HCM 2010 Multimodal LOS Methodology

Broward Metropolitan Planning Organization

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Kittelson & Associates, Inc.
Transportation Engineering/Planning

Overview

- **<u>What's New for HCM 2010?</u>**
- **Brief history of HCM multimodal analysis**
- **Development of the HCM methodology**
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- **FDOT Q/LOS versus HCM 2010**
- **Complete Streets and General Plan Case Studies**
- **Traffic Impact and Sensitivity Case Studies**
- **Q&A**

What's New for HCM 2010?
(The 2010 Highway Capacity Manual)

- **Volume 1 – Concepts**
- **Volume 2 – Uninterrupted Flow Facilities**
  - Freeways, rural highways, rural roads
- **Volume 3 – Interrupted Flow Facilities**
  - Urban arterials, intersections, roundabouts
  - Signals at freeway interchanges,
  - Bicycle and Pedestrian trails
- **Volume 4 – Supplemental Materials (Website)**

What's New for HCM 2010?

- **Guidance on How to Apply the HCM**
  - How and when to use microsimulation
  - Interpretation and presentation of results
- **New Freeway Weaving Method**
- **New Chapter on Active Traffic Management**
- **New Arterial Street Method**
  - Multimodal Level of Service
  - New Roundabout Method

What's New for HCM 2010?
(HCM 2010 Urban Street Analysis)

- **Predict Stops, Speed, Queues**
- **Models signal coordination**
  - force offs, yields
- **Mixed street: signal, stops, roundabout**
- **Sensitive to access management**
  - driveways, median breaks
- **Service Volume Table**

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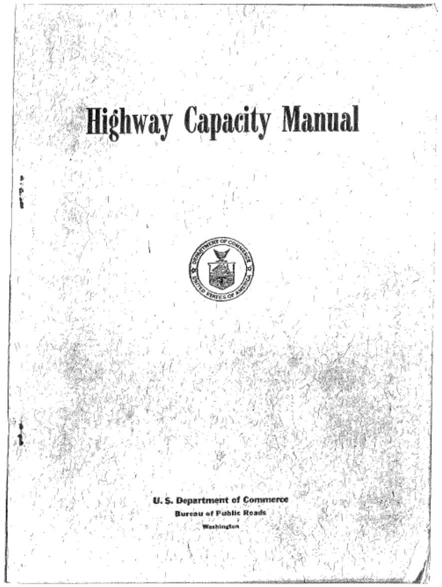
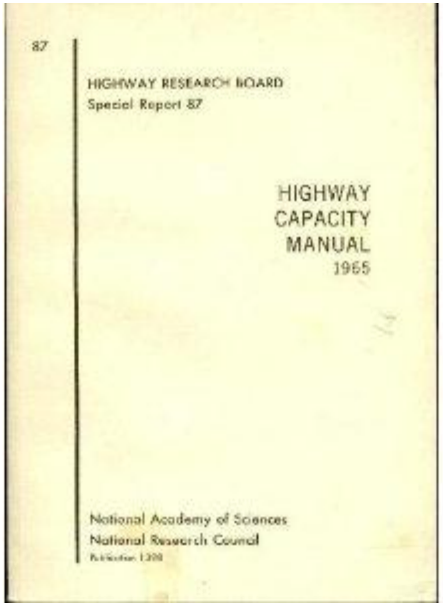
Brief History of HCM Multimodal Analysis

- **1950 HCM**
  - Streetcars and buses impact motorized vehicle capacity at traffic signals
  - Pedestrian impacts on motorized vehicle capacity addressed indirectly
- **1965 HCM**
  - LOS concept introduced
  - Short (11-page) chapter on bus transit

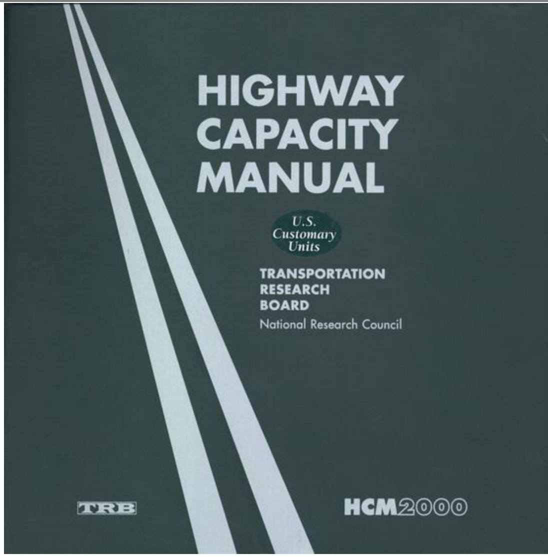




Brief History of HCM Multimodal Analysis

- **1985 HCM**
  - Greatly expanded transit chapter
    - LOS measures based on the probability of a queue of buses forming at a bus stop, passenger loads
  - New pedestrian chapter
    - LOS for sidewalks and street corners based on pedestrian space
  - New 4-page bicycle chapter
    - Focused mainly on bicycle impacts on motorized vehicle capacity

Brief History of HCM Multimodal Analysis



- **HCM 2000**
  - Transit chapter an abridgement of the then-new *Transit Capacity & Quality of Service Manual*
    - LOS measures for frequency, hours of service, passenger load, reliability
  - Expanded pedestrian chapter
    - Methods for additional facility types
    - LOS based on pedestrian space, speed, delay
  - Expanded bicycle chapter
    - LOS based on bicycle speed, delay, hindrance

Brief History of HCM Multimodal Analysis

- **HCM 2000 focus group findings**
  - Many jurisdictions didn't require multimodal analyses
    - Therefore, they weren't performed
  - Jurisdictions that did want to perform pedestrian & bicycle analyses didn't find the HCM 2000 measures useful
    - For example, Maryland & Florida used measures of user comfort
  - Most pedestrian and bicycle facilities don't have capacity or speed issues
    - No need to analyze them using HCM procedures

Brief History of HCM Multimodal Analysis

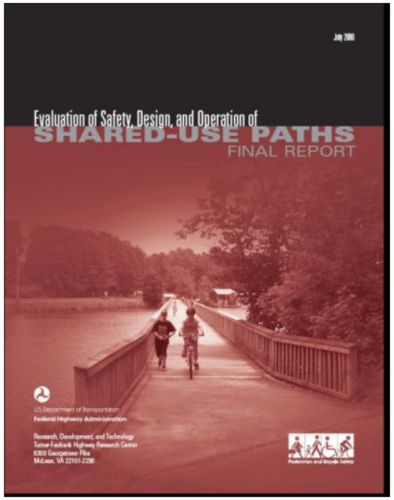
- **Issues with HCM 2000 alternative mode measures:**
  - Pedestrian and bicycle LOS measures reflected a traffic engineer's perspective
  - Transit measures reflected a traveler's perspective, but 4 LOS measures created issues with results interpretation

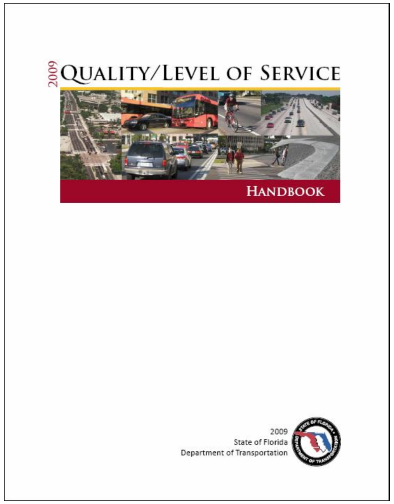
HCM 2000: Ped LOS A

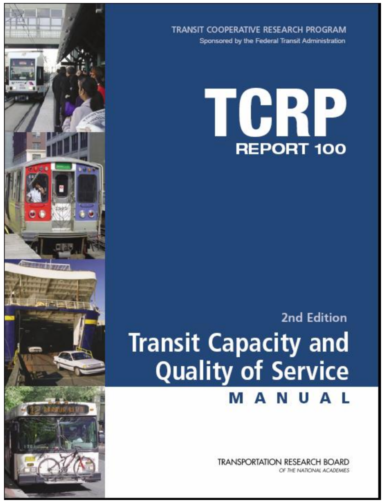
HCM 2000: Ped LOS D

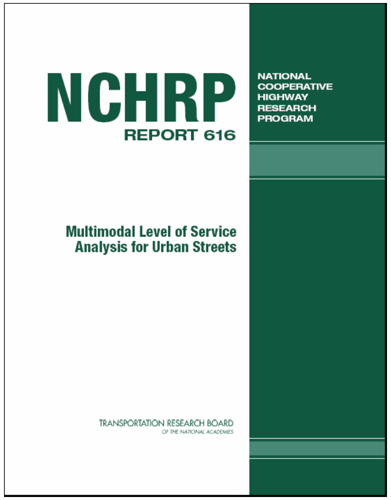
Multimodal Research Since HCM 2000

- **Shared-use path LOS**
  (FHWA, 2006)
- **Florida Quality/Level of Service Handbook**
  (FDOT, 2002 & 2009)
- **Transit Capacity & Quality of Service Manual, 2nd Edition**
  (TCRP Report 100, 2003)
- **Urban street multimodal LOS**
  (NCHRP Report 616, 2008)







