments provide a greater rate of return per dollar investment to the extent that their benefits accruing to the public outweigh the benefits of the less expensive construction alternatives. Projects of this nature would be considered the least desirable TSM candidates and would most likely be better served by construction.

Table 3 presents two examples of the proposed TSM and comparative construction alternatives. Table 3 is designed to provide a general overall description of the specific actions and cost requirements of, as well as economic benefits associated with, each TSM project and its comparative construction alternative. With this generalization, decision makers can quickly view the potential merits associated with each project recommendation.

To simplify the analysis, the project costs for the construction capital program and the project costs for the transit and traffic engineering portion of the TSM capital program are programmed for the year in which the capacity problem occurs. It is realized that this is not always the case because of the time required for completion of preliminary engineering and construction, which take at least a year or more for construction projects. For the ridesharing and staggered-work-hour options of the TSM capital program, project costs are prorated and spread out over the life of the project.

The two elements of the economic analysis used to determine the *B/C* ratio for the construction and TSM alternatives, as set by AASHTO, are road user costs and highway costs. The calculation of these costs has been based on urban arterial highway sections, which are assumed to have homogeneous operational characteristics.

TABLE 2 PROJECTS, DISTRICT 6, SEGMENT 7

| Alternative | Investment ($) | Capital Costs (*C*) ($) | Operating and Maintenance Costs (*M*) ($) | User Costs (*R*) ($) | *B/C* Ratio |
|---|---|---|---|---|---|
| Null | | | 2,700 | 12,590,765 | |
| TSM | 125,099 | 15,253 | 6,453 | 9,680,800 | 153.1 |
| Construction | 1,000,000 | 121,930 | 5,401 | 9,741,776 | 22.9 |

NOTE: Annual items: $i = 10$ percent; $n = (YR_{di} - YR_{pi}) + 1$.

TABLE 3 PROJECT ALTERNATIVES AND ECONOMIC VALUES USED TO DETERMINE RECOMMENDED ACTION: WINSTON-SALEM

| Corridor | | | | | Description of Improvements[a] | | Costs ($) | | | | B/C Ratio | | Recommended Action |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TSM | | Construction | | | | |
| District | Segment | Miles | Lanes | Problem | TSM | Construction | Capital | M&O | Capital | M&O | TSM | Construction | |
| .<br>.<br>. | | | | | | | | | | | | | |
| 6 | 7: Country Club Road between Silas Creek and Lindburgh | 0.8 | 2 | 1983 | RST = 57 (CP);<br>SWHT = 30 (B&A);<br>TMST = 79;<br>TET = F | +2 lanes | RST = 17,820;<br>SWHT = 10,680;<br>TMST = 81,599;<br>TET = 15,000;<br>TOT = 125,099 | TMST = 30,773;<br>TET = 22,147;<br>TOT = 52,921 | 1 million | 44,292 | 153.1 | 22.9 | TSM |
| 6 | 8: Country Club Road between Old Vineyard and Peacehaven | 1.3 | 2 | 1984 | RST = 55(CP);<br>SWHT = 28(B) and 29(A);<br>TMST = 72;<br>TET = F | +2 lanes | RST = 16,200;<br>SWHT = 9,600;<br>TMST = 74,369;<br>TET = 15,000;<br>TOT = 115,169 | TMST = 28,047;<br>TET = 33,990;<br>TOT = 62,036 | 1.3 million | 67,980 | 198.0 | 20.7 | TSM |
| .<br>.<br>. | | | | | | | | | | | | | |

[a] Description of improvements is as follows:

RST (Ridesharing Task) = number of carpools required (CP); CP = number of person-trips to be accommodated/[persons per carpool minus existing vehicle occupancy rate (VOR) of specific corridor] (i.e., Project 6,7 above was based on 98 person-trips to be accommodated, 3 persons per carpool, and 1.28 existing VOR).

SWHT (Staggered-Work-Hour Task) = number of additional person-trips to be diverted before (B) and after (A) the peak periods (i.e., Project 6,7 above was based on 60 additional person-trips to be diverted by design year 2000).

TMST (Transit Mode-Split Task) = number of additional person-trips to be accommodated by design year 2000.

TET (Traffic Engineering Task) = repave and restripe to add an additional lane (F) (i.e., Project 6,7 was based on 161 vehicles to be accommodated by design year 2000).

Construction = roadway widening to add an additional lane in each direction (i.e., Project 6,7 above was based on 332 vehicles to be accommodated).

Road user costs (*RUC*) are basically those incurred by the traveling public that result from the operational characteristicsof both highway and vehicle. The three factors that were used to calculate those costs are vehicle operating costs (*VOC*) travel-time costs (*TTC*), and accident costs (*AC*) (i.e., $RUC = VOC + TTC + AC$).

