ARTPLAN Computational Methodology

Automobile Mode

For Version 9/11/2012

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Inputs

Project Properties

Roadway Variables:

AreaType := 1 — 1 = Large Urbanized, 2 = Other Urbanized, 3 = Transitioning/Urban, 4 = Rural Developed

Class := 2

Intersection

Facility-Wide Values:

BaseSatFlowRate := 1950 Sig := 2 — 0 = Pretimed, 1 = Coordinated Actuated, 2 = Fully Actuated

Intersection Data:

Int_1	Int_2	Int_3	Int_4
No Inputs Required	$Cycle_1 := 120$	$Cycle_2 := 150$	$Cycle_3 := 150$
	$gC_1 := 0.50$	$gC_2 := 0.40$	$gC_3 := 0.45$
	$ArrivalType_1 := 4$	$ArrivalType_2 := 3$	$ArrivalType_3 := 5$
	$IntThruLanes_1 := 3$	$IntThruLanes_2 := 3$	$IntThruLanes_3 := 4$
	$\%LeftTurns_1 := 12$	$\%LeftTurns_2 := 7$	$\%LeftTurns_3 := 9$
	$\%RightTurns_1 := 8$	$\%RightTurns_2 := 5$	$\%RightTurns_3 := 4$
	$LeftTurnBay_1 := 1$	$LeftTurnBay_2 := 1$	$LeftTurnBay_3 := 1$
	$RightTurnBay_1 := 0$	$RightTurnBay_2 := 0$	$RightTurnBay_3 := 1$

*For left turn and right turn bays: 0 = No, 1 = Yes

Link (Auto)

Facility-Wide Values:

$K := 0.095$ $D := 0.55$ $PHF := 0.95$ $\%HV := 2.5$

Link Data:

Link$_1$	Link$_2$	Link$_3$
$LinkLength_1 := 2500$	$LinkLength_2 := 1500$	$LinkLength_3 := 1700$
$AADT_1 := 43250$	$AADT_2 := 43250$	$AADT_3 := 43250$
$HourlyDirVol_1 := round(AADT_1 \cdot K \cdot D)$	$HourlyDirVol_2 := round(AADT_2 \cdot K \cdot D)$	$HourlyDirVol_3 := round(AADT_3 \cdot K \cdot D)$
$HourlyDirVol_1 = 2260$	$HourlyDirVol_2 = 2260$	$HourlyDirVol_3 = 2260$
$LinkNumLanes_1 := 3$	$LinkNumLanes_2 := 3$	$LinkNumLanes_3 := 4$
$FFS_1 := 50$	$FFS_2 := 50$	$FFS_3 := 50$
$MedianType_1 := 1$	$MedianType_2 := 2$	$MedianType_3 := 1$
$OnStreetParking_1 := 1$	$OnStreetParking_2 := 0$	$OnStreetParking_3 := 0$
$ParkingActivity_1 := 2$	$ParkingActivity_2 := 0$	$ParkingActivity_3 := 0$

*For MedianType: 0 = None, 1 = NonRestrictive, 2 = Restrictive

*For On-Street Parking: 0 = No, 1 = Yes

*For Parking Activity: 0 = Not Applicable, 1 = Low, 2 = Medium, 3 = High

Auto LOS Computational Steps

1. Calculate the Saturation Flow Rate Adjustment Factors

A. Calculate the population adjustment factor

$$Population(AreaType) := \begin{array}{|l} out \leftarrow 1.5 \text{ if } AreaType = 1 \\ out \leftarrow 0.4 \text{ if } AreaType = 2 \\ out \leftarrow 0.03 \text{ if } AreaType = 3 \\ out \leftarrow 0.003 \text{ if } AreaType = 4 \end{array}$$

$Population(AreaType) = 1.5$

$$PopFact := \frac{1}{Population(AreaType)^{-0.018}}$$

$PopFact = 1.007$

B. Calculate the number of lanes adjustment factor

$E_{CL} := 1.03$

$$\text{NumLnsFact}(i) := \frac{1}{1 + \frac{1}{\text{IntThruLanes}_i}\cdot\left(E_{CL} - 1\right)}$$

