# APPENDIX B

## DEFINITION OF PERFORMANCE MEANSUREMENT

### B-1 Level of Service Definition (LOS) Calculations

### B-2 Intersection Capacity Utilization (ICU)

### B-3 Arterial Level of Service Report

## B - 1 Level of Service (LOS) Calculations

A qualitative rating of the effectiveness of a transportation component (such as a freeway or a signalized intersection) measured in terms of operating conditions. The Highway Capacity Manual identifies operating conditions ranging from "A" to "F", briefly described below for signalized intersections:

**LOS A** Excellent traffic flow, favourable progression, most vehicles do not stop at all.

**LOS B** Very good traffic flow, short delays, more vehicles stop than under LOS A causing higher levels of delay.

**LOS C** Traffic flow is still good, but the number of vehicles stopping is significant. Many vehicles still proceed without stopping.

**LOS D** The influence of congestion becomes noticeable. Few vehicles advance through the intersection without stopping.

**LOS E** The limit of acceptable delay for many agencies. Virtually no vehicles proceed without stopping.

**LOS F** Traffic volume exceeds available capacity. All vehicles must stop at least once, and possibly must wait through several signal cycles before proceeding.

The level of service can be shown in the greatest detail for each individual **movement** (left, right, or through) or as a sub-aggregate value for the **approach** of a roadway which combines the individual movement terms from one approach to the intersection into one. The **intersection** LOS combines all the approach into one aggregate value.

The term “at capacity” is termed for the limit of acceptable delay to be experienced by the driver. The term “at failure” indicates that the delay experienced by the driver is beyond what is generally considered acceptable for the type of traffic control encountered. Generally, longer delay times are acceptable at traffic signals, as the driver does not have to continually look for gaps in the traffic flow, whereas drivers at unsignalized intersection tend to become impatient and take greater risks at longer experienced delay times. The two differences in delay times and the qualifying letter grade associated with each delay range are summarized below.

For unsignalized intersections, the LOS is defined as a function of the total elapsed time from when a vehicle stops at the end of the queue until when the vehicle departs from the stop line. For unsignalized intersections, the range of vehicle delay times for each LOS grade is summarized in ***Table B-1***.

For signalized intersections, the LOS grade is defined by the average controlled delay per vehicle, including starting, stopping, and slowing. For these intersections, the delay times for each LOS grade are summarized in ***Table B-2***.

**Table B-1: LOS Criteria for Unsignalized Intersections**

| Level of Service | Delay (secs/vehicle) |
|---|---|
| A | Less than 10 |
| B | 10 to 15 |
| C | 15 to 25 |
| D | 25 to 35 |
| E | 35 to 50 |
| F | More than 50 |

**Table B-2: LOS Criteria for Signalized Intersections**

| Level of Service | Delay (secs/vehicle) |
|---|---|
| A | Less than 10 |
| B | 10 to 20 |
| C | 20 to 35 |
| D | 35 to 55 |
| E | 55 to 80 |
| F | More than 80 |

## B - 2 Intersection Capacity Utilization (ICU) Calculations

The Intersection Capacity Utilization (ICU) method is a simple yet powerful tool for measuring an intersection's capacity. The ICU can be calculated using a single page worksheet, that is both easy to generate and easy to review. The ICU is the perfect tool for planning applications such as roadway design and traffic impact studies.

The method sums the amount of time required to serve all movements at saturation for a given cycle length and divides by that reference cycle length. This method is similar to taking a sum of critical volume to saturation flow ratios (v/s), yet allows minimum timings to be considered. The ICU can tell how much reserve capacity is available or how much the intersection is overcapacity. The ICU does not predict delay, but it can be used to predict how often an intersection will experience congestion.

The ICU is timing plan independent, yet has rules to insure that minimum timing constraints are taken into account. This removes the choice of timing plan from the capacity results. The ICU can also be used on unsignalized intersections to determine the capacity utilization if the intersection were to be signalized.

## B - 3 Arterial Level of Service Report

The Arterial Level of Service report contains information about the speed and travel time for an arterial. This report mirrors the reports used in the Arterials section of the HCM, Chapter 15. The Arterial report can also be compared with field travel time studies.

A report is created for each direction of the arterial.

The **Arterial Class** is calculated automatically based on the distances between intersections and the link speeds as indicated in ***Table B-3***. The Speed is the total distance divided by the total travel time. The segment distance is the total distance divided by the number of segments.

**Table B-3: Arterial Class for Level of Service Report**

| Speed (mph) | Segment Distance | Class |
|---|---|---|
| 1 to 29 | any | IV |
| 30 to 35 | < 2000 ft | IV |
| 30 to 35 | >= 2000 ft | III |
| 36 to 45 | any | II |
| above 45 | any | I |

A sample of the Arterial Level of Service Report is illustrated below in ***Table B-4***

**Table B-4: Sample Arterial Level of Service Report**

Arterial Level of Service

8/8/2003

Arterial Level of Service: NB 3rd St

| Cross Street | Arterial Class | Flow Speed | Running Time | Signal Delay | Travel Time (s) | Dist (mi) | Arterial Speed | Arterial LOS |
|---|---|---|---|---|---|---|---|---|
| Main Street | II | 45 | 22.4 | 77.3 | 99.7 | 0.2 | 7.4 | F |
| 1st Ave | II | 45 | 23.6 | 9.9 | 33.5 | 0.2 | 23.2 | C |
| 2nd Ave | II | 45 | 14.7 | 21.2 | 35.9 | 0.1 | 13.5 | E |
| Total | II | | 60.7 | 108.4 | 169.1 | 0.6 | 11.8 | F |

Arterial Level of Service: SB 3rd St

| Cross Street | Arterial Class | Flow Speed | Running Time | Signal Delay | Travel Time (s) | Dist (mi) | Arterial Speed | Arterial LOS |
|---|---|---|---|---|---|---|---|---|
| Mall Ent. | II | 45 | 13.9 | 28.1 | 42.0 | 0.1 | 10.9 | F |
| 1st Ave | II | 45 | 14.7 | 1.1 | 15.8 | 0.1 | 30.8 | B |
| Main Street | II | 45 | 23.6 | 16.2 | 39.8 | 0.2 | 19.6 | D |
| Total | II | | 52.2 | 45.4 | 97.6 | 0.5 | 17.7 | D |

The **Flow Speed** is the free flow speed or link speed input for each link.

For segments over 0.5 miles, the **Running Time** is the link distance divided by the flow speed. For shorter links, the running time is based on the running times in the HCM 2000, Table 15-3. This table is based on FHWA research that shows longer running times on networks with short segments. This will cause longer travel times and lower LOS than using the free flow speeds.

The **Signal Delay** is the percentile delay for the through lane group.

The **Travel Time** is equal to Running time plus Signal Delay.

**Arterial Speed** is thus Distance divided by Travel Time.

The **Arterial LOS** is based on the speed and the Arterial Class.