The computational procedures used to determine the various road user costs are detailed elsewhere *(5, 6)*. However, the procedure used to estimate these costs for the TSM alternative has been altered *(2)*.

TSM alternatives are designed to manage the peak-hour traffic volumes, and the cost reductions and costs incurred by these alternatives reflect the resulting improvements to peak-hour traffic congestion. To account for the improvements occurring during the peak hours, it is necessary to evaluate the peak-hour traffic volumes. The design-year estimated ADT ($EADT_{di}$) and the desired estimated ADTs required to maintain level-of-service D ($EADT_{di}$), or vehicle capacity at level-of-service D, are converted to peak-hour volumes.

The difference between these peak-hour volumes ($PHEADT_{di} - PHEADT'_{di}$) is the number of vehicles required to be reduced, diverted, or accommodated by the TSM alternative to allow the existing facility to operate at level-of-service D. Therefore, the only difference in the process used to compute the road user costs for TSM alternatives is the procedure used to determine the reduction in the design-year ADTs that result from the TSM improvement.

The process used to estimate the capital-cost and maintenance-and-operating-cost elements of the highway costs for the construction alternative differs somewhat from that for the TSM alternative. The highway costs for the construction alternative were provided by the Thoroughfare Planning Unit of the North Carolina Department of Transportation (NCDOT), Winston-Salem's Traffic Engineering Section, and the NCDOT Maintenance and Equipment Branch. The capital costs consisted primarily of drainage, pavement, right-of-way acquisition, and signalization costs, and maintenance and operating costs included equipment, materials, labor, and administration. Project-specific detailed engineering estimates prepared for each alternative construction project were used for capital cost estimates. Maintenance and operating costs ($769.00/lane-mile) were average and were derived by dividing the total annual urban highway maintenance and operating costs of the state's urban system by the total lane miles for the state's urban system.

When the costs are developed for a TSM alternative, which acts to defer the need for construction, it is necessary to determine or estimate the costs associated with implementing and continuing the TSM alternative during the peak hour. These costs are somewhat subjective and very sensitive to an area's political, social, and economic environment.

The TSM alternatives consisted of various combinations of the TSM actions identified earlier: increasing the vehicle occupancy rate, the effects of staggered work hours, and the transit mode split and improving operational characteristics through traffic engineering. For each of these options, the estimated capital costs and maintenance and operating costs associated with their initial implementation and continuation were determined from ongoing TSM activities both within the state and in Winston-Salem.

The capital costs for the traffic engineering options were determined by the Winston-Salem traffic engineering staff. Any roadway improvements (e.g., intersections, paving, widening) were based on the same criteria as was the construction alternative, and any signalization or signing was based on purchase price and installment costs.

Before the capital costs associated with the non-traffic-engineering TSM options are estimated, it is necessary to determine the number of additional peak-hour person-trips that each of these options is to accommodate or divert by the design year. As discussed earlier, these person-trips are determined during Phase 4 of the analysis, when the preliminary TSM alternatives are developed. These alternatives are designed to accommodate a portion of the estimated design-year peak-hour person-trip demand as required to enable the facility to operate at level-of-service D.

For the vehicle-occupancy-rate and staggered-work-hour TSM improvements, a cost of $20 a person to divert an individual from a single-occupancy vehicle (SOV) to a high-occupancy vehicle (HOV) was used to estimate the capital costs. This figure was derived by evaluating the annual average costs and participation of the state's various ridesharing programs (i.e., cost per person = state's total annual ridesharing costs divided by estimated total ridesharing participation). Although this cost is subjective and sensitive to an area's environment, it was believed to be representative of Winston-Salem's ridesharing program. However, this cost was believed to be higher than the actual costs of diverting individual travel from the peak hour, but it was used in order to preclude the probability of underestimating the cost of the staggered-work-hour option. Also, the estimate is believed to be ambitious in light of existing transportation policy, which is based on support for construction alternatives.

In order to estimate the capital costs associated with improvements in the vehicle occupancy rate ($VORC_i$) and in staggered work hours ($SWHC_i$), it is necessary to determine the cumulative effect associated with the number of person-trips to be accommodated by these improvements. The cost of $20 a person is considered to be a continuing cost and each trip accommodated by these options requires this expenditure to be maintained from the date that an individual begins participating through the design year. Therefore, the annual costs associated with the person-trips of these options, which are prorated from the inception of the capacity problem through the design year, have to be incurred each year during this period.

