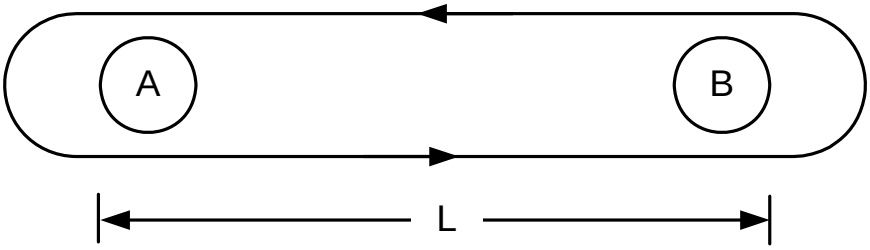
Basic Speed/Fleet Size Relationships

For a given route, where policy is used to determine the level of service, the number of vehicles necessary to provide service at a given headway and average speed can be found as follows:

1. Cycle time is the time for one vehicle to make a complete cycle of the route. It is twice the route length (L) divided by the average speed (S) plus layover times at each end of the route.



$$\text{Cycle Time} = 2 * \text{Length} * \frac{60}{\text{Speed}}$$

$$\text{Cycle Time} = \frac{12 * L}{S}$$

$$\text{Cycle Time} = \frac{12 * L}{S} + TA + TB$$

2. In order to allow for layover and terminal activity, add the layover or terminal time in minutes at each end of the route (TA, TB).

3. Vehicle requirements (NV) can be calculated as a function of cycle time and headways.

$$\textit{Number of Vehicles} = \frac{\textit{Cycle Time}}{\textit{Headway}}$$

or, taking the cycle time as given before,

$$\text{Number of Vehicles} = \frac{120 * L}{S * H} + \frac{TA + TB}{H}$$

Fleet Size as Determined by Policy

A transit board of commission can set headways by policy. For example the board can declare that all vehicles operate at 30 minute headway. Once that policy set, then the number of vehicles needed is directly determined given the cycle time on each route.

The actual number of vehicles provided is found by rounding up to the next whole number. Thus if there is a cycle time of 100 minutes and a 30 minute headway, four vehicles would be needed. This is somewhat inefficient. The route cycle time could change (a 120 minute cycle time for four vehicles or 90 minutes for three vehicles) or the headway could be changed (to 25 minutes) to make the route more efficient.

Fleet Size as Determined by Demand

Vehicle needs can also be determined as a function of vehicle capacity and peak point travel demand. The peak point demand is a triple peak, at the peak load point on the route, in the peak direction and at the peak time of day, given in passengers per hour.

1. Calculate the required headway from vehicle capacity divided by the peak point demand (D). Vehicle capacity is the number of seats (C) times the allowable load factor (LF) at the peak point. The equation is multiplied by 60 to convert hours to minutes.

$$\text{Headway} = \frac{\text{Seating Capacity} * \text{Load Factor} * 60}{\text{Peak Point Demand}}$$

$$H = \frac{C * LF * 60}{D} \text{ (in minutes)}$$

2. The number of vehicles needed to service a route with a given length (L), terminal times (TA + TB), and average speed (S) can be determined by combining the equation above with the previous equations.

$$NV = \frac{2 * L * D}{S * C * LF} + \frac{D * TA * TB}{C * LF * 60}$$

The capacity of a route can be determined by rearranging terms in previous equations. Note this is the level of peak point demand that can be accommodated on the route (D), not individual vehicle capacity (C).

$$D_m = \frac{C * LF * 60}{H}$$

$$D_m = \frac{60 * NV * S * C * LF}{120 * L + S(TA + TB)}$$

Vehicle Hours, Vehicle Miles

Given that you know the number of vehicles, average speeds and lengths of time periods when service is provided, vehicle hours and vehicle miles can be calculated.

1. Calculate daily vehicle hours (VH) as a function of the length of the peak (P) and the length of the base period (B) and the vehicles operated in each period (NVP, NVB).

   Vehicle Hours Peak = No. of Vehicles Peak * Length of Peak

   Vehicle Hours Base = No. of Vehicles Base * Length of Base

   Total Vehicle Hours = Vehicle Hours Peak + Vehicle Hours in Base

   VH = NVP * P + NVB * B

   If you want to adjust total vehicle hours by the ratio (PP) of total pay hours to total platform hours (hours of providing service), then the total vehicle hours is as follows:

   VH = PP * (NVP * P + NVB * B)

2. Daily vehicle miles (VM) are given by multiplying the vehicle hours by the average speed (S).

   VM = S * (NVP * P + NVB * B)

   If there is also a ratio (DH) of deadhead miles to total miles you would adjust vehicle miles by that factor as well.

   VM = DH * S * (NVP * P + NVB * B)