NumLnsFact(1) = 0.99
NumLnsFact(2) = 0.99
NumLnsFact(3) = 0.993

C. Calculate the posted speed adjustment factor

* FFS - 5 is equivalent to the posted speed entered in ARTPLAN

$$\text{PostedSpd}(i) := \min\left(\max\left(30, \text{FFS}_i - 5\right), 55\right)$$

$$\text{SpdFact}(i) := \frac{1}{1 - 0.0066(\text{PostedSpd}(i) - 50)}$$

SpdFact(1) = 0.968 SpdFact(2) = 0.968 SpdFact(3) = 0.968

D. Calculate the traffic pressure adjustment factor

$$\text{CalcPctTurns}(\%LT, \%RT, i) := \begin{cases} \%LT & \text{if } \text{LeftTurnBay}_i = 1 \wedge \text{RightTurnBay}_i = 0 \\ \%RT & \text{if } \text{LeftTurnBay}_i = 0 \wedge \text{RightTurnBay}_i = 1 \\ \%LT + \%RT & \text{if } \text{LeftTurnBay}_i = 1 \wedge \text{RightTurnBay}_i = 1 \\ 0 & \text{otherwise} \end{cases}$$

$\%\text{Turns}_1 := \text{CalcPctTurns}\left(\%\text{LeftTurns}_1, \%\text{RightTurns}_1, 1\right)$ $\%\text{Turns}_1 = 12$
$\%\text{Turns}_2 := \text{CalcPctTurns}\left(\%\text{LeftTurns}_2, \%\text{RightTurns}_2, 2\right)$ $\%\text{Turns}_2 = 7$
$\%\text{Turns}_3 := \text{CalcPctTurns}\left(\%\text{LeftTurns}_3, \%\text{RightTurns}_3, 3\right)$ $\%\text{Turns}_3 = 13$

$$\text{ThruMvmtFlowRate}(i) := \frac{\text{HourlyDirVol}_i}{\text{PHF}}\cdot\left[1 - \left(\frac{\%\text{Turns}_i}{100}\right)\right]$$

ThruMvmtFlowRate(1) = 2093.5
ThruMvmtFlowRate(2) = 2212.4
ThruMvmtFlowRate(3) = 2069.7

$$v(i) := \min\left(\frac{\text{ThruMvmtFlowRate}(i)\cdot\text{Cycle}_i}{\text{IntThruLanes}_i\cdot 3600}, 30\right)$$

v(1) = 23.261 v(2) = 30 v(3) = 21.559

$$\text{TrafFact}(i) := \frac{1}{1 - 0.0032(v(i) - 20)}$$

TrafFact(1) = 1.011 TrafFact(2) = 1.033 TrafFact(3) = 1.005

E. Calculate the lane width adjustment factor

$$W_{inln}(i) := \begin{cases} 12 & \text{if } W_{outln_i} \ge 12 \\ W_{outln_i} & \text{if } W_{outln_i} < 12 \end{cases}$$

$W_{inln}(1) = 12$
$W_{inln}(2) = 12$
$W_{inln}(3) = 12$

$$W_{avg}(i) := \frac{\left[W_{inln}(i)\cdot\left(IntThruLanes_i - 1\right)\right] + W_{outln_i}}{IntThruLanes_i}$$

$W_{avg}(1) = 12$
$W_{avg}(2) = 12$
$W_{avg}(3) = 12$

$$LnWidthFact(i) := 1 + \frac{W_{avg}(i) - 12}{30}$$

$LnWidthFact(1) = 1.00$
$LnWidthFact(2) = 1.00$
$LnWidthFact(3) = 1.00$

F. Determine the Median adjustment factor

$$MedianFact(i) := \left| \begin{array}{l} out \leftarrow 0.95 \ \text{ if } \ MedianType_i = 0 \\ out \leftarrow 1.0 \ \text{ if } \ MedianType_i = 1 \\ out \leftarrow 1.0 \ \text{ if } \ MedianType_i = 2 \\ out \end{array} \right.$$

$MedianFact(1) = 1.0$
$MedianFact(2) = 1.0$
$MedianFact(3) = 1.0$

G. Determine the left turn bay adjustment factor

$$LTFact(i) := \left| \begin{array}{l} out \leftarrow 0.8 \ \text{ if } \ LeftTurnBay_i = 0 \wedge \%LeftTurns_i \neq 0 \\ out \leftarrow 1.0 \ \text{ if } \ LeftTurnBay_i = 1 \vee \%LeftTurns_i = 0 \\ out \end{array} \right.$$