The methodology used to estimate the capital costs associated with the TSM transit mode-split option ($TSMC_{TSMi}$) was based on the purchase price of a bus ($135,000) with an expected life of 15 years; the capacity of each route, determined by the number of buses operating, frequency of operation, number of seats per bus (40), and number of standees allowed per bus during the peak hour (15); the existing ridership for each route during the peak hour; and the number of additional person-trips that each route was designated to accommodate during the planning period by the TSM analysis.

For the planning period, the TSM transit mode split option was designated to accommodate 1,307 additional person-trips during the peak hour, requiring an additional 10 buses to be added to the area's existing peak-hour fleet of 40 buses.

In order to associate a capital cost with each of the TSM transit mode split options, a transit mode split person-trip ratio was determined for each option. This ratio was derived by dividing the number of additional person-trips to be accommodated by each transit mode split option ($PTTSM_{TSMdi}$) by the total number of additional person-trips to be accommodated by transit for the entire urban area ($TPTTMS_{TSMj}$). The result was multiplied by the total transit capital costs ($1.35 million).

The transit and traffic engineering options were the only ones considered to have costs that could be adequately termed maintenance and operating costs as compared with the construction alternative. However, the cost of $20 a person associated with the ridesharing and staggered-work-hour program was judged adequate to cover administrative and operating costs.

The maintenance and operating costs associated with the traffic engineering option ($TE_{TSMi}$) were determined by the Winston-Salem traffic engineering staff. These costs were negligible in most cases, with only those projects requiring roadway widening and major intersection improvements being considered to have increased maintenance and operating costs. Also, the maintenance and operating costs of the null alternative (i.e., $769/lane-mile) are included as part of these costs.

The methodology used to estimate the transit maintenance and operating costs was based on the number of additional buses to be added during the planning period (10), the number of years that the additional buses would be operational during the planning period (44), and the estimated annual peak-hour maintenance and operating cost associated with each bus ($11,571). In order to associate a maintenance and operating cost with each of the TSM transit mode split options, the transit mode split person-trip ratio ($PTTMS_{TSMdi}/TPTTMS_{TSMj}$), as used to estimate the capital costs, was multiplied by the total operation subsidy ($509,124).

## CAPITAL-COST PROGRAMS

The development of the capital-cost program for the systemwide TSM analysis was not based on Winston-Salem's available transportation revenues. Instead, the program was based on the funding needed to finance the TSM needs package in its entirety, as well as an alternative construction needs package. This approach was taken in order to properly document the potential cost saving associated with the implementation of the systemwide TSM program, as well as to document the required expenditures needed to finance an ongoing long-range TSM program responsive to the area's multimodal transportation needs.

The annual financial requirements (i.e., capital-cost portion, as discussed earlier) were determined by associating a cost with each element of the TSM alternatives and a cost with each of the comparative construction alternatives. These costs were then totaled to develop the TSM and construction capital-cost programs shown in Table 5 (discussed later).

As stated earlier, the capital costs for the ridesharing and staggered-work-hour options include both administrative and operational costs, whereas the capital costs for the other TSM options and construction alternatives do not. However, because of the variable nature of these costs, no effort was taken to separate them, and no appreciable error in capital-cost estimates is believed to be associated with these additional costs.

Table 4 gives the annual capital costs and the total capital costs associated with each of the TSM improvements for the project discussed earlier (District 6, Segment 7: Country Club Road between Silas Creek and Lindburgh), as well as the annual capital costs and total capital costs associated with the entire TSM improvement.

Based on the design level-of-service D $v/c$ ratio of 0.85, this project's $v/c$ ratio of 0.88 ($ADT/EVC$ = 14,000/16,000) suggests that this facility has an existing capacity problem. Moreover, by the design year 2000 it is estimated that it will have an ADT of 19,180 ($EADT_{di}$), which produces a $v/c$ ratio of 1.20.

In order for capacity problems that occur most often during the peak hour to be evaluated by TSM, the existing vehicle capacity or ADT based on level-of-service D ($EADT_{Di} = 16{,}000$), the base-year ADT ($EADT_{bi} = 14{,}000$), and the design-year ADT ($EADT_{di} = 19{,}180$) were converted to peak-hour volumes as follows:

$$PHEADT_{Di} = 816$$

$$PHEADT_{bi} = 840$$

$$PHEADT_{di} = 1{,}151$$

These volumes indicate that the facility's existing peak-hour capacity at level-of-service D ($PHEADT_{Di} = 816$) at present cannot adequately accommodate 24 vehicles ($24 = 840 - 816$), and will not be able to adequately accommodate 335 vehicles ($335 = 1{,}151 - 816$) by the design year.

On the basis of this capacity deficiency, it was estimated that an additional lane in each direction costing $1 million would be required if this deficiency were to be accommodated by a construction alternative.