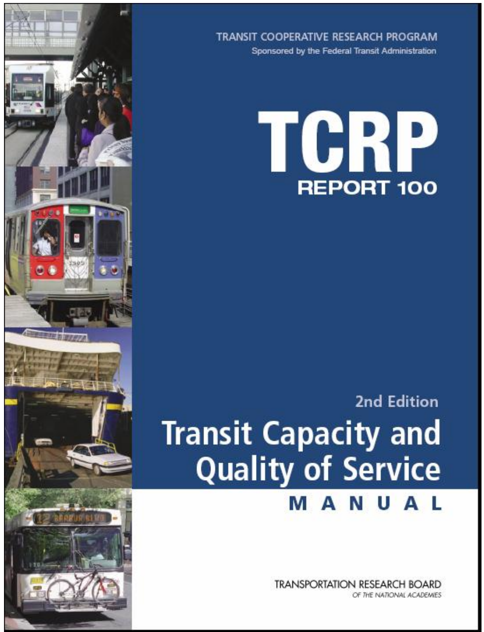


HCM 2010 Multimodal Philosophy

- **Integrate multimodal analysis methods into the appropriate HCM methodological chapters wherever possible**
  - Alternative mode material is presented side-by-side with auto mode material to encourage greater consideration of alternative modes by analysts
  - Encourage software developers to add multimodal analysis features
  - No separate bike, ped, transit chapters

HCM 2010 Multimodal Philosophy

- **Refer readers to the *Transit Capacity & Quality of Service Manual* (TCQSM) for most transit operational analysis methods**
  - Difficult to keep the HCM & TCQSM in synch
  - HCM still presents transit material used for a multimodal analysis of an urban street



HCM 2010 Multimodal Philosophy

- **Allow trade-offs in the use of the right-of-way by different modes to be evaluated**

Mode Affected	Impacting Mode: Auto	Ped	Bike	Transit
Auto	Auto & HV volumes Turning patterns Lane configurations	Minimum green time Turn conflicts Mid-block xings	Turn conflicts Passing delay	Heavy vehicle Blocking delay: stops Signal priority
Ped	Auto & HV volumes Signal cycle length Driver yielding Turn conflicts Traffic separation	Sidewalk crowding Crosswalk crowding Cross-flows	Shared-path conflicts Bicyclist yielding	Heavy vehicle Transit stop queues Bus stop cross-flows Vehicle yielding
Bike	Auto & HV volumes Auto & HV speed On-street parking Turn conflicts Traffic separation	Shared-path conflicts Min. green time Turn conflicts Mid-block xings	Bike volumes	Heavy vehicle Blocking delay: stops Tracks
Transit	Auto volumes Signal timing	Ped. env. quality Minimum green time Turn conflicts Mid-block xings	Bike environment quality Bike volumes	Bus volumes

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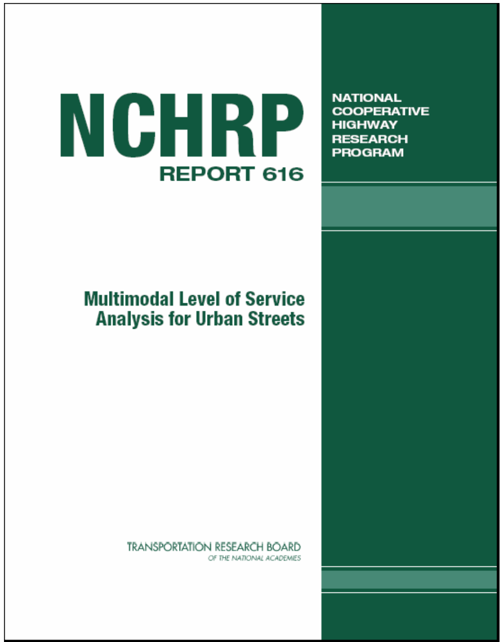
Methodology Selection

- **NCHRP Report 616 method used in HCM 2010**
  - Designed specifically for the HCM
  - LOS measures based on traveler perceptions
  - Modal LOS scores can be directly compared to each other and reflect average traveler satisfaction by mode
  - Model developed and tested based on national conditions



Methodology Development

- **Pedestrian, bicycle, auto modes:**
  - 90 typical street segments recorded
  - Video labs in four cities around the U.S.
  - 120 Participants rated conditions on a A–F scale

Methodology Development

- **Transit mode:**
  - Video lab not a feasible
  - On-board surveys conducted in 4 cities
    - However, results were biased capturing only transit passengers
  - Final model was based on national traveler response data to changes in transit service quality
    - For example, when service frequency or travel time is improved, ridership increases

Methodology Characteristics

- **All models generate an perception score that is generally in the range of 1–6**
- **All models have multiple service quality factors as inputs**
  - Traditional HCM service measures are based on a single factor (e.g., delay)
- **LOS thresholds are the same across models**

LOS Score Interpretation

LOS	LOS Score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

- **Auto LOS is based on *travel speed as a percentage of base free-flow speed* instead of on the auto perception score**

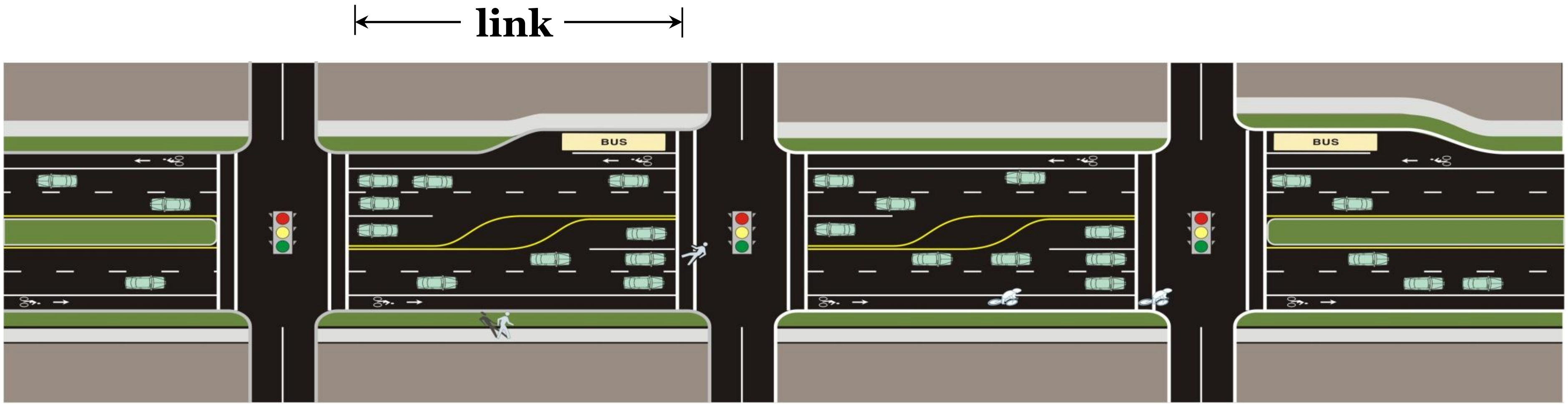
LOS Score Interpretation

- **LOS is reported individually by mode and direction**
- **No combined LOS for the street**
  - Auto volumes would typically dominate an LOS weighted by number of travelers
  - Combined LOS would potentially mask important deficiencies for a given mode
- **Measures the degree to which urban streets meet the need of all users**

Treatment of Safety in Multimodal LOS

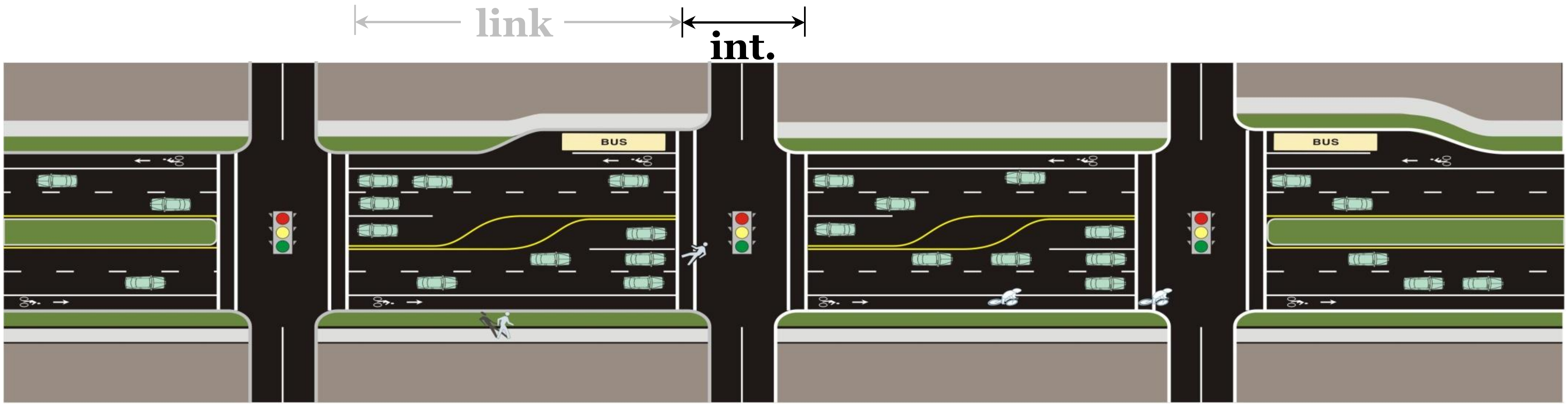
- **HCM 2010 does not explicitly include safety in LOS calculations.**
  - Crash history does not affect LOS
- **However, HCM 2010 does include safety implicitly.**
  - Traveler Perceived Safety
    - Speed of traffic, percent heavy vehicles, barriers between sidewalk and street, lateral separation between vehicle stream and bicyclists and pedestrians.

