Multicorridor Project Traffic Analysis

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An approach used by the Puget Sound Council of Governments to analyze the regional traffic impacts of alternative major regional transit investments is described and evaluated. Because the transit system capacity increases resulting from each alternative were roughly equivalent and the proportion of overall regional travel carried by transit was relatively small, the traffic impacts of the alternatives did not differ significantly on a regional scale. The technical analysis was of a general nature and was aimed at elected officials and the public, who often do not have a comfortable grasp of the meaning and implications of *v/c* data as they relate to traffic congestion. The problem is more easily understood when presented in terms of length of the peak period or the number of hours of congestion. One of the key elements of the regional traffic analysis was to determine the length of the peak period on various segments of the highway system. For the purposes of this analysis, length of peak was defined to be the number of hours during which level-of-service E conditions exist (*v/c* greater than 0.90). Peak-period length was estimated empirically on the basis of the average *v/c* for a longer time period. A linear regression equation was developed to represent the relationship between 12-hr average *v/c* and the number of hours of *v/c* greater than 0.90 for a set of actual freeway counts. Traffic assignments were plugged into the regression equation to generate estimates of future congestion. The analysis results provided a good sense, not only of relative congestion problems, but also of the magnitude of those problems in absolute terms. The analysis approach proved to be useful educationally as well as simple and straightforward computationally.

An approach used by the Puget Sound Council of Governments (PSCOG) to analyze the regional traffic impacts of alternative major regional transit investments is described and evaluated. First, however, it is important to understand the context in which it was applied.

The bottom line to the various growth and travel forecasts for the central Puget Sound region (Seattle-Tacoma-Everett) is much the same as that in other expanding urban-suburban areas: growth in regional travel demand resulting from continuing increases in population and employment will lead to increasingly severe congestion in major transportation corridors unless (or even if) additional capacity is provided.

Policies adopted in the Regional Transportation Plan (RTP) recognize that additional capacity will be required in the major transportation corridors to implement urban development and activity center policies. The RTP policies further state that most new capacity in major corridors should be provided by investment in transit and high-occupancy-vehicle (HOV) facilities and services.

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MULTICORRIDOR PROJECT

In response to these policies, the PSCOG Executive Board and the Municipality of Metropolitan Seattle (Metro) Council in 1984 initiated a 2-year effort called the Multicorridor Project to analyze alternative major transit and HOV investments in the region's three highest-priority corridors (see Figure 1).

The purpose of the Multicorridor Project was to identify the best long-range transit or HOV alternatives for the three corridors in terms of (a) corridor utilization trade-offs (among transit, HOVs, and other users), (b) cost-effectiveness, (c) support for regional and local land use plans, (d) user benefits, and (e) impacts. The main purpose of the traffic analysis conducted for the Multicorridor Project, then, was to compare the traffic impacts of the major transit investment alternatives in order to identify impacts that would make a difference in the selection of a preferred alternative.

After a screening process and preliminary cost, ridership, and impact analyses, three basic regional transit system alternatives were selected for detailed analysis. These included the baseline-bus alternative, the trunk–feeder-bus alternative, and the bus-LRT alternative. The baseline-bus alternative included a major expansion of the existing transit-HOV system, including more local bus service, more express bus service, more

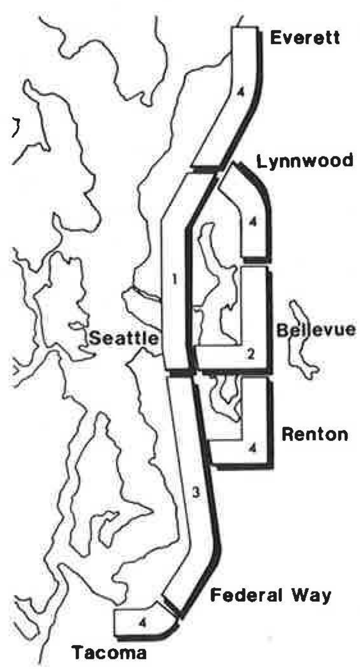

FIGURE 1 Transit corridors.

park-and-ride lots, more HOV lanes, more transit centers, and so on. The trunk–feeder-bus alternative was based on a fundamental change in the route structure of the existing bus system that would introduce an extensive system of line-haul bus service on major highway facilities (trunks), with local bus service feeding it (feeders). Finally, the bus-LRT alternative included an LRT line in each of the three highest-priority corridors. The rail lines were to be fed by local bus service, with supplementary bus service connecting activity centers not served by LRT. Two variations of the LRT alignments in each corridor were assessed.