Alternatively, it was estimated the capacity deficiency could be mitigated by TSM for a capital cost of $125,099, which consisted of the following peak-hour improvements:

- Increase the existing VOR of 1.28 to 1.38 by the design year through a ridesharing program ($VOR_{TSMdi} = 1.38$), which would enable the facility to accommodate an additional 98 person-trips at a cost of $17,820;
- Divert 4 percent of the person-trip demand by design year through a staggered-work-hour program ($SWH_{TSMi} = 0.04$), which would enable the facility to divert 60 person-trips from the peak hour at a cost of $10,680;
- Increase the transit mode split of 1 percent to 6 percent by design year ($TMS_{TSMdi} = 0.06$), which would enable the facility to accommodate 79 additional person-trips at a cost of $81,599; and
- Increase existing capacity by 19.82 percent, which was scheduled during the base year ($TE_{TSMdi} = 0.1982$) and would enable the facility to accommodate an additional 161 vehicles at a cost of $15,000.

The non-traffic-engineering improvements were designed to reduce or divert a portion of the peak-hour vehicle demand, whereas the traffic-engineering improvement was designed to increase the peak-hour level-of-service D roadway capacity.

A composite of these annual improvements and costs, as shown in Table 4, is the method used to develop the TSM capital-cost program. For the ridesharing and staggered-work-hour improvements, the scheduling of annual costs is based on

**TABLE 4 TSM ANNUAL CAPITAL COSTS AND ASSOCIATED PERSON OR VEHICLE TRIPS TO BE ACCOMMODATED: WINSTON-SALEM**

| Year | Ridesharing | | Staggered Work Hours | | Transit | | Traffic Engineering | | Total Costs |
|---|---|---|---|---|---|---|---|---|---|
| | NAPT/Y | Costs | NAPT/Y | Costs | NAPT/Y | Costs | NAVT/Y | Costs | |
| 1983 | 5 | $ 100 | 3 | $ 60 | 4 | $ 0 | 15 | $15,000 | $ 15,600 |
| 1984 | 5 | 200 | 3 | 120 | 4 | 0 | | 0 | 320 |
| 1985 | 5 | 300 | 3 | 180 | 4 | 0 | | 0 | 480 |
| 1986 | 5 | 400 | 3 | 240 | 4 | 0 | | 0 | 640 |
| 1987 | 5 | 500 | 3 | 300 | 4 | 0 | | 0 | 800 |
| 1988 | 5 | 600 | 3 | 360 | 4 | 8,159 | | 0 | 9,119 |
| 1989 | 5 | 700 | 3 | 420 | 4 | 0 | | 0 | 1,120 |
| 1990 | 5 | 800 | 3 | 480 | 4 | 0 | | 0 | 1,280 |
| 1991 | 5 | 900 | 3 | 540 | 4 | 0 | | 0 | 1,440 |
| 1992 | 5 | 1,000 | 3 | 600 | 4 | 0 | | 0 | 1,600 |
| 1993 | 6 | 1,120 | 3 | 660 | 4 | 0 | | 0 | 1,780 |
| 1994 | 6 | 1,240 | 3 | 720 | 5 | 16,320 | | 0 | 18,280 |
| 1995 | 6 | 1,360 | 4 | 800 | 5 | 0 | | 0 | 2,160 |
| 1996 | 6 | 1,480 | 4 | 880 | 5 | 8,160 | | 0 | 10,500 |
| 1997 | 6 | 1,600 | 4 | 960 | 5 | 0 | | 0 | 2,560 |
| 1998 | 6 | 1,720 | 4 | 1,040 | 5 | 8,160 | | 0 | 10,920 |
| 1999 | 6 | 1,840 | 4 | 1,120 | 5 | 32,640 | | 0 | 35,600 |
| 2000 | 6 | 1,960 | 4 | 1,200 | 5 | 8,160 | 161 | 0 | 11,320 |
| Totals | 98 | $17,820 | 60 | $10,680 | 79 | $81,599 | 161 | $15,000 | $125,099 |

NAPT/Y = Number of Additional Person-Trips per year required to be accommodated during the peak hour.

NAVT/Y = Number of Additional Vehicle-Trips per year required to be accommodated during the peak hour.

an annually prorated portion of the costs associated with their design-year improvements, beginning with the year that the facility is expected to exceed capacity through the design year. Although the transit improvement is prorated in the same manner as the foregoing two options, the scheduling of capital cost is treated somewhat differently as a result of the manner in which expenditures are required to purchase the additional transit stock. For example, the cost to purchase the 10 buses required to meet design-year transit demand during the planning period (one during 1988, two during 1994, one during 1996, one during 1998, four during 1999, and one during 2000) is shown in Table 4 for these years, which is when additional transit capacity is needed. During those years, the costs of each transit improvement include a weighted portion of the capital expenditure required to purchase additional transit stock.

