Summary of Final Report, BC-354-92
June 2005

FACILITY PERFORMANCE MODEL ENHANCEMENTS FOR MULTIMODAL SYSTEMS PLANNING (Part II)

PROBLEM STATEMENT

This project consisted of two tasks (herein identified as Task 3 and Task 4), which are described in separate sections. It should be noted that this project was a continuation of a previous project, *Facility Performance Model Enhancements for Multi-Modal Systems Planning: Part I, BC354-38*.

Task 3: Development of a Procedure for Estimating Level of Service on Rural Freeways

The Highway Capacity Manual (HCM) contains a methodology for evaluating Level of Service (LOS) on basic freeway segments. This methodology prescribes one service measure, density, for assessing LOS and one set of LOS thresholds. While this methodology seems to apply fairly well to freeway segments in urban areas, the Florida Department of Transportation (FDOT) has had difficulty applying this methodology to freeway segments in rural areas. Rural freeways can differ significantly from urban freeways. For example, rural freeways typically have greater distances between interchanges, higher speed limits, and a higher percentage of social and recreational trips (and lower percentage of work and shopping trips) than urban freeways. Urban freeways typically experience the full range of traffic congestion conditions whereas rural freeways rarely experience enough traffic congestion to cause significant travel speed reductions. Rural freeway travelers likely expect these free-flowing conditions and take travel time for granted, while urban freeway travelers are probably more concerned with their overall travel time and the reliability of this travel time. Historically, the Highway Capacity and Quality of Service (HCQS) committee has selected facility LOS analysis methodology performance measures and corresponding thresholds based upon their own expert opinion and judgment. The intent is that the chosen performance measures and thresholds are highly correlated with traveler perceptions of quality of service. The FDOT, however, believes that the use of density and, especially, its HCM LOS thresholds do not correlate well with traveler expectations and perceptions of quality of service on rural freeways.

Task 4: Investigation of Capacity Values for Freeway Merge and Diverge Areas

The HCM prescribes operations analysis methodologies for basic freeway segments and ramp junctions. The ramp junctions analysis chapter implies that capacity in the outer two lanes of a ramp influence area is reduced by 100 passenger cars/hour/lane (pc/h/ln) and 200 pc/h/ln for merge influence areas and diverge influence areas, respectively. However, this chapter also indicates that the maximum downstream freeway flow is the basic freeway segment capacity times the number of lanes (e.g., 9600 pc/h for 4 lanes at a free-flow speed of 75 mi/h). The implication of this is that while the capacity may be reduced in the outside two lanes of the ramp influence area, the inside lanes (assuming more than 2 lanes in one direction) can carry more traffic than the typical basic freeway segment per lane capacity (e.g., 2400 pc/h/ln). The FDOT believes that freeway capacity measurements do not support this interpretation of the capacity guidelines of the ramp junctions analysis chapter. The FDOT believes that the friction effects of merging and diverging do lead to an overall reduced freeway segment capacity in the vicinity of on- and off-ramps. However, past research has not been able to establish a satisfactory model for predicting the extent of this reduction, and no such reduction is, therefore, recognized by the HCM.

OBJECTIVES

The objective for Task 3 was to develop a model for assessing level of service specifically on rural freeway segments, based upon actual traveler perceptions rather than the opinions and judgments of transportation experts.

Two issues were addressed in Task 4. The first issue dealt with the interpretation of the language in Chapter 25 (Ramps and Ramp Junctions) of the HCM with regard to the capacity of a freeway segment in a ramp influence area. Thus, one objective of this task was to review the applicable HCM (2000 edition) chapters and determine if the HCM offered clear guidance on which capacity values should be used. The second issue dealt with the use of archived loop detector data to measure freeway throughput values and the potential for measuring the impact of ramp activity on freeway capacity values. Therefore, the other objective of this task was to evaluate maximum traffic flow rate measurements for a variety of freeway segments within and across different geographic areas and to perform an exploratory investigation of capacity differences between freeway segments with varying interchange spacing.