Urban Street System Elements: Link



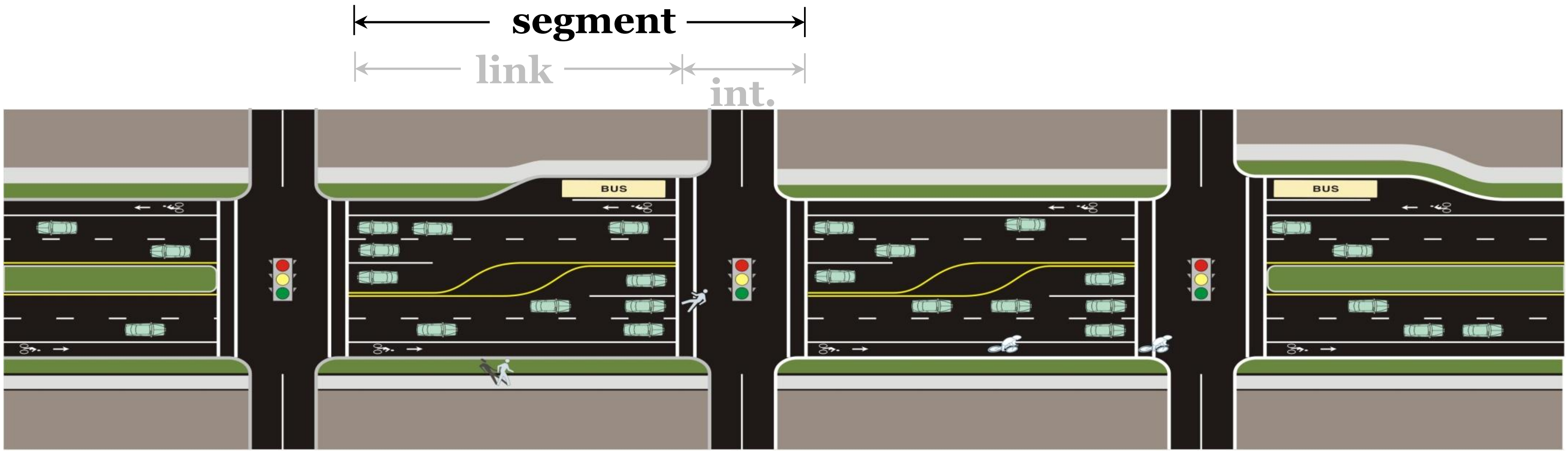
- **Distance between two signalized intersections**
  - Roundabout or all-way STOP could also be an end point
- **Perception score for bike, ped modes**

Urban Street System Elements: Intersection



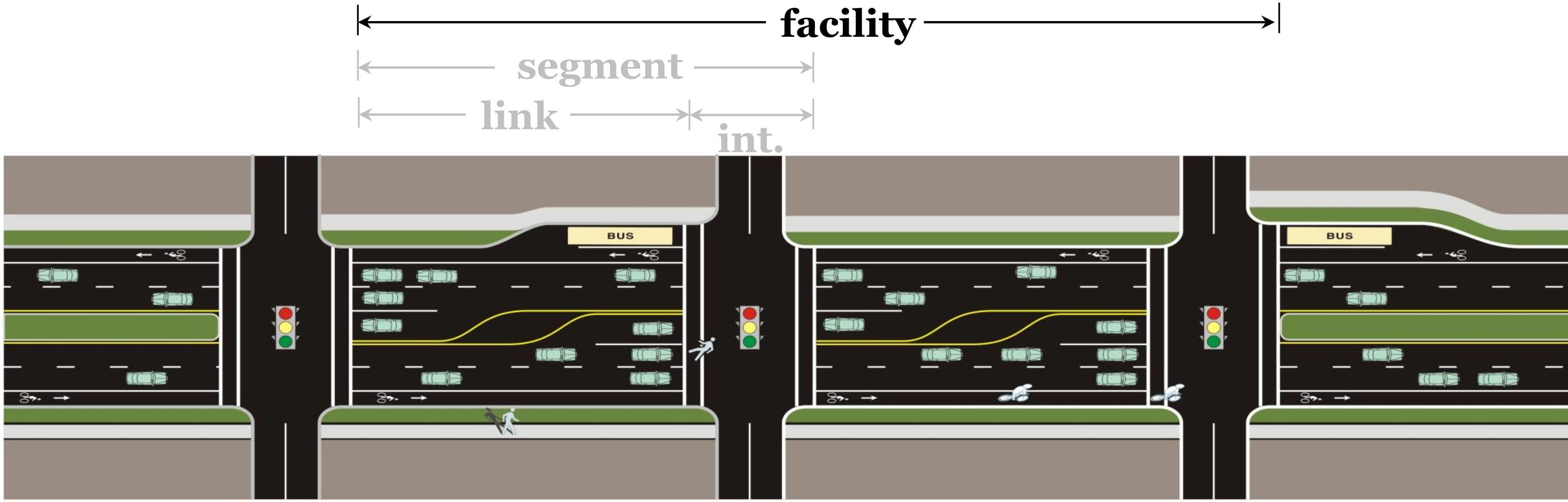
- **Signalized intersection, roundabout, or all-way STOP that terminates a link**
- **Intersection scores only for ped/bike modes**

Urban Street System Elements: Segment



- **Segment = link + downstream intersection**
- **Perception scores available for all modes**
  - Ped & bike scores based on combination of link, intersection, and additional factor

Urban Street System Elements: Facility



- **Facility = 2 or more consecutive segments**
- **Perception scores available for all modes**
  - Length-weighted average of the segment scores

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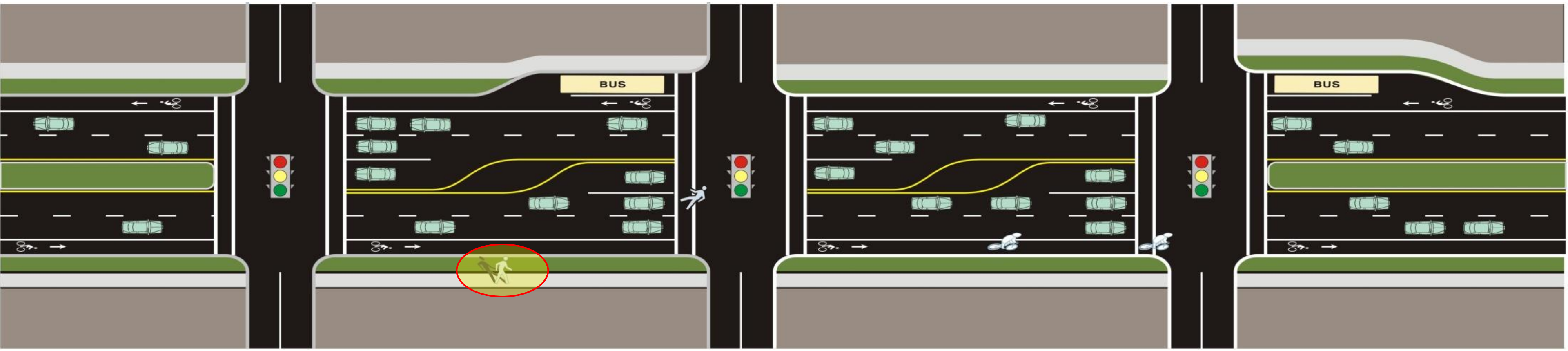
Pedestrian LOS: Links



Pedestrian LOS: Links Model Factors

- **Factors included:**
  - Outside travel lane width (+)
  - Bicycle lane/shoulder width (+)
  - Buffer presence (e.g., on-street parking, street trees) (+)
  - Sidewalk presence and width (+)
  - Volume and speed of motor vehicle traffic in outside travel lane (–)
- **Pedestrian density considered separately**
  - Worse of (density LOS, link LOS score) used in determining overall link LOS

Pedestrian LOS: Links Model Form

$$I_{p,link} = 6.0468 + F_v + F_S + F_w$$

Ped Link LOS Score | Constant | Vehicle Volume | Vehicle Speed | Cross-Section Factor

Mid-segment demand flow rate (veh/h)

$$F_v = 0.0091 \frac{v_m}{4\, N_{th}}$$

Number of through lanes in direction of travel

$$F_s = 4\left(\frac{S_R}{100}\right)^2$$

Motorized vehicle running speed (mi/h) [from auto model]

Pedestrian LOS: Links Model Form

$$F_w = -1.2276 \ln(W_v + 0.5\, W_1 + 50\, p_{pk} + W_{buf}\, f_b + W_{aA}\, f_{sw})$$

Constant

W_v = effective total width of outside through lane, bike lane, and shoulder

W_1 = effective total width of bike lane and shoulder

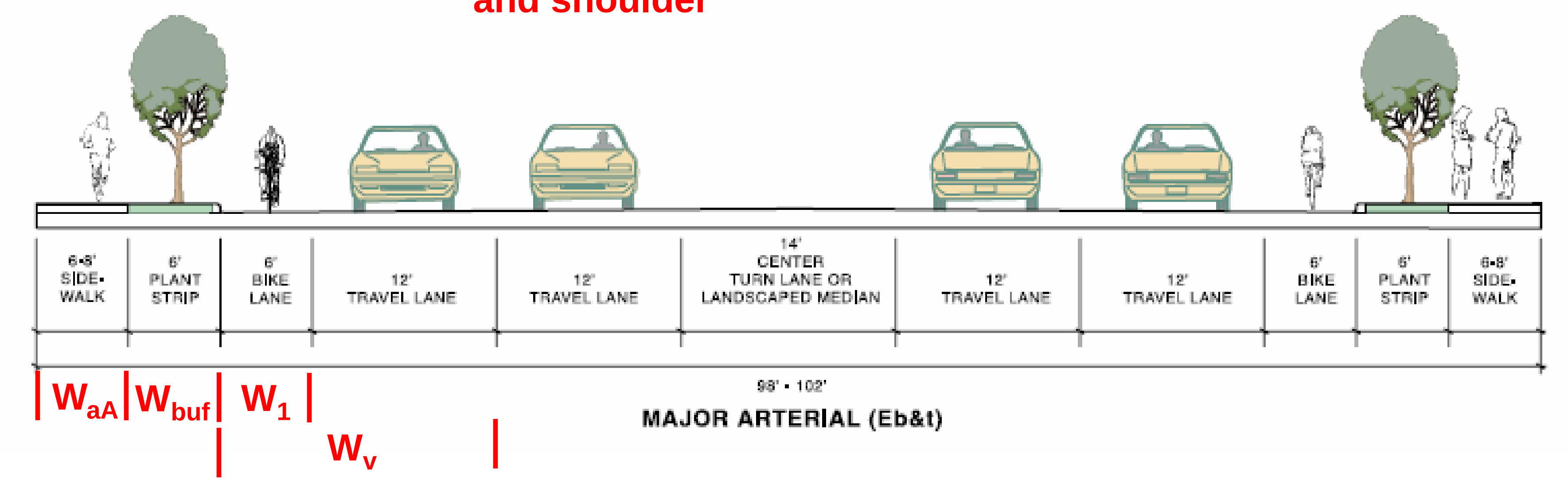
% occupied on-street parking

F_b = 1.00 (no barrier)