Unlike the foregoing TSM options, the traffic engineering costs are scheduled for the year in which the capacity problem has been estimated to occur, as are the construction costs.

Figure 1 presents a comparison of the capital costs required to fund the 15-year capital improvement programs for both the construction and TSM scenarios detailed in Table 5. These scenarios are based on 1983 base data. As shown in Figure 1, because the needs associated with the 1983 and 1984 costs have not yet been met, these costs have been carried forward to 1985.

Not surprisingly, the construction scenario would require a capital layout many times larger than the TSM scenario, with 1985 requiring the largest initial capital expenditure for both scenarios. The capital layout of $2.90 million for TSM during 1985 comprises 48.01 percent of total TSM program costs ($6.04 million), whereas the capital layout of $16.60 million for construction during 1985 comprises 50.61 percent of total construction program costs ($32.08 million). These initial costs associated with both scenarios represent a substantial portion of the program needs that have not yet been met, indicating that Winston-Salem's transportation funding requirements have not kept pace with its transportation demands.

The potential capital-cost savings associated with the implementation of the systemwide TSM program are overwhelming when compared with those for the construction program. A comparison of the TSM and construction cumulative capital costs associated with the 15-year capital improvement program (1985 to 2000) costs as shown in Figure 1 reveals the following:

1. TSM cumulative capital costs for 1985 ($2.90 million) comprise 19.52 percent of comparable construction capital costs ($16.60 million); that is, the construction program is 4.72 times more costly than the TSM program, thus indicating a potential cumulative capital-cost savings of $13.70 million associated with the TSM program.

TABLE 5 COMPARISON OF ANNUAL CAPITAL COSTS BETWEEN TSM AND CONSTRUCTION ALTERNATIVES: WINSTON-SALEM

| Year | Transportation System Management (TSM) | | | | | Construct |
|---|---|---|---|---|---|---|
| | Rideshare | Stg. Wr. Hr | Transit | Traf. Eng. | Total | |
| 1983 | $ 1680 | $ 400 | $ 0 | $ 2754800 | $ 2756880 | $ 14493200 |
| 1984 | 3940 | 960 | 0 | 117000 | 121900 | 1700000 |
| 1985 | 6440 | 1560 | 0 | 10600 | 18600 | 405000 |
| 1986 | 9100 | 2200 | 0 | 77400 | 88700 | 1165000 |
| 1987 | 12040 | 2920 | 0 | 309600 | 324560 | 1942100 |
| 1988 | 15760 | 3760 | 135000 | 75000 | 229520 | 1330000 |
| 1989 | 19600 | 4660 | 0 | 205000 | 229260 | 1042200 |
| 1990 | 24720 | 5840 | 0 | 215300 | 245860 | 4293000 |
| 1991 | 29940 | 7020 | 0 | 0 | 36960 | 0 |
| 1992 | 35420 | 8260 | 0 | 21800 | 65480 | 1400000 |
| 1993 | 41720 | 9600 | 0 | 0 | 51320 | 1539000 |
| 1994 | 48140 | 11020 | 270000 | 20300 | 349460 | 2100000 |
| 1995 | 54800 | 12520 | 0 | 13200 | 80520 | 80000 |
| 1996 | 61640 | 14140 | 135000 | 0 | 210780 | 534600 |
| 1997 | 68520 | 15820 | 0 | 0 | 84340 | 0 |
| 1998 | 75640 | 17740 | 135000 | 31000 | 259380 | 55000 |
| 1999 | 82800 | 19740 | 540000 | 0 | 642540 | 0 |
| 2000 | 90080 | 21780 | 135000 | 0 | 246860 | 0 |
| Totals: | $ 681980 | $ 159940 | $ 1350000 | $ 3851000 | $ 6042920 | $ 32079100 |

2. TSM cumulative capital costs for 1990 ($4.02 million) comprise 15.24 percent of the comparable construction capital costs ($26.37 million); that is, the construction program is 5.60 times more costly than the TSM program, thus indicating a potential cumulative capital-cost savings of $22.35 million associated with the TSM program.

3. TSM cumulative capital costs for 1995 ($4.60 million) comprise 14.60 percent of the comparable construction capital costs ($31.50 million); that is, the construction program is 5.85 times more costly than the TSM program, thus indicating a potential cumulative capital-cost savings of $26.90 million associated with the TSM program.

4. TSM cumulative capital costs for 2000 ($6.04 million) comprise 18.87 percent of the comparable construction capital costs ($32.08 million); that is, the construction program is 4.31 times more costly than the TSM program, thus indicating a potential cumulative capital-cost savings of $26.04 million associated with the TSM program.