TRANSIT ROUTE WORKSHEET

DATA

Route Length - miles - (L) _____

Average speed - mph - (S) _____

Layover - (TA + TB) _____

COMPUTE

Cycle time = (120 * L/S) + TA + TB _____

DATA

Peak headway - minutes - (PH) _____

Base headway - minutes - (BH) _____

Seats per bus - (SE) _____

Load factor - (LF) _____

COMPUTE

Peak vehicles = cycle time/PH _____

Base vehicles = cycle time/BH _____

Capacity = SE * LF * 60/PH _____

DATA

Length peak - hours - (P) _____

Length base - hours - (B) _____

Deadhead - portion - (D) _____

Pay/Platform ratio - (PD) _____

COMPUTE

Daily vehicle hours =
(Peak veh. * P + Base veh. * B) * PP _____

Daily vehicle miles =
vehicle hours * speed * (1 + D)/PP _____

TRANSIT ROUTE WORKSHEET

DATA	
Route Length - miles - (L)	10 miles
Average speed - mph - (S)	15 mph
Layover - (TA + TB)	8 minutes
COMPUTE	
Cycle time = (120 * L/S) + TA + TB	(120 * 10/15) + 8 = 88 minutes
DATA	
Peak headway - minutes - (PH)	15 minutes
Base headway - minutes - (BH)	30 minutes
Seats per bus - (SE)	50
Load factor - (LF)	1.2
COMPUTE	
Peak vehicles = cycle time/PH	88/15 = 6 buses
Base vehicles = cycle time/BH	88/30 = 3 buses
Capacity = SE * LF * 60/PH	50 * 1.2 * 60/15 = 240 passengers/hour
DATA	
Length peak - hours - (P)	4 hours
Length base - hours - (B)	12 hours
Deadhead - portion - (D)	.10
Pay/Platform ratio - (PD)	1.1
COMPUTE	
Daily vehicle hours = (Peak veh. * P + Base veh. * B) * PP	(6 * 4) + (3 * 12) * 1.1 (24 + 36) *1.1 = 66 hours
Daily vehicle miles = vehicle hours * speed * (1 + D)/PP	66 * 15 * (1 +.10)/1.1 = 990 miles

Example: Racine Spreadsheet Analysis,

	Estimated Route Performance for Next Year									
Route	Red (1)	Brown (2)	Yellow (3)	Blue (4)	Pink (5)	Grey (6)	Purple (7)	Orange (8)	Green (9)	Average
Length (miles)	7.80	9.20	9.00	9.30	8.20	8.40	6.00	6.80	8.00	8.08
Headways										
Weekdays peak	30.00	30.00	20.00	20.00	30.00	30.00	20.00	30.00	30.00	26.67
Weekdays base	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Sat./holidays	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	9999.00	30.00
Speed (mph)	10.40	12.30	12.00	12.40	11.00	11.20	9.00	14.00	16.00	12.03
Hours peak	4.00	4.00	7.00	7.50	4.00	4.00	8.00	4.00	4.00	5.17
Hours base	8.00	8.00	5.00	4.50	8.00	8.00	4.00	8.00	8.00	6.83
Hrs. Sat./holidays	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00	9.00
Ridership										Totals
Weekdays	571	553	1284	1171	683	288	986	391	227	6154
Sat./holidays	335	321	465	886	361	230	729	212	0	3539
% chg weekdays	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
% chg Sat./hol.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Calculations										Totals
% change fares	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Mod weekdays	571	553	1284	1171	683	288	986	391	227	6154
Mod Sat./holidays	335	321	465	886	361	230	729	212	0	3539
Weekdays										
Peak veh (calc)	3.00	2.99	4.50	4.50	2.98	3.00	4.00	1.94	2.00	28.92
Peak buses	3	3	5	5	3	3	4	2	2	30
Base veh (calc)	3.00	2.99	3.00	3.00	2.98	3.00	2.67	1.94	2.00	24.58
Base buses	3	3	3	3	3	3	3	2	2	25
Veh-miles	438	518	702	740	463	472	463	393	449	4639
Veh-hours	41.47	41.47	57.60	58.75	41.47	41.47	50.69	27.65	27.65	388
Fare revenue	$378	$366	$849	$774	$452	$190	$652	$259	$150	$4,069
Cost	$1,651	$1,727	$2,417	$2,484	$1,675	$1,683	$1,963	$1,197	$1,250	$16,047
Subsidy	$1,274	$1,362	$1,568	$1,710	$1,223	$1,493	$1,311	$938	$1,100	$11,978
Subsidy/pass	$2.23	$2.46	$1.22	$1.46	$1.79	$5.18	$1.33	$2.40	$4.85	2.55
Oper ratio	0.23	0.21	0.35	0.31	0.27	0.11	0.33	0.22	0.12	0.24
Yearly cost	$421,017	$440,424	$616,312	$633,362	$427,145	$429,188	$500,646	$305,192	$319,811	$4,092,096

Spreadsheet Analysis, Transit Routes

Estimated Route Performance for Next Year

Route	Red (1)	Brown (2)	Yellow (3)	Blue (4)	Pink (5)	Grey (6)	Purple (7)	Orange (8)	Green (9)	Average
Sat./holidays	.									
Buses (calc)	3.00	2.99	3.00	3.00	2.98	3.00	2.67	1.94	0.01	22.59
Buses used	3	3	3	3	3	3	3	2	0	23
Vehicle-miles	329	389	379	392	347	354	284	295	0	2768
Vehicle-hours	31.10	31.10	31.10	31.10	31.10	31.10	31.10	20.74	0.00	238
Fare revenue	$222	$212	$307	$586	$239	$152	$482	$140	$0	$2,340
Cost	$1,270	$1,327	$1,318	$1,330	$1,288	$1,294	$1,228	$918	$0	$9,971
Subsidy	$1,048	$1,114	$1,010	$744	$1,049	$1,142	$746	$778	$0	$7,631
Subsidy/pass	$3.13	$3.47	$2.17	$0.84	$2.91	$4.96	$1.02	$3.67	$0.00	$2.46
Operating ratio	0.17	.016	0.23	0.44	0.19	0.12	0.39	0.15	0.00	0.21
Yearly cost	$72,366	$75,620	$75,106	$75,791	$73,394	$73,736	$69,969	$52,354	$0	$568,336
									Total cost =	$4,660,432
Performance										
Pass/bus hr.- daily	13.77	13.33	22.29	19.93	16.47	6.94	19.45	14.14	8.21	15.85
Pass/bus hr. - Sat.	10.77	10.32	14.95	28.49	11.61	7.39	23.44	10.22		14.84