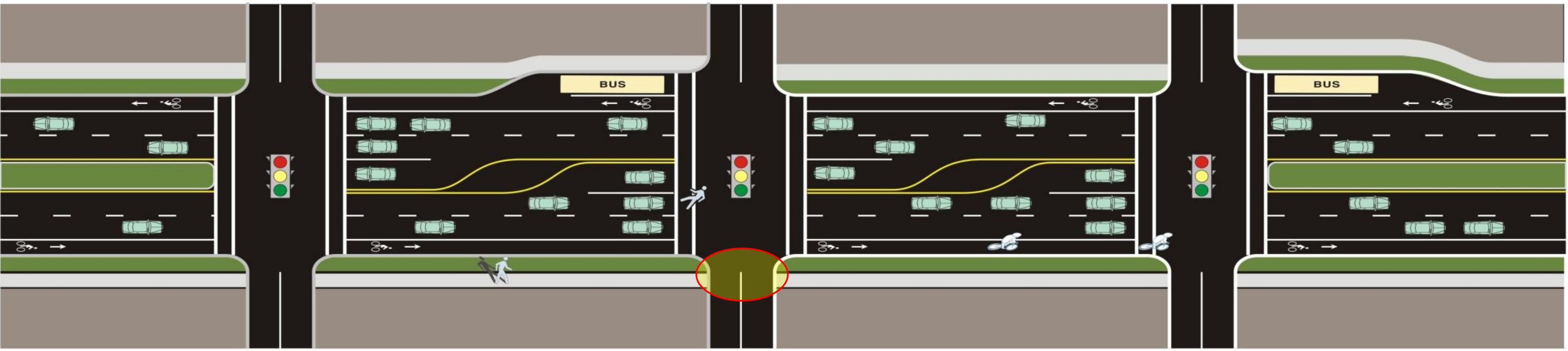
F_b = 5.37 (barrier)

$f_{sw} = 6.0 - 0.3W_{aA}$

$W_{aA} = \min(W_A, 10$ ft)



Pedestrian LOS: Signalized Intersections



Pedestrian LOS: Signalized Intersections Model Factors

- **Factors included:**
  - Permitted left turn and right-turn-on-red volumes (–)
  - Cross-street motor vehicle volumes and speeds (–)
  - Crossing length (–)
  - Average pedestrian delay (–)
  - Right-turn channelizing island presence (+)

Pedestrian LOS: Signalized Intersections Model Form

$$I_{p,int} = 0.5997 + F_w + F_S + F_{\text{delay}} + F_v$$

Ped Intersection LOS Score	Constant	Cross-Section Factor	Speed Factor	Pedestrian Delay Factor [from auto model]	Volume Factor

$$F_w = 0.681\left(N_d\right)^{0.514}$$

Number of traffic lanes crossed

$$F_S = 0.00013\, n_{15,mi}\; S_{85,mi}$$

Minor street traffic volume (veh/ln/15 min)

Minor street midblock auto speed (mi/h)

Pedestrian LOS: Signalized Intersections Model Form

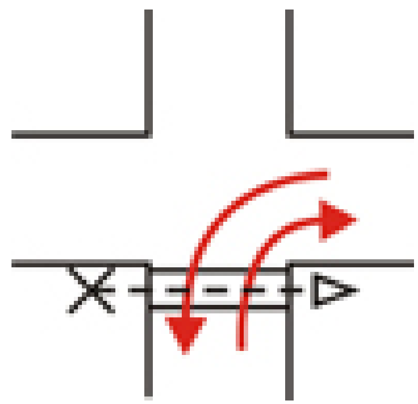
$$F_v = 0.00569\left(\frac{v_{rtor} + v_{lt,perm}}{4}\right) - N_{rtci,d}\left(0.0027\, n_{15,mj} - 0.1946\right)$$

Constant

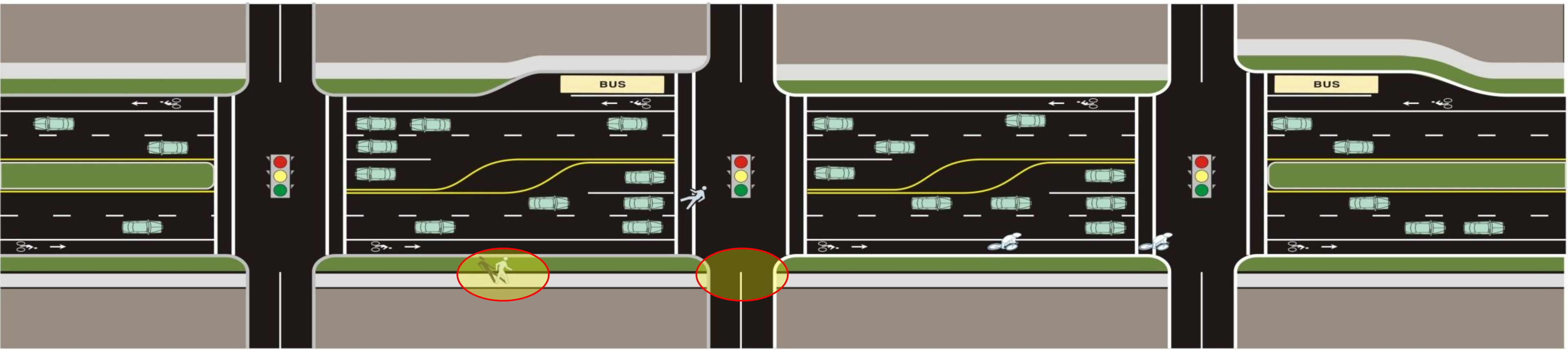
Conflicting traffic flow over crosswalk (veh/h)

Number of right-turn channelizing islands along crossing

Traffic volume of street being crossed (veh/ln/15 min)



Pedestrian LOS: Segments



Pedestrian LOS: Segments Model Factors

- **Factors included:**
  - Pedestrian link LOS (+)
  - Pedestrian intersection LOS (+)
  - Street-crossing difficulty (–/+)
    - Delay diverting to signalized crossing
    - Delay crossing street at legal unsignalized location

Pedestrian LOS: Segments Model Form

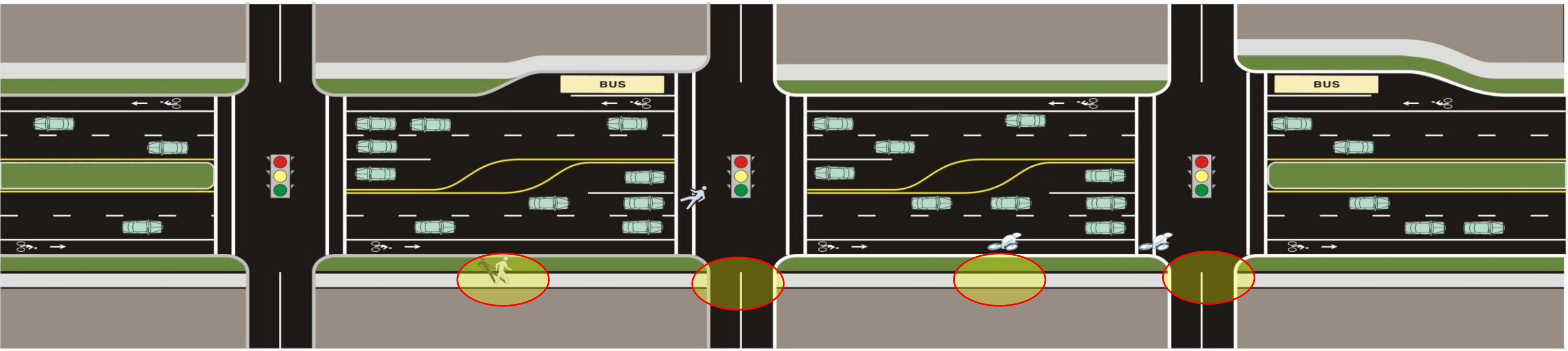
$$I_{p,seg} = F_{cd}\left(0.318\ I_{p,link} + 0.220\ I_{p,int} + 1.606\right)$$

Ped Segment LOS Score — **Ped Link LOS Score** — **Ped Intersection LOS Score** — **Constant**

Minimum of diversion time & unsignalized crossing delay time

$$F_{cd} = 1.0 + \frac{0.10\ d_{px} - (0.318\ I_{p,link} + 0.220\ I_{p,int} + 1.606)}{7.5}$$

Pedestrian LOS: Facility



- **Length-weighted average of segment LOS scores**
  - **Can mask deficiencies in individual segments**
  - **Consider also reporting segment LOS score for the worst segment in the facility**