Given the rough equivalence of the transit system capacity increases included in each alternative and the relatively small proportion of overall regional travel that is carried by transit, it was recognized from the outset that the traffic impacts of the alternatives would not be fundamentally different on a regional scale. Nevertheless, differences worth noting or crucial flaws might exist at specific locations or along specific highway segments. The traffic analysis was designed on these premises. A general assessment of the overall regional highway system was made, with more detailed analyses focusing on specific screenlines and small areas of interest.

CONCEPTUAL APPROACH FOR REGIONAL TRAFFIC ANALYSIS

Despite the expected similarity among future regional traffic conditions under the various alternatives, the regional portion of the traffic analysis was not considered to be an unnecessary exercise. The regional traffic analysis was useful in that it painted a general picture of future conditions on the regional highway system. This provided an important context for the Multicorridor Project decisionmakers (local elected officials) and for the public.

Rather than a more technical analysis geared solely toward technical staff, then, the regional traffic analysis was of a general nature and was aimed at a lay audience. For this audience, the typical means of presenting traffic congestion information—peak-hour or peak-period volume-to-capacity ratios (*v/c*)—was deemed inappropriate. Elected officials and the public often do not have a comfortable grasp of the meaning and implications of *v/c* data, and transportation planning and engineering professionals themselves have argued over how to interpret traffic forecasts that result in computed peak *v/c*'s greater than 1.0. In addition, the accuracy of the future *v/c*'s was suspect, because the ratios were computed by simply taking assignments of daily traffic and applying a rule-of-thumb 8, 9, or 10 percent factor to compute the peak-hour traffic volumes (peak-period assignments were not used for lack of a good peak-period trip table). Finally—and most important—peak *v/c* information does not adequately describe future congestion in a way that elected officials and the public can easily comprehend. It would be more understandable if expressed in terms of the length of the peak period or the number of hours of congestion.

For the foregoing reasons, one of the key elements of the regional traffic analysis was to determine the length of the peak on various segments of the highway system. For the purposes of this analysis, length of peak was defined as the number of hours during which level-of-service E conditions exist (*v/c* greater than 0.90). The analysis focused on the afternoon and evening hours, because in most cases the p.m. peak is longer than the a.m. peak.

PEAK-PERIOD LENGTH

Peak-period length was estimated empirically by using an approach based on the thesis that the number of hours of congestion on a given freeway segment varies with the average *v/c* for a longer time period (e.g., 12 or 24 hr, the time period for which traffic assignments are available). In other words, the higher the daily or 12-hr traffic volume relative to capacity, the longer the peak period. (A corollary to this thesis suggests that the peaking characteristics on currently congested freeway segments elsewhere in the country provide a more realistic model of future local peaking characteristics than would an extrapolation of current, less-congested local conditions.)

In order to test the thesis as well as to actually estimate peak-period length at various points on the regional highway system, traffic count data were obtained from a number of U.S. cities. Hourly counts were obtained for 50 directional freeway segments in Seattle; Portland, Oregon; Chicago; suburban northern Virginia; and San Francisco–Oakland. (The amount of data collected was dictated by the Multicorridor Project schedule, not by statistical requirements.) In each case, the hourly counts included a composite of 1 to 2 weeks' worth of weekday counts. The data set contained four downtown freeway segments, 20 central city radial segments, 24 suburban radial segments, and two suburban circumferential segments. Several