$LTFact(1) = 1.0$
$LTFact(2) = 1.0$
$LTFact(3) = 1.0$

H. Determine the right turn adjustment factor

$$PctMultiplier(i) := \left| \begin{array}{l} \text{if } \ IntThruLanes_i > 1 \\ \quad \left| \begin{array}{l} \text{return } \ 0 \ \text{ if } \ \%RightTurns_i < 2.5 \\ \text{return } \ 0.14 \ \text{ if } \ \%RightTurns_i > 30 \\ \left[\text{return } \ 0.00007\cdot\left(\%RightTurns_i\right)^2 + 0.0004\cdot\%RightTurns_i + 0.0611 \right] \ \text{ otherwise} \end{array} \right. \\ \text{if } \ IntThruLanes_i = 1 \\ \quad \left| \begin{array}{l} \text{return } \ 0 \ \text{ if } \ \%RightTurns_i < 2.5 \\ \text{return } \ 0.13 \ \text{ if } \ \%RightTurns_i > 30 \\ \left[\text{return } \ 0.0001\cdot\left(\%RightTurns_i\right)^2 + 0.0004\cdot\%RightTurns_i + 0.0253 \right] \ \text{ otherwise} \end{array} \right. \end{array} \right.$$

$PctMultiplier(1) = 0.069$

$PctMultiplier(2) = 0.065$

$PctMultiplier(3) = 0.064$

$$RTFact(i) := \begin{cases} out \leftarrow 1 - \left(PctMultiplier(i) \cdot \frac{\%RightTurns_i}{12}\right) & \text{if } RightTurnBay_i = 1 \\ out \leftarrow \frac{1}{1 + \left(\frac{\%RightTurns_i}{100} \cdot 0.07\right)} & \text{otherwise} \end{cases}$$

$RTFact(1) = 0.994$
$RTFact(2) = 0.997$
$RTFact(3) = 0.979$

I. Calculate the heavy vehicle adjustment factor

$E_T := 2.3$ (per "Impact of Trucks on Arterial LOS" FDOT project; BD-545-51)

$$f_{HV} := \frac{1}{1 + \left[\frac{\%HV}{100} \cdot (E_T - 1)\right]}$$

$f_{HV} = 0.969$

2. Calculate the Adjusted Saturation Flow Rate

$$FactAdj(i) := LnWidthFact(i) \cdot MedianFact(i) \cdot f_{HV} \cdot PopFact \cdot TrafFact(i) \cdot NumLnsFact(i) \cdot SpdFact(i) \cdot LTFact(i) \cdot RTFact(i)$$

$FactAdj(1) = 0.94$
$FactAdj(2) = 0.963$
$FactAdj(3) = 0.922$

$$AdjSatFlowRate(i) := BaseSatFlowRate \cdot FactAdj(i)$$

$AdjSatFlowRate(1) = 1832.41$
$AdjSatFlowRate(2) = 1877.153$
$AdjSatFlowRate(3) = 1798.053$

ARTPLAN reports (IntThruLanes)(AdjSatFlowRate)

$AdjSatFlowRate(1) \cdot IntThruLanes_1 = 5497$
$AdjSatFlowRate(2) \cdot IntThruLanes_2 = 5631$
$AdjSatFlowRate(3) \cdot IntThruLanes_3 = 7192$

3. Calculate signal delay

A. Calculate volume to capacity ratio (v/c)

$ThruMvmtFlowRate(1) = 2093.474$
$ThruMvmtFlowRate(2) = 2212.421$
$ThruMvmtFlowRate(3) = 2069.684$

$$c(i) := AdjSatFlowRate(i) \cdot IntThruLanes_i \cdot gC_i$$

$c(1) = 2748.616$
$c(2) = 2252.584$
$c(3) = 3236.496$

$$vc(i) := \frac{ThruMvmtFlowRate(i)}{c(i)}$$

$vc(1) = 0.762$
$vc(2) = 0.982$
$vc(3) = 0.639$

1. Determine Platoon Ratio — From Exhibit 18-8 HCM 2010

$$\mathrm{CalcR_p(i)} := \left| \begin{array}{l} \mathrm{out} \leftarrow 0.333 \ \ \mathrm{if}\ \ \mathrm{ArrivalType_i} = 1 \\ \mathrm{out} \leftarrow 0.667 \ \ \mathrm{if}\ \ \mathrm{ArrivalType_i} = 2 \\ \mathrm{out} \leftarrow 1.0 \ \ \mathrm{if}\ \ \mathrm{ArrivalType_i} = 3 \\ \mathrm{out} \leftarrow 1.333 \ \ \mathrm{if}\ \ \mathrm{ArrivalType_i} = 4 \\ \mathrm{out} \leftarrow 1.667 \ \ \mathrm{if}\ \ \mathrm{ArrivalType_i} = 5 \\ \mathrm{out} \leftarrow 2 \ \ \mathrm{otherwise} \\ \mathrm{out} \end{array} \right.$$