As shown by both Table 5 and Figure 1, the successful implementation of the systemwide TSM program (recognizing the need for innovative TSM policy changes and separate TSM funding sources) would have the ability to generate substantial cost savings and at the same time provide an acceptable level of service comparable to the construction program. The potential cumulative cost savings ($26.04 million) associated with the 15-year TSM capital program suggest that every dollar invested in TSM would have the ability to defer or replace $5.31 in construction costs or generate $4.31 in savings. The potential to increase the purchasing power of scarce tax dollars would be great. However, in the real world, it is obvious that neither of these programs would be implemented in its entirety.

The primary advantage of such an analysis is that it identifies the potential cost savings that could be realized from TSM. Also, it establishes a comprehensive approach designed to estimate TSM program needs based on future transportation demand, comparable to the highway construction program. This process also enables TSM professionals to document the economic advantages of modal trade-offs in their efforts to justify specific budget requirements.

For example, consider the recurring political implications associated with the highway construction program when it needs additional tax dollars. Without supporting documentation based on a comprehensive long-range planning approach designed to forecast transportation needs, the justification for public tax dollars would become even more burdensome. Not only does this urban highway planning approach help to justify revenue needs, it also aids in the documentation of needed policy changes required to generate such revenues. Similarly, the TSM capital-cost program provides an analogous approach in documenting revenue needs and the necessary lead time required to implement the difficult policy changes needed to generate public acceptance of innovative TSM measures. In other words, if TSM is to be more successful in improving urban transportation systems, its planning process has to be at least as comprehensive as, and an integral part of, the urban highway planning and construction program.