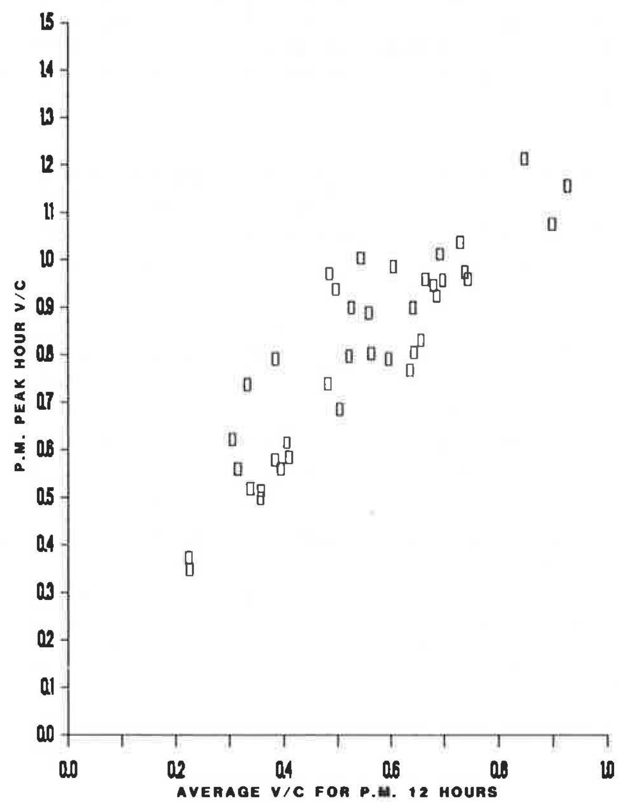

FIGURE 2 P.M. peak and 12-hr *v/c*.

of the radial segments had peak flows in both directions, whereas others were highly directional (i.e., inbound in the morning and outbound in the evening).

The analysis of the traffic counts and assignments focused on the 12-hr period from noon to midnight in order to avoid inconsistencies created by differing directional splits and peaking characteristics on different freeway segments. Because some segments experience peaking in both directions in both the morning and the afternoon whereas others only experience the typical peaking (inbound in the morning and outbound in the afternoon), two segments with similar afternoon peaks could have very different 24-hr average *v/c*'s. It would have been useful to further separate the data and analysis by freeway type—radial versus circumferential or urban versus suburban, or both—but there were insufficient data to do so. Focusing on the 12-hr p.m. period (and thereby accounting for directional split and peaking) accounts for much of the difference between different freeway types.

The relationship between p.m. peak length and the p.m. 12-hr average *v/c* for the freeway counts was assessed by comparing several characteristics of the individual counts, including the peak-hour *v/c*, the *v/c*'s for each of the 12 hr between noon and midnight, the proportional distribution of traffic volume over the 12 hr, and the number of hours during which *v/c* exceeded 0.90.

Three of these comparisons are shown in Figures 2 through 4. Figure 2 shows the peak-hour *v/c*'s for the various freeway counts plotted against their corresponding p.m. 12-hr average *v/c*. Not surprisingly, peak-hour *v/c* increases with increasing 12-hr average *v/c*. In addition, the rate of increase of peak-hour *v/c* decreases with increasing 12-hr average *v/c*, indicating that at higher 12-hr volumes the peak is more spread out. This information supports the thesis that the number of hours of congestion (i.e., length of peak period) increases with increasing 12-hr average *v/c*.

Grouping the counts by 12-hr average *v/c* yielded some interesting insights into the different traffic demand patterns on congested and free-flowing freeways. The counts were divided into five groups on the basis of 12-hr average *v/c*: 12-hr *v/c* greater than 0.8, 0.7 to 0.8, 0.6 to 0.7, 0.4 to 0.6, and less than 0.4. Proportion of 12-hr volume and *v/c* were computed for each count for each p.m. hour. These proportions and *v/c*'s were then averaged within each group. Figure 3 shows the group average hourly *v/c*'s for the five groups. Here again, the results were not surprising: the group average *v/c*'s in any given hour were higher for the groups with higher 12-hr average *v/c*.

Figure 4 shows the hourly proportions of total 12-hr volume averaged for each group of counts. The proportion of 12-hour traffic occurring in the early afternoon is somewhat higher for the groups with the lower 12-hr average *v/c*'s. This difference is much more pronounced in the afternoon peak period, when the groups with the higher 12-hr *v/c*'s have a much smaller average proportion of 12-hr traffic than do the groups with lower 12-hr *v/c*'s. This progressive flattening of the peaks with increasing 12-hr *v/c* is further evidence that the congested period on freeways increases in length with increasing 12-hr average *v/c*. The proportions reverse in the evening and night hours; the groups with low 12-hr *v/c* have the lowest hourly proportions.