$R_{p_1} := \mathrm{CalcR_p}(1)$ $\quad R_{p_1} = 1.333$

$R_{p_2} := \mathrm{CalcR_p}(2)$ $\quad R_{p_2} = 1$

$R_{p_3} := \mathrm{CalcR_p}(3)$ $\quad R_{p_3} = 1.667$

2. Calculate the proporation of arrivals on green Equation 18-2 HCM 2010

$$\mathrm{CalcPropGreen(i)} := \left| \begin{array}{l} \mathrm{out} \leftarrow 1.0 \ \ \mathrm{if}\ \left(R_{p_i} \cdot gC_i\right) > 1.0 \\ \mathrm{out} \leftarrow R_{p_i} \cdot gC_i \ \ \mathrm{otherwise} \\ \mathrm{out} \end{array} \right.$$

$\mathrm{PropGreen}_1 := \mathrm{CalcPropGreen}(1)$ $\quad \mathrm{PropGreen}_1 = 0.667$

$\mathrm{PropGreen}_2 := \mathrm{CalcPropGreen}(2)$ $\quad \mathrm{PropGreen}_2 = 0.4$

$\mathrm{PropGreen}_3 := \mathrm{CalcPropGreen}(3)$ $\quad \mathrm{PropGreen}_3 = 0.75$

3. Calculate the flow rates during green and red Eqs. 18-23, 18-24 HCM 2010

$$\mathrm{FlowRateGreen(i)} := \frac{\frac{\mathrm{ThruMvmtFlowRate(i)}}{3600} \cdot \mathrm{PropGreen_i}}{gC_i}$$

$\mathrm{FlowRateGreen}(1) = 0.775$ veh/sec

$\mathrm{FlowRateGreen}(2) = 0.615$

$\mathrm{FlowRateGreen}(3) = 0.958$

$$\mathrm{FlowRateRed(i)} := \frac{\frac{\mathrm{ThruMvmtFlowRate(i)}}{3600} \cdot \left(1 - \mathrm{PropGreen_i}\right)}{\left(1 - gC_i\right)}$$

$\mathrm{FlowRateRed}(1) = 0.388$

$\mathrm{FlowRateRed}(2) = 0.615$

$\mathrm{FlowRateRed}(3) = 0.261$

4. Calculate uniform delay (d_1)

$$\mathrm{RedTime(i)} := \mathrm{Cycle_i} - \mathrm{Cycle_i} \cdot gC_i$$

$\mathrm{RedTime}(1) = 60$

$\mathrm{RedTime}(2) = 90$

$\mathrm{RedTime}(3) = 82.5$

$$\text{TimeQueueClear}(i) := \frac{\text{FlowRateRed}(i)\cdot\text{RedTime}(i)}{\frac{\text{AdjSatFlowRate}(i)\cdot\text{IntThruLanes}_i}{3600} - \text{FlowRateGreen}(i)}$$

$\text{TimeQueueClear}(1) = 30.954$

$\text{TimeQueueClear}(2) = 58.238$

$\text{TimeQueueClear}(3) = 20.728$

$$\text{TotalDelay}(i) := \left(0.5\cdot\text{FlowRateRed}(i)\cdot\text{RedTime}(i)^2\right) + \left(0.5\cdot\text{FlowRateRed}(i)\cdot\text{RedTime}(i)\cdot\text{TimeQueueClear}(i)\right)$$

$\text{TotalDelay}(1) = 1058.36$

$\text{TotalDelay}(2) = 4099.56$

$\text{TotalDelay}(3) = 1112.093$

$$d_1(i) := \frac{\text{TotalDelay}(i)}{\left(\frac{\text{ThruMvmtFlowRate}(i)}{3600}\cdot\text{Cycle}_i\right)}$$

$d_1(1) = 15.17$

$d_1(2) = 44.47$

$d_1(3) = 12.90$

5. Calculate incremental delay (d_2)

a. Determine k, signal controller mode delay adjustment factor

If the intersection is operating under pretimed mode, k = 0.5.