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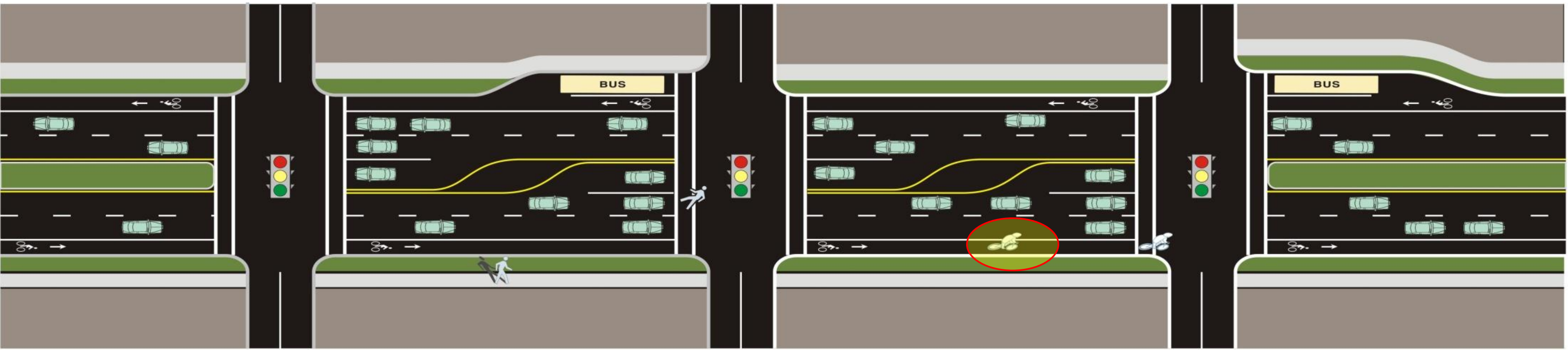
Bicycle LOS: Links



Bicycle LOS: Links Model Factors

- **Factors included:**
  - Volume and speed of traffic in outside travel lane (–)
  - Heavy vehicle percentage (–)
  - Pavement condition (+)
  - Bicycle lane presence (+)
  - Bicycle lane, shoulder, and outside lane widths (+)
  - On-street parking utilization (–)

Bicycle LOS: Links Model Form

$$I_{b,link} = 0.760 + F_v + F_S + F_p + F_w$$

Bike Link LOS Score | Constant | Volume Factor | Speed Factor | Pavement Condition Factor | Cross-Section Factor

$$F_p = \frac{7.066}{P_c^{\,2}}$$

Pavement condition rating (1–5)

Adjusted midblock vehicle flow rate (veh/h)

$$F_v = 0.507 \ln\left(\frac{v_{ma}}{4\,N_{th}}\right)$$

Number of through lanes in travel direction

$$F_S = 0.199\left[1.1199 \ln(S_{Ra} - 20) + 0.8103\right]\left(1 + 0.1038\,P_{HVa}\right)^2$$

Vehicle running speed (>= 21 mi/h)

Adjusted percent heavy vehicles

Bicycle LOS: Links Model Form

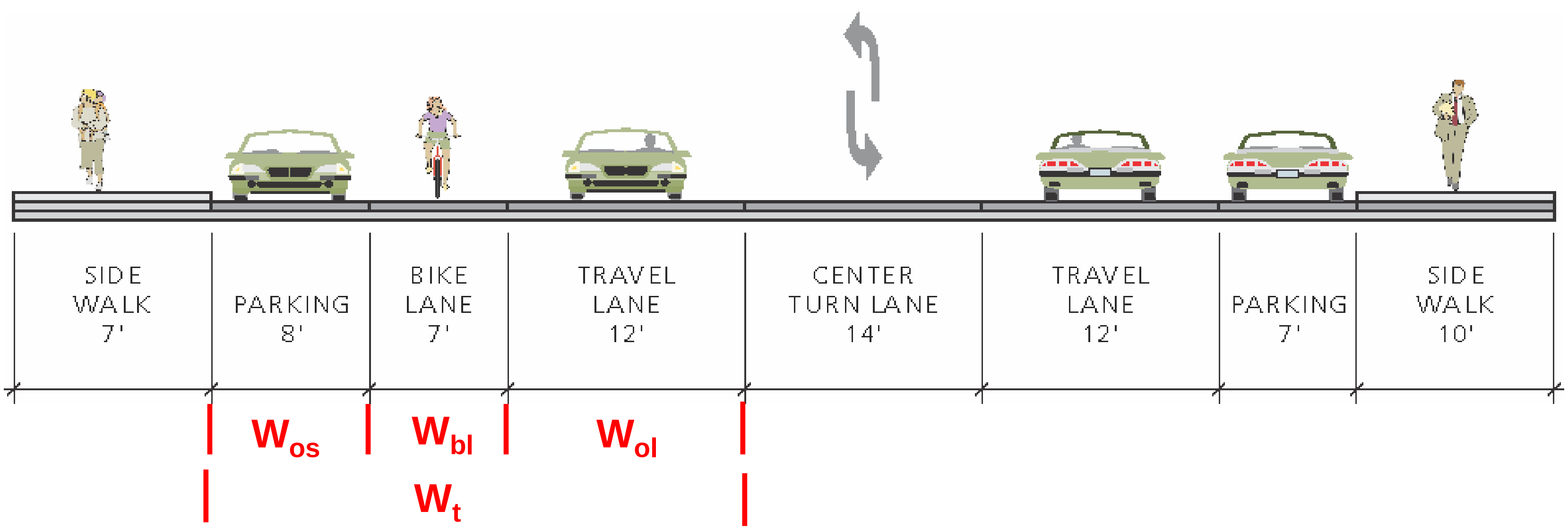
$$F_w = -0.005\, W_e^2$$

Effective width of outside through lane

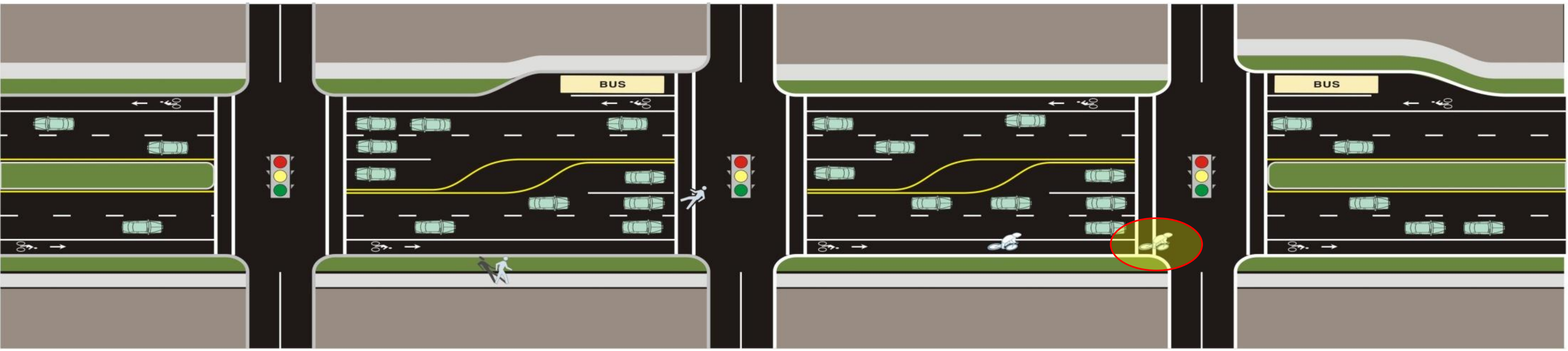
Condition	Variable When Condition Is Satisfied	Variable When Condition Is Not Satisfied
$p_{pk} = 0.0$	$W_t = W_{ol} + W_{bl} + W_{os}^*$	$W_t = W_{ol} + W_{bl}$
$v_m > 160$ veh/h or street is divided	$W_v = W_t$	$W_v = W_t(2 - 0.005\, v_m)$
$W_{bl} + W_{os}^* < 4.0$ ft	$W_e = W_v - 10\, p_{pk} \geq 0.0$	$W_e = W_v + W_{bl} + W_{os}^* - 20\, p_{pk} \geq 0.0$

W_{os} = width of paved outside shoulder

W_{os}^* = adjusted width of paved outside shoulder (same as ped link LOS)



Bicycle LOS: Signalized Intersections



Bicycle LOS: Signalized Intersections Model Factors

- **Factors included:**
  - Width of outside through lane and bicycle lane (+)
  - Cross-street width (–)
  - Motor vehicle traffic volume in the outside lane (–)

Bicycle LOS: Signalized Intersections Model Form

$$I_{b,int} = 4.1324 + F_w + F_v$$

Bike Intersection LOS Score — **Constant** — **Cross-Section Factor** — **Vehicle Volume Factor**

$$F_w = 0.0153\, W_{cd} - 0.2144\, W_t$$

Curb-to-curb cross-street width

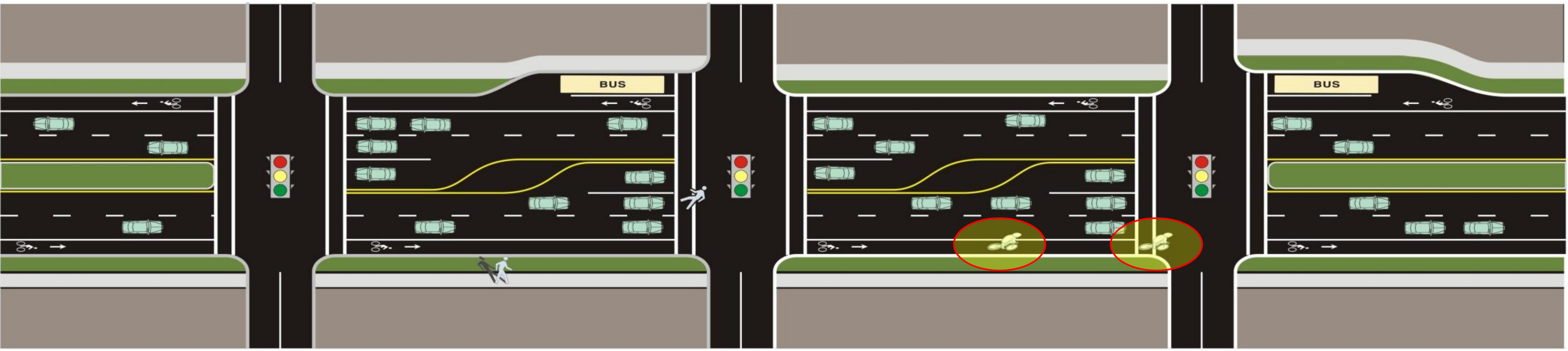
Total width of outside lane, bike lane, paved shoulder