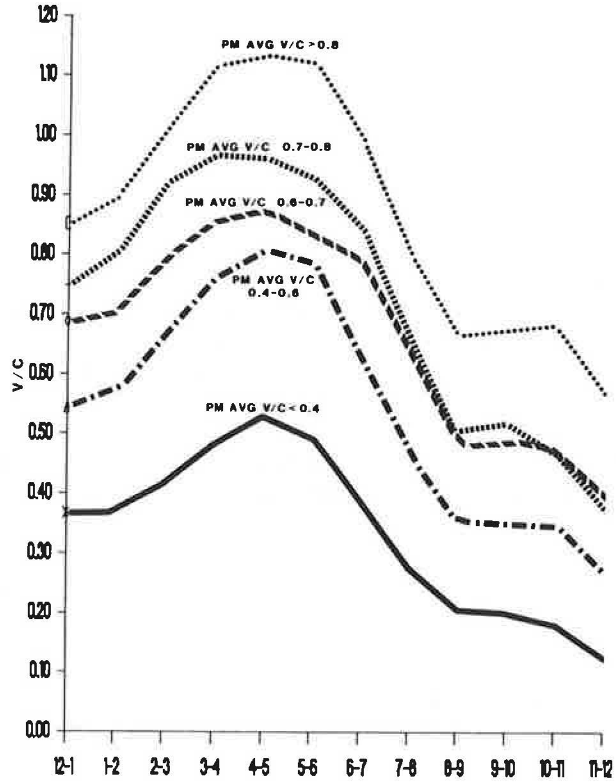

FIGURE 3 Hourly *v/c*.

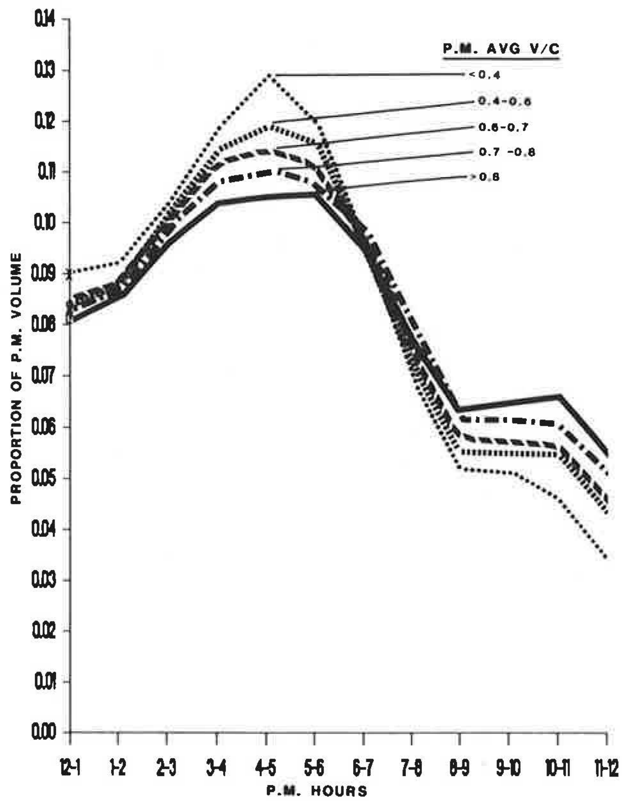

FIGURE 4 Hourly proportion of 12-hr traffic.

METHODOLOGY

Two methods of computing the number of hours of congestion were developed. The first used the hourly proportions of the 12-hr volume averaged for each group of counts. Applying the proportions to forecast freeway volumes yielded hourly volumes from which hourly *v/c*'s were computed. The number of hourly *v/c*'s exceeding 0.90 was then counted. The second method developed a linear regression equation to represent the relationship between 12-hr average *v/c* and the number of hours of *v/c* greater than 0.90 for the full set of individual counts.

Both of these methods require as input directional traffic volume for the 12 p.m. hr. Because the traffic assignments available were two-way daily assignments, the directional 12-hr volumes had to be estimated. The first step was to estimate the two-way traffic volume in the 12 p.m. hr. Based on the p.m. percentages computed from the available freeway counts, p.m. volume was assumed to be 60 percent of the 24-hr total. (The 25 or so freeway segments carried an average of 59.7 percent of daily traffic between noon and midnight; standard deviation of this data was only 2.6 percent.) Next, the directional p.m. volumes were determined by estimating the directional splits of two components of p.m. traffic. One component was the 20 percent of daily traffic represented by the difference between a.m. and p.m. volumes (60 percent minus 40 percent). This was assumed to be traffic making a round trip entirely during p.m. hours, and it was assumed to have a 50-50 directional split. A peak-period traffic assignment was run, and the directional splits were used to estimate the directional split of the remainder of the p.m. volume (40 percent of daily).