$\text{PassTime} := 2.0$

$$\text{kmin} := \max\left(0.04, -0.375 + 0.354\cdot\text{PassTime} - 0.0910\cdot\text{PassTime}^2 + 0.00889\cdot\text{PassTime}^3\right)$$

$\text{kmin} = 0.04$

$$\text{kfact}(i) := \begin{array}{|l} \text{return } .5 \text{ if } \text{Sig} = 0 \\ \text{return } .5 \text{ if } \text{Sig} = 1 \\ \text{return } (1 - 2\cdot\text{kmin})\cdot(\text{vc}(i) - 0.5) + \text{kmin} \text{ if } \text{Sig} = 2 \end{array}$$

Eqs. 18-41, 18-42 HCM 2010

$k_1 := \text{kfact}(1) \quad k_2 := \text{kfact}(2) \quad k_3 := \text{kfact}(3)$

$k_1 = 0.281$

$k_2 = 0.484$

$k_3 = 0.168$

Note: k cannot exceed 0.5

b. Determine I, the upstream filtering/metering adjustment factor

If the v/c ratio for the upstream signal is greater than 1, then I = 0.09.

When there is no upstream signal, use the v/c ratio for that intersection.

$$Ifact(i) := \begin{array}{|l} \text{return } 1.0 - 0.91 \cdot vc(i)^{2.68} \text{ if } vc(i) < 1 \wedge i = 1 \\ \text{return } 0.09 \text{ if } vc(i) \ge 1 \wedge i = 1 \\ \text{return } 1.0 - 0.91 \cdot vc(i-1)^{2.68} \text{ if } vc(i-1) < 1.0 \\ \text{return } 0.09 \text{ if } vc(i-1) \ge 1.0 \end{array}$$

From Exhibit 18-3 HCM 2010

$I_1 := Ifact(1) \quad I_2 := Ifact(2) \quad I_3 := Ifact(3)$

$I_1 = 0.561$
$I_2 = 0.561$
$I_3 = 0.133$

$T := 0.25$ (ARTPLAN default)

Equation 18-45 HCM 2010

$$d_2(i) := 900 \cdot T \cdot \left[(vc(i) - 1) + \sqrt{(vc(i) - 1)^2 + \frac{8 \cdot k_i \cdot I_i \cdot vc(i)}{T \cdot c(i)}} \right]$$

$d_2(1) = 0.656$
$d_2(2) = 10.405$
$d_2(3) = 0.044$

6. Calculate the total signal delay

Equation 18-19 HCM 2010

$CalcCtrlDelay(i) := d_1(i) + d_2(i)$

$CtrlDelay_1 := CalcCtrlDelay(1)$ $\quad CtrlDelay_1 = 15.82$
$CtrlDelay_2 := CalcCtrlDelay(2)$ $\quad CtrlDelay_2 = 54.88$
$CtrlDelay_3 := CalcCtrlDelay(3)$ $\quad CtrlDelay_3 = 12.94$

4. Calculate the Segment and Facility Running Time/Speed

$$IntWidth := \begin{array}{|l} out \leftarrow 60 \text{ if } AreaType = 1 \\ out \leftarrow 60 \text{ if } AreaType = 2 \\ out \leftarrow 36 \text{ if } AreaType = 3 \\ out \leftarrow 24 \text{ if } AreaType = 4 \end{array}$$

$IntWidth = 60$

$SegLength(i) := LinkLength_i + IntWidth$

$SegLength(1) = 2560$ ft
$SegLength(2) = 1560$
$SegLength(3) = 1760$

A. Calculate the signal density

$$CalcSigs(i) := \min\left(\frac{5280}{SegLength(i)}, 9\right)$$

$SigsPerMile_1 := CalcSigs(1) \quad SigsPerMile_1 = 2.063$
$SigsPerMile_2 := CalcSigs(2) \quad SigsPerMile_2 = 3.385$
$SigsPerMile_3 := CalcSigs(3) \quad SigsPerMile_3 = 3.00$