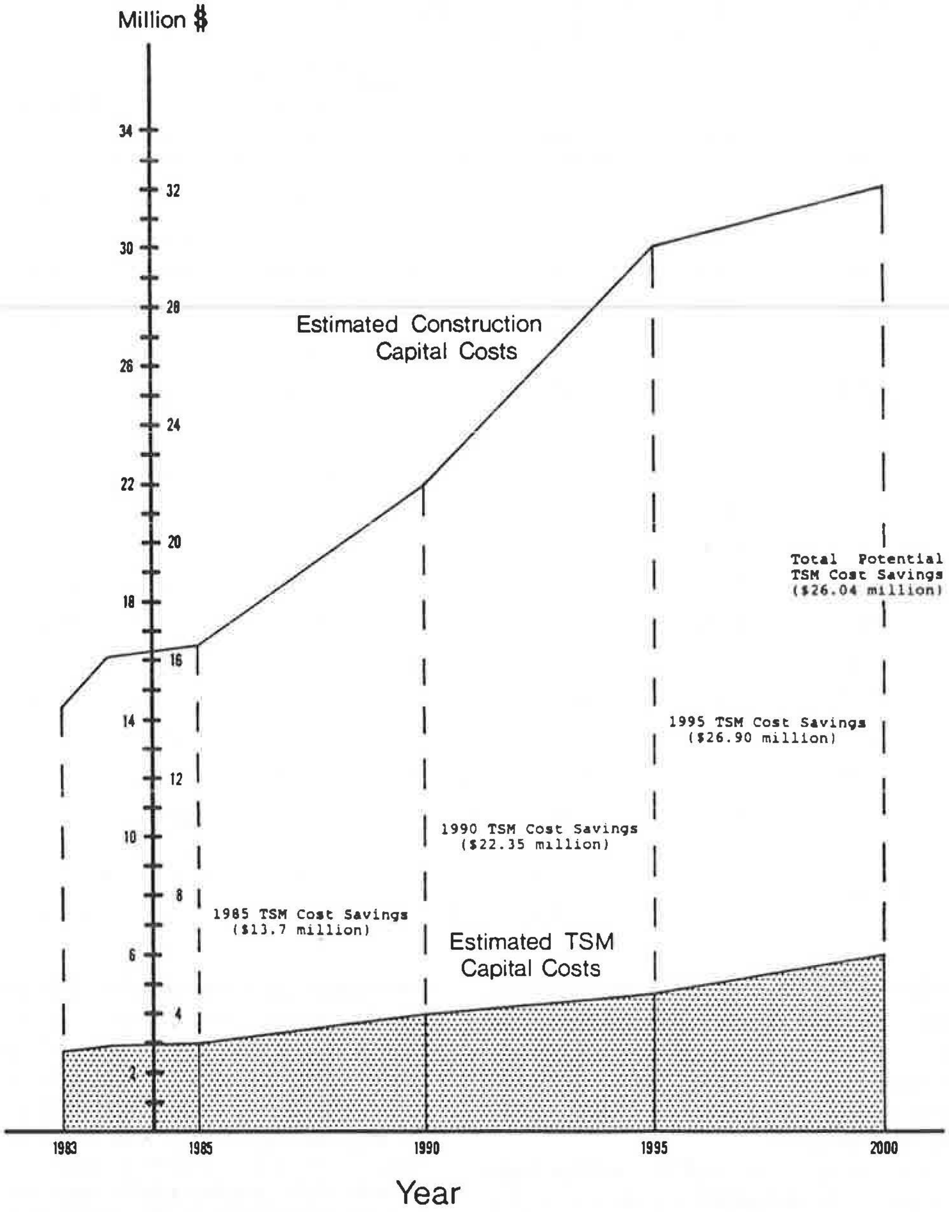

**FIGURE 1 Comparison of TSM and construction cumulative capital-cost program.**

## PROSPECTIVE TSM MANAGEMENT PROGRAM

Although the demands on the urban transportation system continue to grow, elected officials and professionals continue to be pressured to plan for an even larger urban highway infrastructure with only limited concern for any financial constraints. The compounding effect of inflation, coupled with project overplanning that exceeds available funding many times over, accelerates urban demand for funds at an unmanageable rate.

Perhaps an analogy can be drawn to the business community, where one key to any successful business is the development and implementation of an effective management plan. Such a plan is designed to maximize profits by ensuring that investments are made in an effort to produce the greatest rate of return. When the TSM input costs (TSM capital-costs program = $6,042,920) are compared with the construction input costs (construction capital-costs program = $32,079,100), both of which could produce the same output (operation of the facility at level-of-service D), it is evident that TSM maximizes the benefits of its available revenue potential. Of course, few businesses have a board of directors as large and diverse in opinion as the general motoring public.

Another attribute of the business approach is the provision of a marketable product in response to consumer demand. In U.S. government context, that product, of course, typically would be additional urban highway access and expansion, with TSM relegated to a much less frequently demanded commodity.

Although the concept of TSM is well understood, it continues to be treated as a short-term demand-responsive measure. Unlike the planning and development of the urban highway system, TSM has not grown or developed as an integral part of the transportation system. As a result, many professionals, guided largely by public pressure, remain reluctant to consider TSM as a workable alternative to construction.

It is judged that this systemwide TSM planning methodology can help provide officials and professionals with a necessary tool to better consider TSM options, resulting effects, and necessary steps to bring about the results.

The effective management of urban transportation systems requires that TSM planning encompass both short- and long-term horizons, as does the development of the urban highway system. The TSM requirements (i.e., designated actions to accommodate a targeted portion of the transportation demand) ideally should be conceived well in advance of their need (i.e., before a system begins to operate at an undesired level of service) in order to be given the opportunity to grow and develop as an integral part of the urban transportation system.

If TSM were to be planned in this manner, it is the author's perception that policy initiatives designed to support TSM could be considered and developed in advance of a corridor's congestion problem and before commuting habits were well established. Before the year of the estimated congestion problem, a portion of the number of person-trips estimated to be accommodated or diverted from the peak hour to maintain level-of-service D could be targeted by the various TSM programs. This gradual process of implementation over time would likely produce the necessary modal changes.

As is the case with any new product perceived to be of lesser quality and designed to capture a portion of an existing product's market that has been proven and accepted by the consumer, precise timing and adequate exposure are required to gradually introduce the attributes of the new product to an otherwise reluctant consumer if the desired market share is to be obtained. In the same context, TSM should be introduced at an appropriate time before a corridor develops a congestion problem in order to provide the necessary lead time to capture a designated portion of the traffic demand.

Of course, current transportation policy, or lack thereof, generally supports the use of the SOV for the daily work trip until the highway system becomes congested. Then the public may be requested to consider alternative transportation modes, which consist of both voluntary and mandatory measures. These measures are sometimes designed to persuade the public to instantly shift to a higher-occupancy vehicle, which restricts the freedom of movement they enjoy by using their own vehicle. Consequently, the introduction of TSM measures at this time (i.e., when a corridor exceeds its desired vehicle capacity) is often viewed as undesirable and the public's resentment of sporadic changes often precludes the ability of TSM to extend the economic life of a corridor.

In the majority of urban areas, major congestion problems currently exist and the introduction of TSM measures on such corridors is not provided the luxury of being gradual. Therefore, the effective implementation of TSM requires a strong commitment from both an urban area's political leaders and those responsible for the management of sizable employment centers (say, those with 50+ employees) in order to mitigate the congestion to an acceptable level of service. With the comprehensive systemwide TSM planning approach, which estimates the number of person-trips required to be accommodated or diverted during the peak hour from the inception of the capacity problem through the design year, as done in the Winston-Salem study, it is possible to determine the percent of congestion generated by each employment center. The number of person-trips to be accommodated can be equally distributed among the area's employment centers on the basis of the percent of each center's employment of the total area's employment.