For each link analyzed, then, p.m. 12-hr directional traffic volume was computed by multiplying the two-way daily volume by the following factor:

$$\text{Factor} = (0.1) + (0.4 \times \text{peak-period directional split}) \quad (1)$$

The following linear regression equation, derived from the freeway count data shown in Figure 5, was then used to estimate the number of p.m. hours in which volume would exceed 90 percent of capacity on each link:

$$\text{No. of hours with } v/c > 0.9 = [13.92 \times (\text{12-hr average } v/c)] - 6.25 \quad (2)$$

Using a spreadsheet, it was a fairly simple task to compute for the various freeway links the directional p.m. 12-hr volumes, the p.m. 12-hr average *v/c*, and finally, the hours of congestion. Lotus 1-2-3 was used for this project, but the computations are so straightforward that virtually any spreadsheet program could be used. Computations are done individually for each link, so the spreadsheet contained one row for each link. Vertically, in addition to link identification columns (e.g., road name, A Node, B Node), the spreadsheet should have five input data columns: daily traffic; capacity; peak-period traffic, A–B; peak-period traffic, B–A; and peak-period directional split (computed from the directional peak volumes). A final column is used to compute the number of hours of congestion using Equations 1 and 2.

Using the hourly proportions of 12-hr volumes and linear regression—the two methods of computing hours of congestion—yielded similar results. The linear regression method was employed for the Multicorridor Project because of its computational simplicity and the consistency of its results.

APPLICATION

The methodology just described was applied to the Multicorridor Project traffic forecasts. Estimated hours of congestion were computed for each freeway link in the Multicorridor Project study area. For all but a handful of the most congested links in the system, the computation of hours of congestion involved interpolation of the traffic count data; that is, the forecasted average *v/c*'s for Seattle area freeways were within the range of average *v/c*'s that actually occurred on the freeway segments for which counts were available. This made the results of the analysis more credible, because it was not necessary to extrapolate the worst freeway conditions experienced elsewhere and claim that the Seattle area should expect worse.

The results of the Multicorridor Project traffic analysis as they were presented to local elected officials and the public are shown in Figures 6 through 8, which show the number of hours of congestion on the freeway system computed from daily traffic assignments for 1980, 2000, and 2020. The first thing to note is that even though the number of hours of congestion were computed with some superficial precision, they were presented in very broad terms, as befits their actual range of accuracy.

The 1980, 2000, and 2020 congestion analysis results provided the same basic information that the more traditional

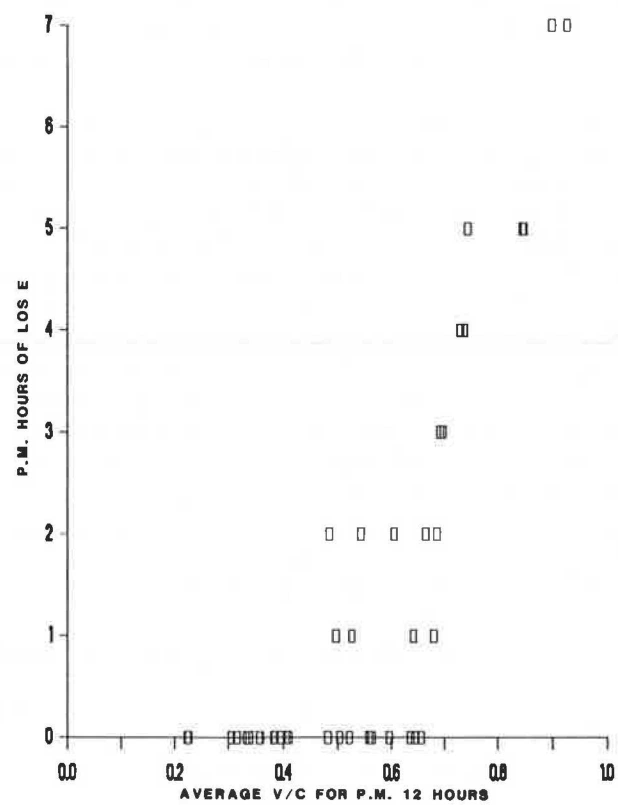

FIGURE 5 Hours of congestion.