B. Calculate the peak per-lane hourly volume

$$\text{Calcv\_temp}(i) := \min\left(\frac{\text{HourlyDirVol}_i}{\text{LinkNumLanes}_i \cdot \text{PHF}}, 1000\right)$$

$v\_temp_1 := \text{Calcv\_temp}(1)$ $v\_temp_1 = 792.982$ veh/h

$v\_temp_2 := \text{Calcv\_temp}(2)$ $v\_temp_2 = 792.982$ veh/h

$v\_temp_3 := \text{Calcv\_temp}(3)$ $v\_temp_3 = 594.737$ veh/h

C. Calculate the running speed

$$\text{MidSegDemand}(i) := \frac{\text{HourlyDirVol}_i}{\text{PHF}}$$

$\text{MidSegDemand}(1) = 2378.9$ veh/h

$\text{MidSegDemand}(2) = 2378.9$

$\text{MidSegDemand}(3) = 2378.9$

$$\text{MidBlockPctTurns} := \begin{vmatrix} out \leftarrow 7 \ \text{ if } \ \text{AreaType} = 1 \\ out \leftarrow 5 \ \text{ if } \ \text{AreaType} = 2 \\ out \leftarrow 3 \ \text{ if } \ \text{AreaType} = 3 \\ out \leftarrow 2 \ \text{ if } \ \text{AreaType} = 4 \end{vmatrix}$$

$\text{MidBlockPctTurns} = 7$

$$\text{PropSegRestrictMed}(i) := \begin{vmatrix} out \leftarrow 0 \ \text{ if } \ \text{MedianType}_i = 0 \\ out \leftarrow 0 \ \text{ if } \ \text{MedianType}_i = 1 \\ out \leftarrow 1.0 \ \text{ if } \ \text{MedianType}_i = 2 \end{vmatrix}$$

Proportion of segment length with restricted median

$\text{PropSegRestrictMed}(1) = 0$

$\text{PropSegRestrictMed}(2) = 1$

$\text{PropSegRestrictMed}(3) = 0$

$$\text{PropSegWithCurb} := \begin{vmatrix} out \leftarrow 1.0 \ \text{ if } \ \text{AreaType} = 1 \\ out \leftarrow 1.0 \ \text{ if } \ \text{AreaType} = 2 \\ out \leftarrow 0.5 \ \text{ if } \ \text{AreaType} = 3 \\ out \leftarrow 0.0 \ \text{ if } \ \text{AreaType} = 4 \end{vmatrix}$$

Proportion of segment length with right-side curb

$\text{PropSegWithCurb} = 1.0$

$$\text{NumAccessPts}(i) := \begin{vmatrix} out \leftarrow 0 \ \text{ if } \ \text{LinkLength}_i < 660 \\ out \leftarrow 2 \cdot \dfrac{\text{LinkLength}_i}{1320} \ \text{ if } \ \text{LinkLength}_i \ge 660 \end{vmatrix}$$

$\text{NumAccessPts}(1) = 3.79$

$\text{NumAccessPts}(2) = 2.27$

$\text{NumAccessPts}(3) = 2.58$

$\text{NumAccessPtsSubDir}(i) := \text{NumAccessPts}(i)$

Number of access points in the subject direction

$\text{NumAccessPtsSubDir}(1) = 3.79$

$\text{NumAccessPtsSubDir}(2) = 2.27$

$\text{NumAccessPtsSubDir}(3) = 2.58$

$\text{NumAccessPtsOppDir}(i) := \text{NumAccessPts}(i)$

For planning purposes, assume opposing direction has same number of access points as subject direction

$\text{NumAccessPtsOppDir}(1) = 3.79$

$\text{NumAccessPtsOppDir}(2) = 2.27$

$\text{NumAccessPtsOppDir}(3) = 2.58$

$$\text{OtherDelay}(i) := \begin{cases} \text{return } 0 \text{ if } \text{OnStreetParking}_i = 0 \\ \text{if } \text{OnStreetParking}_i = 1 \\ \quad \text{return } \dfrac{2}{\text{LinkNumLanes}_i} \text{ if } \text{ParkingActivity}_i = 1 \\ \quad \text{return } \dfrac{4}{\text{LinkNumLanes}_i} \text{ if } \text{ParkingActivity}_i = 2 \\ \quad \text{return } \dfrac{6}{\text{LinkNumLanes}_i} \text{ if } \text{ParkingActivity}_i = 3 \end{cases}$$

planning level assumptions

$\text{OtherDelay}(1) = 1.33$ sec/veh

$\text{OtherDelay}(2) = 0.00$

$\text{OtherDelay}(3) = 0.00$

$\text{StartUpLostTime} := 2.0$ HCM default; Artplan does not contain an input for startup lost time because effective green time is entered directly (i.e., g/C ratio)

