Presentation on

Bus Operation Design

Operation Plan Components

- Adopted headway
- Cycle Time
- Terminal Time
- Fleet Size
- Commercial Speed

Expressions for Operation Plan Components

- The capacity of a transit route = The passenger capacity per vehicle × Maximum capable number of vehicle to travel on that route
- An expression for the headway of a bus stop

$$h_m = 2t_d/60$$

Here,

h_m = Minimum headway between buses (minutes)

t_d = Average dwell time

- Capacity of a bus route is governed by four factors:

1. The street capacity
2. The bus station platform capacity
3. The vehicle capacity
4. The headway

Expressions for Operation Plan Components

- Dwell Time: The amount of time a bus spends while stopped to service passengers. When buses operate in mixed traffic and stop in a travel lane, the reduction in the roadway capacity is directly related to the amount of time the buses stop.
- Dwell Time = Time required to serve the passengers + Time required to open and close the doors
- A value of 2-5 seconds for door opening and closing is reasonable for normal operation

Expressions for Operation Plan Components

- Dwell Time Assumptions:

- $t_d =$
  - 60 sec; for central business districts (CBD), transit center, major online transfer center
  - 30 sec; for major outlying stops
  - 15 sec; for typical outlying stops

Expressions for Operation Plan Components

- Dwell time, t_d, is best measured in the field for determining capacity and LOS of an existing transit line.
- An expression can be used to compute the dwell time

$$t_d = P_{a*}t_a + P_{b*}t_b + t_{oc}$$

Here,

t_d = Dwell time (sec)

P_a = Alighting passengers per bus through the busiest door during peak 15-min (person)

t_a = Passenger alighting time (sec/person)

P_b = Boarding passengers per bus through the busiest door during peak 15-min (person)

t_b = Passenger boarding time (sec/person)

t_{oc} = Door opening and closing time

Expressions for Operation Plan Components

- Estimates of hourly passenger volume are required for the highest-volume stops. The peak-hour factor is used to adjust hourly passenger volumes to reflect 15-minute condition.

$$P_{15} = \frac{P}{4(PHF)}$$

Here,

PHF = peak-hour factor

P = passenger volume during peak hour (person)

P_{15} = passenger volume during peak 15 minutes (person)

Expressions for Operation Plan Components

- The frequency of service is given by the following expression

  $$f = \frac{n}{N}$$

Here,

f = Frequency required (buses/hr)

n = Demand for service (passenger/hr)

N = Maximum number of passengers per bus

Expressions for Operation Plan Components

- Vehicle capacity depends on two factors:

1. Seating capacity
2. Standing capacity

- A load factor is often used to measure seat availability, and a load factor of 1.0 indicates that every seat is occupied.
- The passenger capacity of a bus is given by

$$c_t = c_a + \alpha * c_b$$

Where,

c_t = Total passenger capacity per vehicle; c_a = Vehicle seating capacity

c_b = Vehicle standing capacity; α = Fraction of C_b allowed

Hence,

Capacity R_c of a bus routing during any time period

$$R_c = \frac{60c_t}{h_m} = \frac{60\,(c_a + \alpha * c_b)}{h_m}$$

Expressions for Operation Plan Components

- The fleet size, or the number of vehicles needed to serve a particular route, can be determined, based on the time it takes a bus to complete a round trip. Thus,

$$t_R = \frac{d}{v_c}$$

Where,

t_R = Round-trip travel (hr)

d = Distance of a round trip (mi or km)

v_c = Average vehicle speed or commercial speed (mph or km/hr)

Expressions for Operation Plan Components

- Example: A bus system needs to be set up between the Washington State University Campus and The University of Idaho, a distance of 8.5 mi. The operating time is 30 min. It has been estimated that the peak-hour demand is 400 passenger/hour and 45-seater buses are available, which can safely accommodate 20 standees. Design the basic system and determine the fleet size, assuming that the policy headway is 30 min and that the minimum terminal time is 7.5 min, which may be revised if necessary.

Expressions for Operation Plan Components

- Solution:

Operating Speed, $v_o = 60L/t_o = 60*8.5/30 = 17$ mph; t_o = operating time

Policy headway = 30 min (which is arbitrary)

Terminal time = 7.5 min

Headway, $h_{min} = 60c_t/R_c = \frac{60*(45+20)}{400}$ =9.75 min (adopt 10 min)

Cycle time, $T = 2\,(t_o + t_t) = 2(30+7.5) = 75$ min

Fleet size, $N_f = T/h = 75/10 = 7.5 \approx 8$ vehicle

Revised cycle time, $T' = N_f*h = 8*10 = 80$ min

Revised terminal time, $t_t' = (T'-2\,t_o)/2 = [80-(2*30)]/2 = 10$ min

Commercial Speed, $v_c = d/t_R = 120L/\,T' = 120(8.5)/80 = 12.75$ mph

Expressions for Operation Plan Components

- In summary,

Headway, $h = 10$ min

Cycle time, $T = 80$ min

Terminal time, $t_t = 10$ min

Fleet size, $N_f = 8$ vehicles

Commercial speed, $v_c = 12.75$ mph