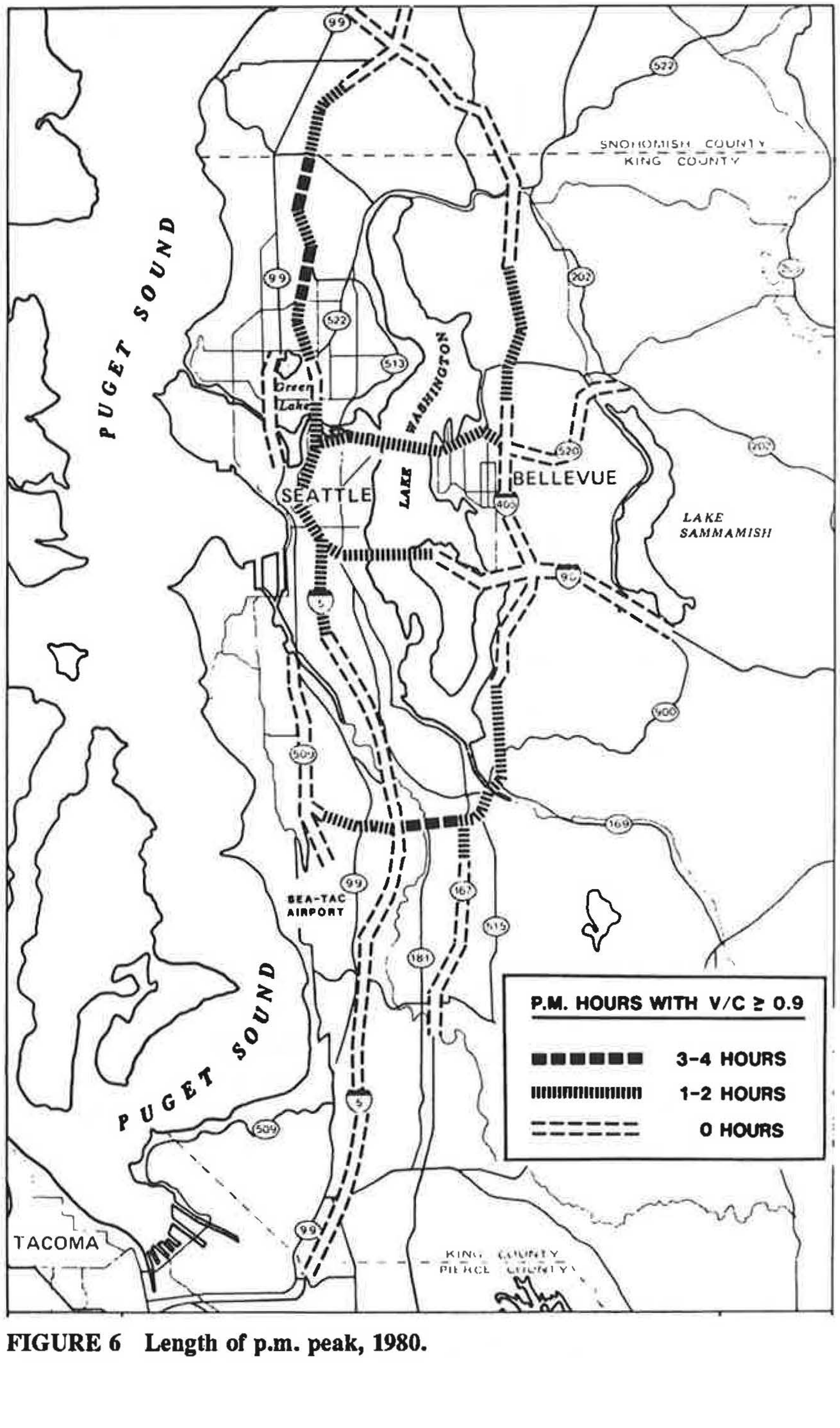

FIGURE 6 Length of p.m. peak, 1980.