$\text{ControlDelay} := 16.1$ Obtained from signal delay calculation procedure

$$\text{MidSegVolPerLane}(i) := \frac{\text{MidSegDemand}(i)}{\text{LinkNumLanes}_i}$$

$\text{MidSegVolPerLane}(1) = 793.0$ veh/h/ln

$\text{MidSegVolPerLane}(2) = 793.0$

$\text{MidSegVolPerLane}(3) = 594.7$

$$\text{TurningDelay}(i) := \begin{cases} out \leftarrow 0.0208 \cdot \exp(0.0022 \cdot \text{MidSegVolPerLane}(i)) \text{ if } \text{LinkNumLanes}_i = 1 \\ out \leftarrow 0.00014325313\, \text{MidSegVolPerLane}(i) \text{ if } \text{LinkNumLanes}_i = 2 \\ out \leftarrow 0.000109151\, \text{MidSegVolPerLane}(i) \text{ if } \text{LinkNumLanes}_i \geq 3 \end{cases}$$

$$\text{TurningDelay}(i) := \text{TurningDelay}(i) \cdot \frac{\text{MidBlockPctTurns}}{7}$$

7% turns is assumed typical condition for Florida. Values are adjusted proportationally for different turning percentages.

$\text{TurningDelay}(1) = 0.087$ sec/veh/access pt

$\text{TurningDelay}(2) = 0.087$

$\text{TurningDelay}(3) = 0.065$

$$TotalTurningDelay(i) := TurningDelay(i) \cdot (NumAccessPtsSubDir(i) + NumAccessPtsOppDir(i))$$

$TotalTurningDelay(1) = 0.656$ s/veh

$TotalTurningDelay(2) = 0.393$

$TotalTurningDelay(3) = 0.334$

$$PostedSpeed(i) := FFS_i - 5$$

$$SpeedConstant(i) := 25.6 + 0.47 \cdot PostedSpeed(i)$$

$SpeedConstant(1) = 46.75$ mi/h

$SpeedConstant(2) = 46.75$

$SpeedConstant(3) = 46.75$

$$CrossSectAdjFact(i) := 1.5 \cdot PropSegRestrictMed(i) - 0.47 \cdot PropSegWithCurb - 3.7 \cdot PropSegRestrictMed(i) \cdot PropSegWithCurb$$

$CrossSectAdjFact(1) = -0.47$

$CrossSectAdjFact(2) = -2.67$

$CrossSectAdjFact(3) = -0.47$

$$AccessPtDensity(i) := 5280 \cdot \frac{(NumAccessPtsSubDir(i) + NumAccessPtsOppDir(i))}{\left(LinkLength_i\right)}$$

$AccessPtDensity(1) = 16.0$

$AccessPtDensity(2) = 16.0$

$AccessPtDensity(3) = 16.0$

$$AccessPtAdj(i) := -0.078 \cdot \frac{AccessPtDensity(i)}{LinkNumLanes_i}$$

$AccessPtAdj(1) = -0.416$

$AccessPtAdj(2) = -0.416$

$AccessPtAdj(3) = -0.312$

$$BaseFreeFlowSpd(i) := SpeedConstant(i) + CrossSectAdjFact(i) + AccessPtAdj(i)$$

$BaseFreeFlowSpd(1) = 45.86$

$BaseFreeFlowSpd(2) = 43.66$

$BaseFreeFlowSpd(3) = 45.97$

$$SignalSpacingAdjFact(i) := 1.02 - 4.7 \cdot \frac{(BaseFreeFlowSpd(i) - 19.5)}{\max(SegLength(i), 400)}$$

$$SignalSpacingAdjFact(i) := \begin{array}{|l} out \leftarrow SignalSpacingAdjFact(i) \quad \text{if } SignalSpacingAdjFact(i) \le 1.0 \\ out \leftarrow 1.0 \quad \text{otherwise} \end{array}$$