FINDINGS AND CONCLUSIONS

Task 3: Development of a Procedure for Estimating Level of Service on Rural Freeways

Three LOS model formulations for rural freeways were explored in this study. The first model demonstrated two important points. First, while density is important, it does not explain a large amount of the relationship between traveler perceptions and LOS. Second, travelers are less tolerant of traffic congestion on rural freeways, except at the point of facility failure, than is currently suggested by the HCM. If the single service measure of density is to be retained in the HCM for freeways, the concept of having different sets of thresholds for rural and urban freeways should be considered. This would be consistent with the treatment of arterials in the urban streets chapter of the HCM, where there are currently four different sets of average speed thresholds for four different arterial classifications.

The second model, with the inclusion of additional traffic and roadway variables showed considerable improvement in the replication of LOS perceptions. Density was still significant, but this model indicates that the incorporation of additional traffic and roadway variables (which are easily collected with the traffic monitoring infrastructure and roadway inventories available to almost all transportation agencies) into the LOS methodology is probably warranted.

The third model identified some significant personal traveler and trip characteristic factors, as well as the roadway and traffic characteristics from the previous model. The results of this model indicated that the personal and travel characteristics of the individual road user can influence their perception of LOS. However, from a practical standpoint, the implementation of this model versus the second model is hardly warranted due to the negligible gain in model fit and the complexity of trying to measure these variables.

Task 4: Investigation of Capacity Values for Freeway Merge and Diverge Areas

For the first issue of HCM Chapter 25 guidelines and interpretation, it was determined that the text needs to be revised to provide more clarification on the appropriate segment capacity values to use in ramp merge/diverge areas. More guidance also needs to be provided with regard to interpreting individual lane flow rates, predicted by the methodology, that may significantly exceed standard basic freeway segment per lane capacity values, as happens in situations where the overall segment conditions approach capacity. Furthermore, the text needs to be clarified with regard to how traffic flow rates in excess of the ‘maximum

desirable flow entering influence area' should be interpreted (e.g., simply LOS F, or only LOS F if the total segment capacity is also exceeded).

For the second issue, maximum traffic flow rate measurements were evaluated from archived loop detector data obtained from the Seattle, WA, Orlando, FL, and Tampa, FL regions. Unfortunately, there were several limitations with the loop data obtained from these locations. For example, the Seattle data did not include speeds or vehicle classifications, since most of the data came from single-loop installations; 1-hr was the smallest aggregation interval for the majority of the Florida data; and ramp data were not available for the Florida sites. Other limitations inherent in the use of loop data for this purpose include the difficulty of determining whether maximum flow rates actually correspond to capacity and ambiguity as to whether capacity flow rates or queue discharge flow rates are being measured at lane drop sites.

It was not possible to draw any statistically valid conclusions from the data collected for this study, given its aforementioned limitations, due to the amount of variance in flow rates within each site and across sites. In general, sites with longer mainline segments between interchanges had higher flow rates than those with shorter segments. However, with the limited number of sites, the number of other uncontrolled variables, and the problematic data issues, this relationship cannot be established with any reasonable level of statistical confidence.

This exploratory study illuminated the many difficulties of trying to quantify directly the effect of ramp friction on freeway segment capacities. Nonetheless, it did provide valuable insight on the extensive data collection requirements necessary to ultimately investigate the specific issue of the impact of on- and off-ramps on freeway capacity.

BENEFITS

In performing Task 3, researchers provided (1) significant insight into traveler perceptions of trip quality on rural freeways and (2) a preliminary LOS model that provides better correlation with traveler perceptions than the existing HCM methodology. These results will allow the FDOT to more accurately assess LOS conditions on its rural freeways and to make more appropriate decisions regarding infrastructure investments.

In performing Task 4, researchers identified some significant guidance and interpretation issues with the current HCM (2000) methodology for ramp junctions that will be brought forward to the HCQS committee for clarification. This will result in revisions to the HCM Chapter 25 that will allow the FDOT's FREEPLAN software to be revised accordingly and ensure consistency between FREEPLAN and the HCM. Additionally, the preliminary study on maximum flow rates led to identification of the issues and variables that need to be accounted for in a large scale data collection effort to ultimately relate the impacts of ramps on freeway capacity with statistical validity.

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