Collectively, this concept acts to place an equal burden and responsibility on each employment center, which is a much more systematic approach than merely contacting only those few with, say, 200+ employees. In turn, the employers have well-established annual goals (i.e., based on the number of persons), which can be used to measure their effectiveness, instead of vague, nondescriptive goals that are not directly associated with transportation demand. Moreover, if a few major employers are not singled out as those contributing to the congestion, a unified approach will most likely generate a greater level of participation among them. In addition, this amount of congestion associated with each employment center could be converted into a "congestion tax" to develop corporate tax incentives designed to bring about greater participation.

It is essential to inform employers of the urban congestion problem and to make it apparent that their business-related activities are the source of the problem during the peak hours. The business community bases their decisions on facts and not good will, so it is important that they see the supporting documentation showing where they fit into the overall picture. To appeal to them, a more factual approach detailing the congestion problem and benefits of TSM is needed, that is,

1. The magnitude of the existing and future urban congestion problems,
2. The source of the existing and future urban congestion problems as they relate to each employment center,
3. The economic impact these problems may potentially have on business activities (i.e., deterioration of the economic base caused by businesses relocating or new business locating in fringe areas, which could result in loss of employees or shoppers), and
4. The economic advantages of extending the life of existing highway facilities through effective transportation management techniques (i.e., tax-dollar savings).

This approach, coupled with the traditional approach, which relies heavily on TSM marketing techniques designed to inform the employer and employee of personal benefits of TSM, should produce far greater results than either approach alone.

Also, the transportation professionals responsible for these various programs need to better coordinate their planning function in an effort to develop a qualitative and comprehensive plan that parallels the urban highway planning process. Appropriately, this plan should provide the factual data necessary to justify program goals and budget requirements. Moreover, the alternatives of this plan should complement the construction alternatives.

To best achieve this objective, the scheduling and timing of program needs should be designed to extend the economic life of the existing system before it is enlarged. This does not imply that new roadways needed to induce economic growth should not be built. Instead, the scheduling and timing of TSM alternatives should be based on their potential and directed toward managing the existing system in an effort to minimize capital expenditures. As with the case with most urban areas, the existing congestion problems preclude this process and, as stated earlier, a strong commitment from the political and business community is required.

This commitment is essential to obtain the required policy changes and without quantitative documentation supporting TSM benefits, it is highly unlikely that such support will be pledged. Such an initiative has to be undertaken by an area's transportation professionals and adopted as part of the urban planning process. Policy initiatives detailing the implementation of this planning process have to be supported by top elected and appointed officials (mayors, council members, planning board members, etc.). In turn, these officials have to effectively communicate to the public and business leaders the source of the congestion problems and the advantages of managing the urban transportation system.

As a result of the potential economic benefits to be derived from the deferment or replacement of construction alternatives, TSM planning demands a well-conceived comprehensive approach coupled with an effective implementation mechanism designed to exhaust its potential.

## SUMMARY AND CONCLUSIONS

The traditional reality that TSM has a minimal effect at best suggests that it generally is a less desired product or is not properly structured to penetrate the market. Regardless of which may be the case, financial implications of TSM make it necessary to revise the existing structure in an effort to better identify its market share as well as the strategies necessary for it to effectively penetrate the market.

The systemwide TSM program described here is offered as a tool and a step toward this end. It can provide the data necessary to determine an employment center's contribution to the capacity problem and thus its corresponding responsibility to help mitigate this problem. It can detail the effect that higher vehicle occupancy rates, increased transit frequencies, and traffic engineering improvements would have on an urban corridor. In short, it can provide the technical base from which public implementation policies could be developed in order to better incorporate TSM into solutions to the urban transportation dilemma.

The urbanized area of Winston-Salem is considered to have one of the state's more progressive and successful TSM programs. Over the years, its ridesharing and transit efforts have received national attention as a result of their effective implementation and management. With the area's strong TSM commitment and successful TSM track record, it is believed that the systemwide TSM planning approach will further enhance the area's ability to continue effective transportation management techniques.

The systemwide TSM analysis has been well received by the engineering, planning, and transit staff of the Winston-Salem urbanized area and is planned to be updated in the fall of 1988. To date, a portion of the traffic engineering capital costs (from 1985 to 1992) has been submitted as part of the area's Capital Improvements Program. Portions of the remaining TSM capital costs are planned to be included as part of an urban needs package that will be submitted to the public as justification for a bond referendum. Also, the project designated District 5, Segment 6, of this analysis together with other TSM improvements have been submitted as a TSM demonstration project to the Board of Transportation for funding.

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