$SignalSpacingAdjFact(1) = 0.972$

$SignalSpacingAdjFact(2) = 0.947$

$SignalSpacingAdjFact(3) = 0.949$

$$\text{ProximityAdjFact}(i) := \frac{2}{1 + \left[1 - \frac{\text{MidSegDemand}(i)}{\left(52.8 \cdot \text{LinkNumLanes}_i \cdot \text{FFS}_i\right)}\right]^{0.21}}$$

$\text{ProximityAdjFact}(1) = 1.037$

$\text{ProximityAdjFact}(2) = 1.037$

$\text{ProximityAdjFact}(3) = 1.027$

D. Calculate segment running time

$$\text{RunningTime}(i) := \frac{6 - \text{StartUpLostTime}}{0.0025 \cdot (\text{SegLength}(i))} + \frac{3600 \cdot (\text{SegLength}(i))}{5280 \cdot \text{FFS}_i} \cdot \text{ProximityAdjFact}(i) + \text{TotalTurningDelay}(i) + \text{OtherDelay}(i)$$

$\text{RunningTime}(1) = 38.83$ sec

$\text{RunningTime}(2) = 23.49$

$\text{RunningTime}(3) = 25.89$

F. Calculate the segment average speed

$$\text{AvgSegmentSpd}(i) := \frac{3600}{5280} \cdot \frac{\text{SegLength}(i)}{\text{RunningTime}(i) + \text{CtrlDelay}_i}$$

$\text{AvgSegmentSpd}(1) = 31.94$ mi/h

$\text{AvgSegmentSpd}(2) = 13.57$

$\text{AvgSegmentSpd}(3) = 30.91$

G. Calculate the facility travel time and speed

$$\text{FacTravTime} := \left(\frac{\text{SegLength}(1)}{5280\ \text{AvgSegmentSpd}(1)}\right) + \left(\frac{\text{SegLength}(2)}{5280 \cdot \text{AvgSegmentSpd}(2)}\right) + \left(\frac{\text{SegLength}(3)}{5280 \cdot \text{AvgSegmentSpd}(3)}\right)$$

$\text{FacTravTime} = 0.048$ hours

$$\text{AvgFacilitySpeed} := \frac{\text{SegLength}(1) + \text{SegLength}(2) + \text{SegLength}(3)}{5280 \cdot \text{FacTravTime}}$$

$\text{AvgFacilitySpeed} = 23.33$ mi/h

5. Determine Segment LOS.

FDOT LOS Methodology, from FDOT Report BDK-77, TWO 931-02

$SegLOS_1 := CalcLOS(Class, AvgSegmentSpd(1))$

$SegLOS_2 := CalcLOS(Class, AvgSegmentSpd(2))$

$SegLOS_3 := CalcLOS(Class, AvgSegmentSpd(3))$

$SegLOS_1 = $ "A"

$SegLOS_2 = $ "D"

$SegLOS_3 = $ "A"

$$
\begin{aligned}
CalcLOS(Class, Speed) := \; & \text{if } Class = 1 \\
& \quad out \leftarrow \text{"A"} \quad \text{if } Speed > 40 \\
& \quad out \leftarrow \text{"B"} \quad \text{if } 31 < Speed \le 40 \\
& \quad out \leftarrow \text{"C"} \quad \text{if } 23 < Speed \le 31 \\
& \quad out \leftarrow \text{"D"} \quad \text{if } 18 < Speed \le 23 \\
& \quad out \leftarrow \text{"E"} \quad \text{if } 15 < Speed \le 18 \\
& \quad out \leftarrow \text{"F"} \quad \text{if } Speed \le 15 \\
& \text{if } Class = 2 \\
& \quad out \leftarrow \text{"A"} \quad \text{if } Speed > 28 \\
& \quad out \leftarrow \text{"B"} \quad \text{if } 22 < Speed \le 28 \\
& \quad out \leftarrow \text{"C"} \quad \text{if } 17 < Speed \le 22 \\
& \quad out \leftarrow \text{"D"} \quad \text{if } 13 < Speed \le 17 \\
& \quad out \leftarrow \text{"E"} \quad \text{if } 10 < Speed \le 13 \\
& \quad out \leftarrow \text{"F"} \quad \text{if } Speed \le 10 \\
& out
\end{aligned}
$$

6. Determine Facility LOS.

$FacLOS := CalcLOS(Class, AvgFacilitySpeed)$

$FacLOS = $ "B"