Motorized traffic volume in travel direction

$$F_v = 0.0066 \frac{v_{lt} + v_{th} + v_{rt}}{4\, N_{th}}$$

Number of through lanes in travel direction

Bicycle LOS: Segments



Bicycle LOS: Segments Model Factors

- **Factors included:**
  - Bicycle link LOS (+)
  - Bicycle intersection LOS, if signalized (+)
  - Number of access points on right side (–)
    - Includes driveways and unsignalized street intersections
    - Judgment required on how low-volume residential driveways are treated

Bicycle LOS: Segments Model Form

Number of access points on right side

$$I_{b,seg} = 0.160\, I_{b,link} + 0.011\, F_{bi}\, e^{I_{b,int}} + 0.035 \frac{N_{ap,s}}{(L/5280)} + 2.85$$

Bike Segment LOS Score

Bike Link LOS Score

Indicator Variable

Bike Intersection LOS Score

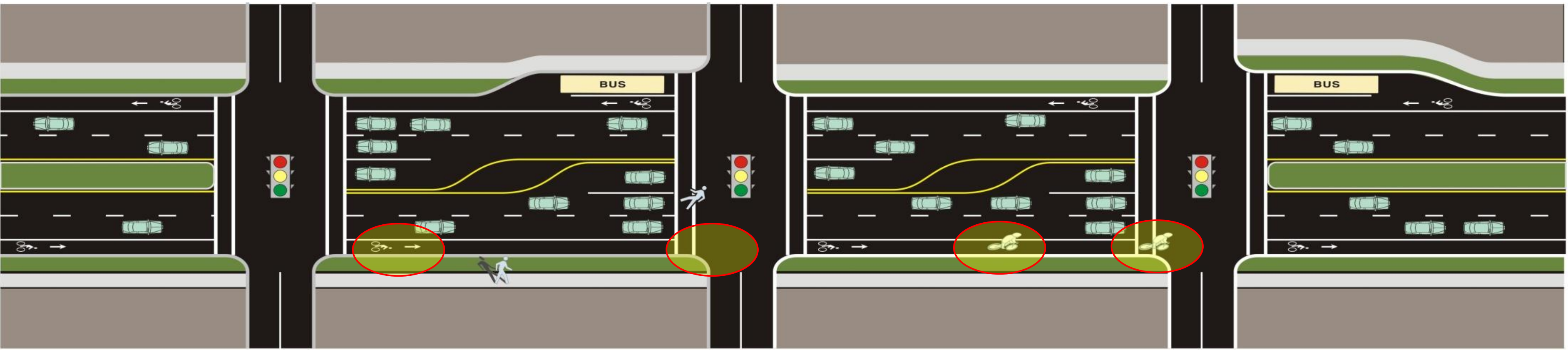
Segment length (mi)

Constant

F_{bi} = 1 if signalized

F_{bi} = 0 if unsignalized

Bicycle LOS: Facility



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Transit LOS: Overview

- **Only segment and facility LOS models**
- **Transit facility LOS is a length-weighted average of segment LOS**
- **“Transit” includes buses, streetcars, and street-running light rail**
- **Three main model components:**
  - Access to transit (pedestrian link LOS)
  - Wait for transit (frequency)
  - Riding transit (perceived travel time rate)

Transit LOS: Segment Model Form

Perceived Travel Time

$$I_{t,seg} = 6.0 - 1.50\, F_h F_{tt} + 0.15\, I_{p,link}$$

Transit Segment LOS Score

Headway Factor

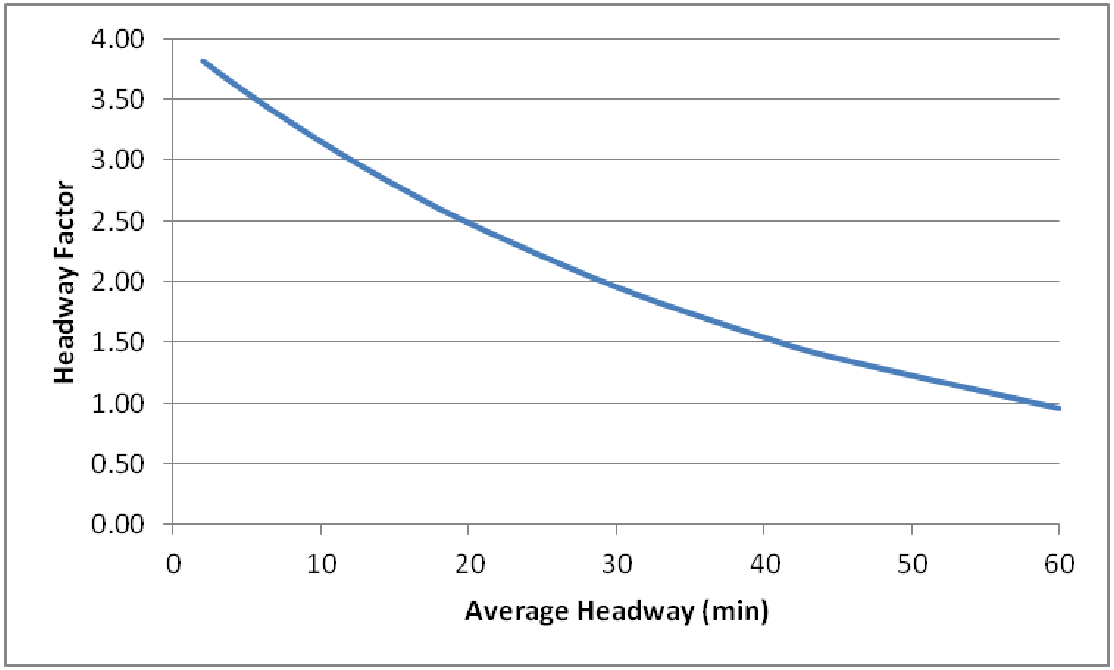
Ped Link LOS Score

Transit LOS:
Headway Factor

$$F_h = 4.00\, e^{-1.434/(v_s + 0.001)}$$

Headway factor

Number of transit vehicles serving segment per hour



Transit LOS: Perceived Travel Time Components

- **Factors included:**
  - Actual bus travel speed (+)
  - Bus stop amenities (+)
  - Excess wait time due to late bus/train arrival (–)
  - On-board crowding (–)
- **Default value of time data and average passenger trip lengths used to convert actual times into perceived times**
  - For example, the trip seems to take longer when one has to stand

Transit LOS: Perceived Travel Time Factor

$$F_{tt} = \frac{(e-1)\,T_{btt} - (e+1)\,T_{ptt}}{(e-1)\,T_{ptt} - (e+1)\,T_{btt}}$$

e = ridership elasticity with respect to travel time changes, default value = -0.4

T_{btt} = base travel time rate (4.0 or 6.0 min/mi)

T_{ptt} = perceived travel time rate

Transit LOS:
Perceived Travel Time Rate

$$T_{ptt} = \left(a_1 \frac{60}{S_{Tt,seg}} \right) + \left(2\,T_{ex} \right) - T_{at}$$

Perceived travel time rate (min/mi)

Crowding perception factor

Actual travel time rate

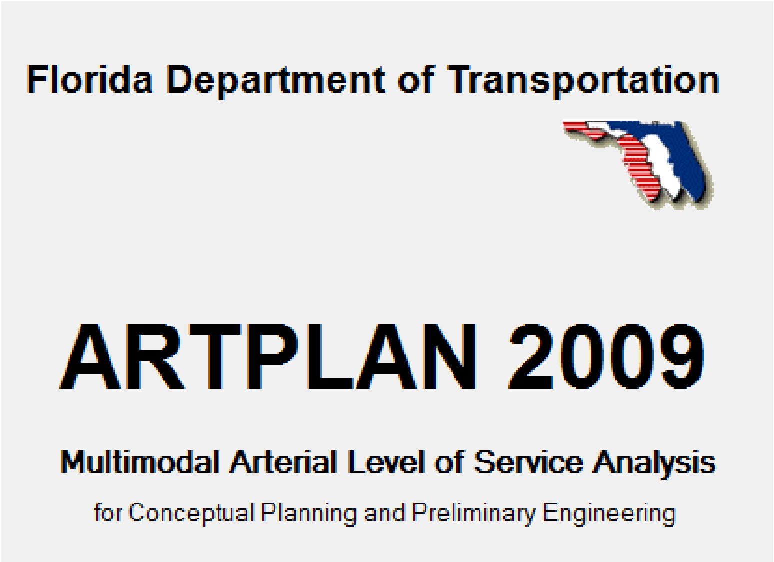
Perceived travel time rate due to late arrivals