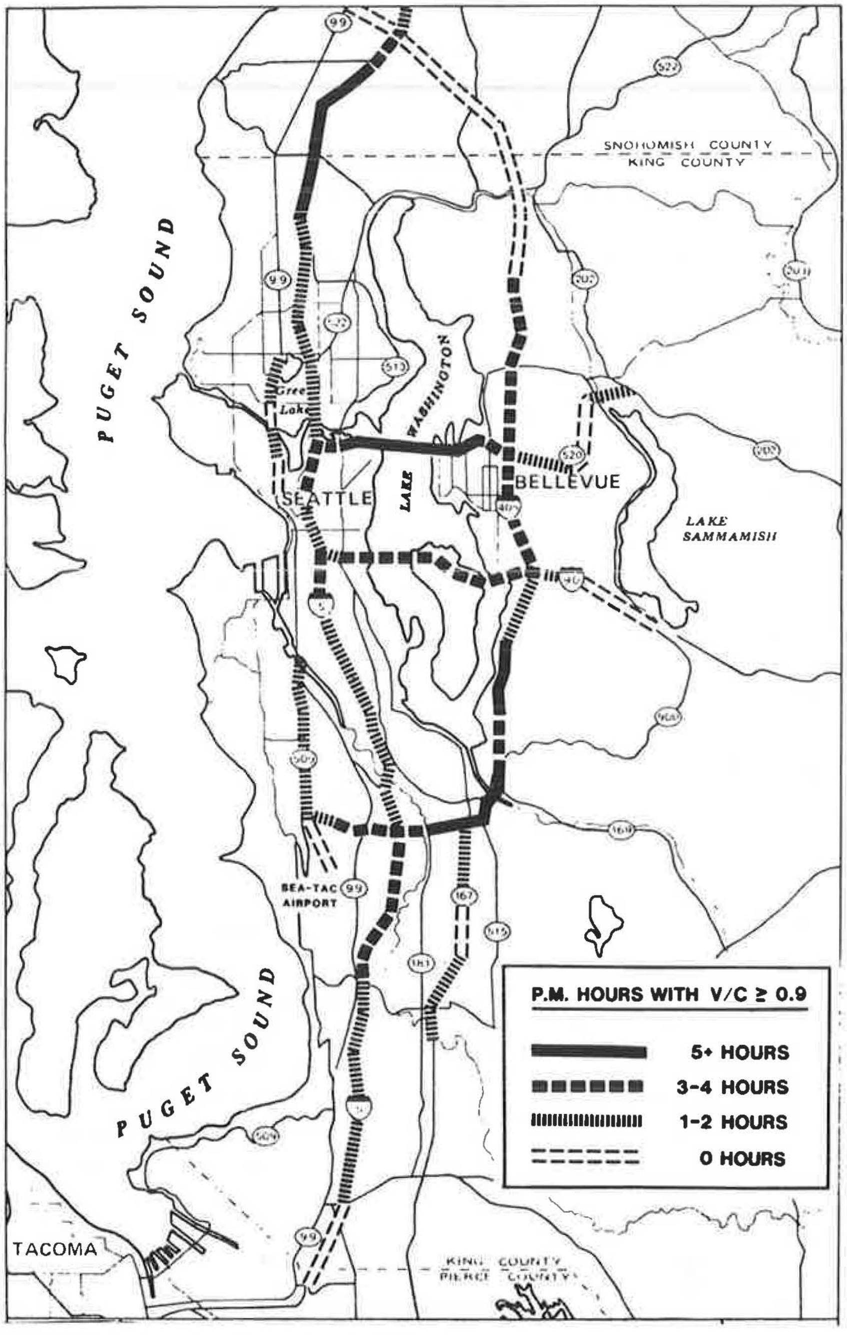

FIGURE 7 Length of p.m. peak, 2000.