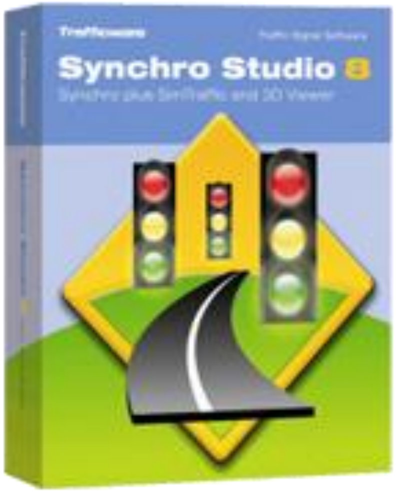
Perceived travel time rate due to stop amenities

$$a_1 = \begin{cases} 1.00 & \text{Load factor (p/seat)} \le 0.80 \\ 1 + \dfrac{(4)(F_l - 0.80)}{4.2} & 0.80 < \text{Load factor} \le 1.00 \\ 1 + \dfrac{(4)(F_l - 0.80) + (F_l - 1.00)(6.5 + [(5)(F_l - 1.00)])}{4.2 \times F_l} & \text{Load factor} > 1.00 \end{cases}$$

Analysis Software for MMLOS

- HCS 2010
- CompleteStreetsLOS
- ARTPLAN
- SYNCHRO





Overview

- **What's New for HCM 2010?**
- **Brief history of HCM multimodal analysis**
- **Development of the HCM methodology**
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- <u>**FDOT Q/LOS versus HCM 2010**</u>
- **Complete Streets and General Plan Case Studies**
- **Traffic Impact and Sensitivity Case Studies**
- **Q&A**

Comparing HCM 2010 with FDOT Q/LOS Methodologies

Kittelson & Associates, Inc.
Transportation Engineering/Planning

Level-of-Service Analysis Similarities

- **Quality of service from traveler's perspective**
  - Perceived safety
  - Comfort
  - Convenience
- **Directional**
  - Can combine for overall LOS
- **Result is a numerical score**
  - Convert to a LOS
- **Link level formulas**

Score Letter Grade Thresholds (Bicycle / Pedestrian)

LOS	Score (FDOT Q/LOS)	Score (HCM 2010)
A	<= 1.50	<= 2.00
B	> 1.50 and <= 2.50	> 2.00 and <= 2.75
C	> 2.50 and <= 3.50	> 2.75 and <= 3.50
D	> 3.50 and <= 4.50	> 3.50 and <= 4.25
E	> 4.50 and <= 5.50	> 4.25 and <= 5.00
F	> 5.50	> 5.00

- **Different limits for all levels**

Bicycle / Pedestrian Level-of-Service

- **FDOT Q/LOS calculates LOS for:**
  - Link (Street section between signalized intersections)
  - Facility (Multiple adjacent links)
- **HCM 2010 calculates LOS for:**
  - Link (Street section between signalized intersections)
  - Signalized intersection
  - Segment (One link and one downstream signalized intersection)
  - Facility (Multiple adjacent segments)

Bicycle LOS

- **Link LOS**
  - Parameters and formulas are the same
- **Signalized Intersection and Segment LOS**
  - Only in HCM 2010
  - Segment LOS accounts for the presence of access points along the corridor

Pedestrian LOS

- **Link LOS**
  - Variables are the same
  - Equations slightly different
    - Greater emphasis on shoulder, bike lane, and on-street parking (HCM 2010)
  - Density consideration in HCM 2010
- **Signalized Intersection and Segment LOS**
  - Only in HCM 2010
  - Segment LOS considers the difficulty in crossing the analysis street.

Score Letter Grade Thresholds (Transit)

LOS	Adjusted Service Frequency - Vehicles/Hour (FDOT Q/LOS)	Score (HCM 2010)
A	>6.00	<= 2.00
B	>4.00 and <= 6.00	> 2.00 and <= 2.75
C	3.00 to 4.00	> 2.75 and <= 3.50
D	2.00 to 2.99	> 3.50 and <= 4.25
E	1.00 to 1.99	> 4.25 and <= 5.00
F	<1.00	> 5.00

- **Numerical scores not directly comparable**

Transit Level-of-Service

- **Parameters:**

FDOT Q/LOS	HCM 2010
Service Frequency (+)	Service Frequency (+)
Pedestrian LOS (+/-)	Pedestrian LOS (-)
Roadway crossing (+/-)	Average bus speed (+/-)
Obstacles between stop and sidewalk (-)	Bus reliability (+/-)
Span of service (+/-)	Passenger load (-)
	Bus stop amenities (+)

- **Service frequency is the most important factor in both**

Transit Level-of-Service

- **Calculate scores differently**
  - Adjusted service frequency (FDOT Q/LOS)
  - Numerical score from equation (HCM 2010)
- **Pedestrian LOS has different effects**
  - FDOT Q/LOS
    - Can increase or decrease adjusted average frequency (0.55 – 1.15 factor range)
  - HCM 2010
    - Only increases numerical score (worsens LOS)
    - *Transit LOS Score = 6.0 – 1.50 * Transit Wait Ride Score + 0.15 * Ped LOS*

Overview

- **What's New for HCM 2010?**
- **Brief history of HCM multimodal analysis**
- **Development of the HCM methodology**
  - Pedestrian LOS model
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- **FDOT Q/LOS versus HCM 2010**
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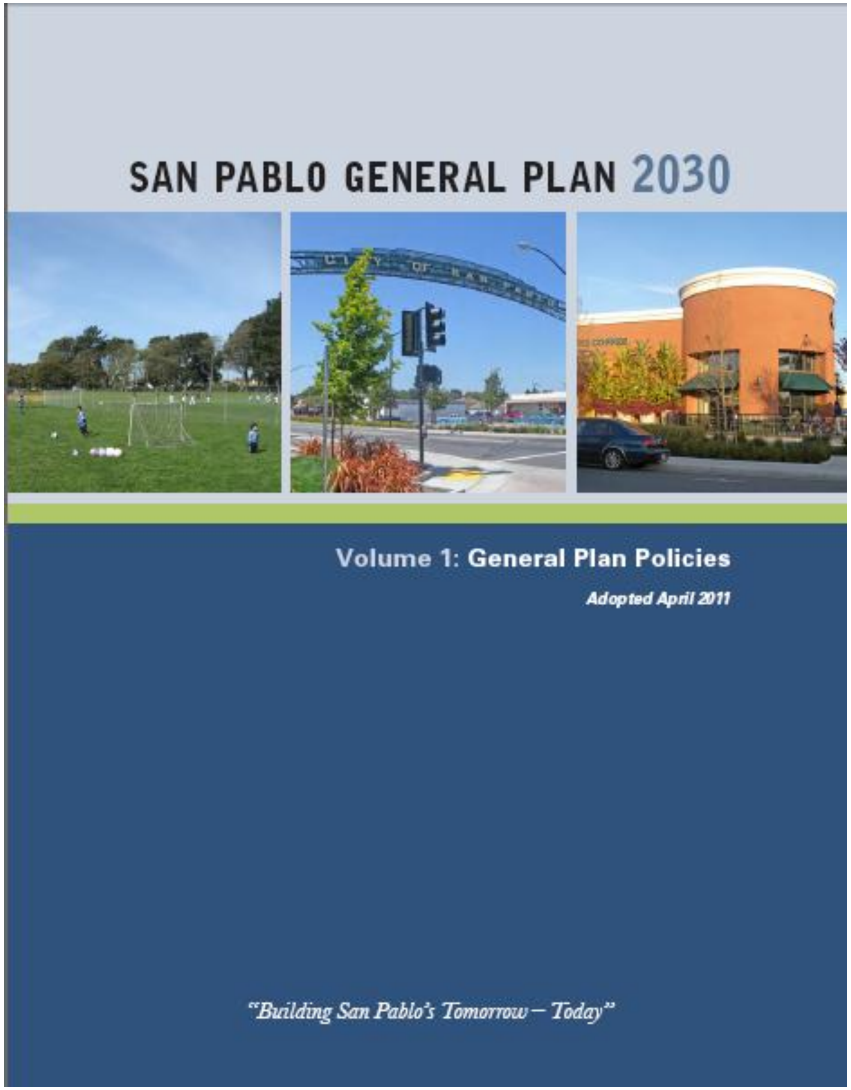
- **Traffic Impact and Sensitivity Case Studies**
- **Q&A**

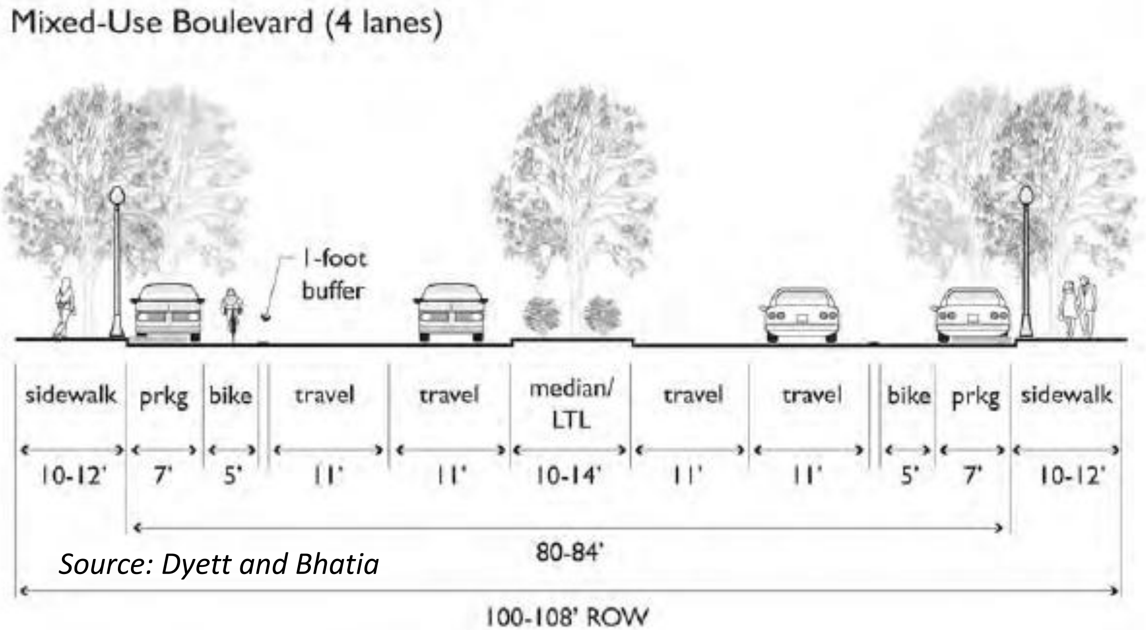
Case Study
General Plan

- **Adopted 2011**
- **Dyett and Bhatia – Prime consultant**
- **How to incorporate MMLOS**