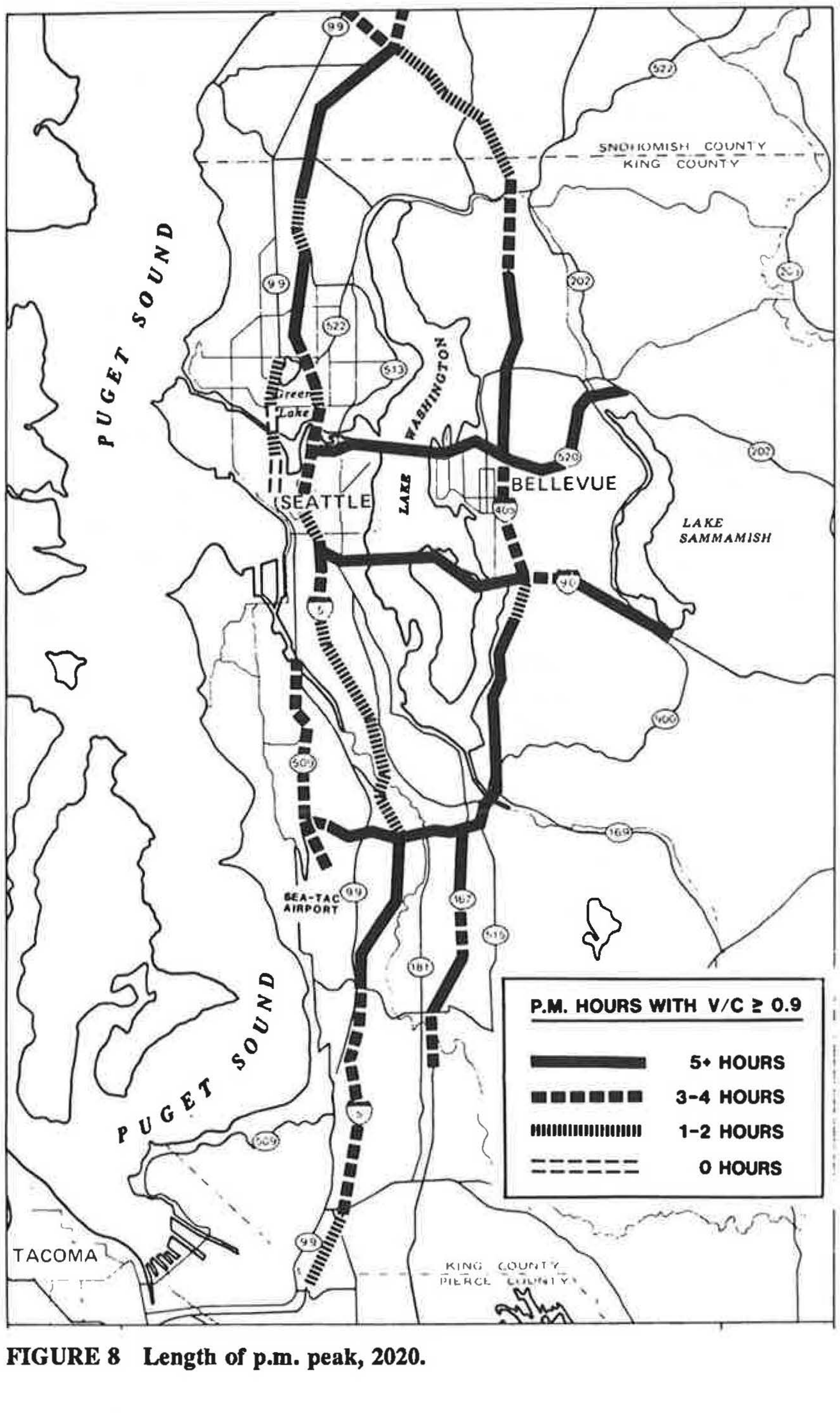

FIGURE 8 Length of p.m. peak, 2020.

analysis of peak-hour v/c ratios provides, for example, geographical distribution of congestion problems, growth of congestion over time, and identification of freeway segments with significant congestion problems. Figures 6 through 8 clearly show the increasing congestion to be expected in the future and the extent to which that increasing congestion spreads out into the suburbs. Also evident is the outward migration of the bottlenecks and constraints that control the overall capacity of the freeway system as a whole. For example, the main capacity constraint on I-5 in the North Corridor (the region's most heavily traveled corridor, extending from downtown Seattle to south Snohomish County) is currently the section just to the north of the downtown. In the future, however, I-5 congestion at the King–Snohomish County line will have more of an effect on who the corridor serves and how it operates than will the closer-in segments.

In addition, however, this congestion analysis provides some things that the more traditional analyses do not. Most important, this analysis gives transportation professionals, as well as elected officials and the public, a good sense not just of relative congestion problems (alternative a versus alternative b, or 2000 versus 2020), but also of the magnitude of those problems in absolute terms. It is easier to relate to, understand, and project what is meant by "5-hr peak period" than "peak hour v/c = 1.21." As a result, the traffic analysis for the Multicorridor Project was more informative and less distracting (from the major transit investment decision at hand) than it would have been otherwise.

By analyzing length of peak directly, the multicorridor traffic analysis also anticipated several questions that invariably arise when peak-hour v/c information is presented. When v/c's in excess of 1.0 show up, professionals and lay persons want to know how much of the excess traffic will actually materialize, how much will be diverted, and how much will divert to traveling at a less congested time. This analysis addressed these concerns before they had to be voiced.

CONCLUSIONS

The traffic analysis approach described in this paper proved to be useful in educational terms. It was also simple and straightforward computationally. The methodology for freeways could be refined by basing the relationship between average v/c and hours of congestion on more actual data and possibly using a curve-fitting technique more sophisticated than linear regression. With adequate traffic count data, the analysis could also be applied to arterials. And finally, this methodology can be used to forecast the number of hours at level-of-service F, or the so-called levels-of-service F-1, F-2, and so on, that are now gaining acceptance in traffic engineering circles.

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