Case Study
General Plan

- **Complete Street general policies**
- **Designation of circulation system**
  - Move away from motorist-only perceptions
  - Incorporate more multimodal designations



Source: Dyett and Bhatia

Case Study
General Plan

CITY OF SAN PABLO
City of New Directions

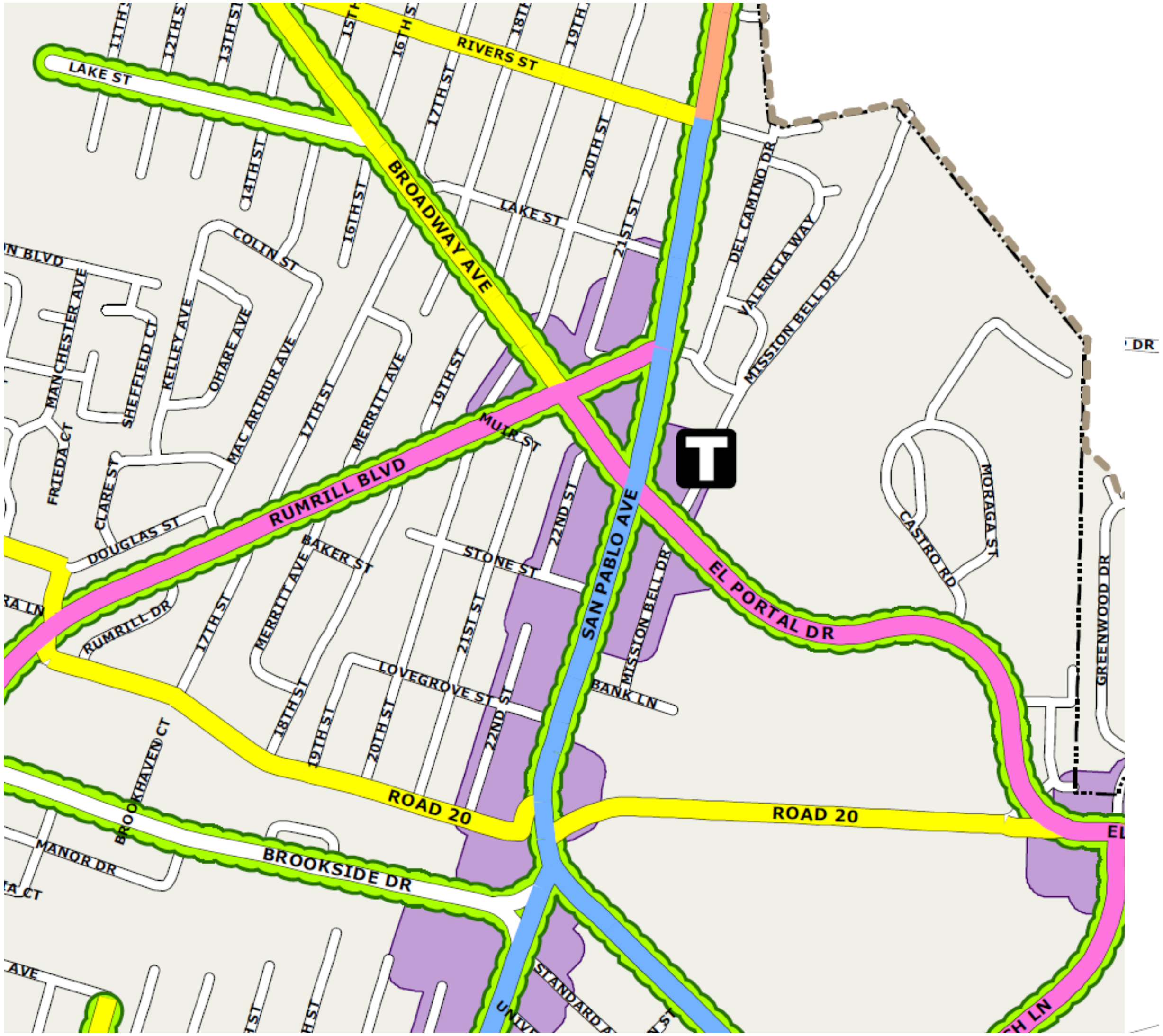


Figure 5-1
Proposed Roadway System

- State Highway
- Mixed Use Boulevard
- Urban Arterial
- Auto Arterial
- Avenue
- Local
- Major Transit Hub
- Pedestrian Priority Zone
- Green Street Overlay
- Planning Area
- City Limits
- Railroads

Case Study
General Plan

CITY OF SAN PABLO
City of New Directions

- **Prioritization of different street types by mode**

Table 5.2-1 Transportation Facilities Matrix

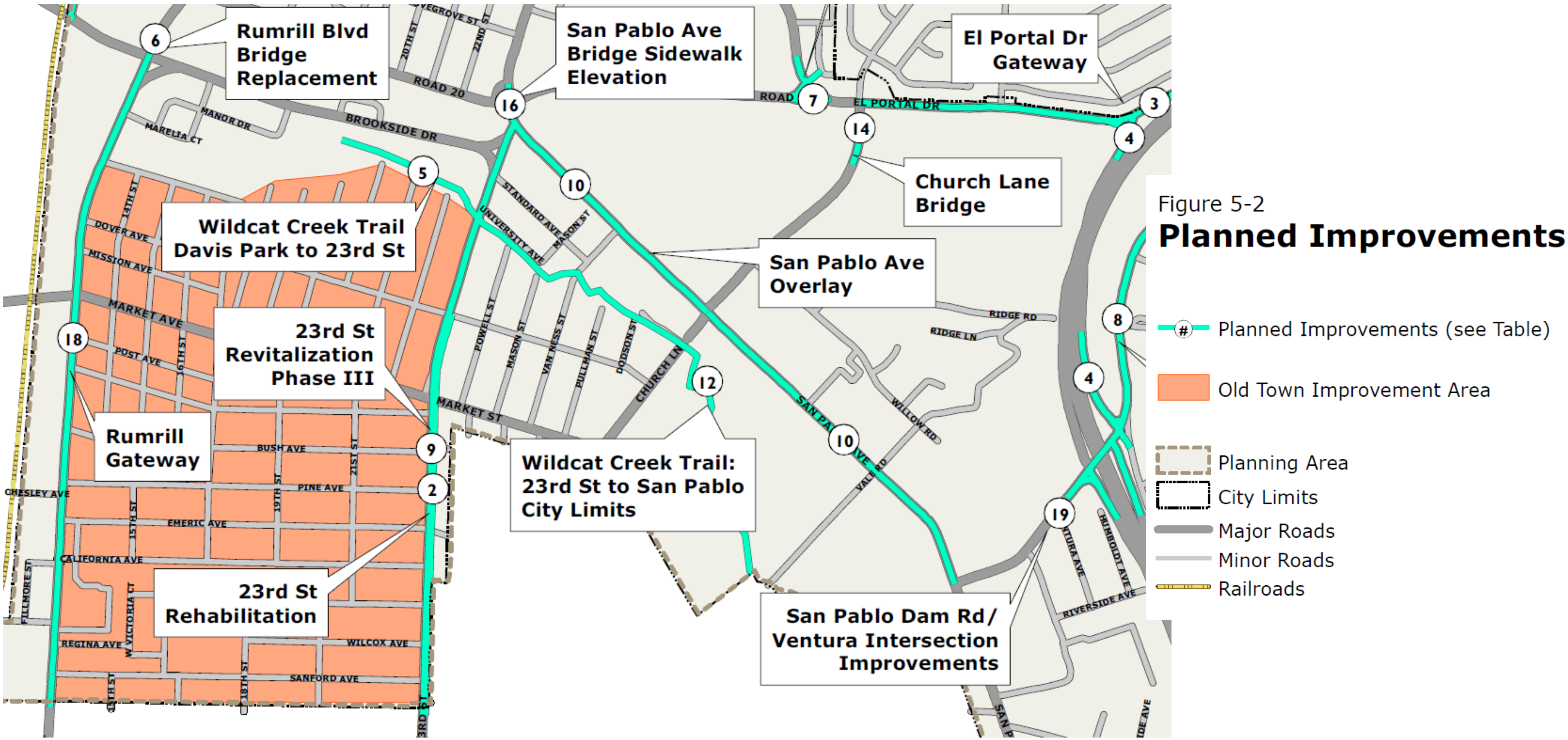
Facility	*Transit*	*Bicycles*	*Pedestrians*	*Trucks*	*Automobiles*
State Highway	□	X	X	□	□
Auto Arterial	□	□	○	■	■
Urban Arterial[1]	■	■	□	○	■
Mixed Used Boulevard	■	□	■	□	□
Avenue	○	□	□	○	□
Local	○	□	□	X	□

■ = Dominant
□ = Accommodated
○ = Incidental
X = Prohibited

[1] Transit has priority over bicycles on Urban Arterials, where conflicts exist.

Case Study
General Plan

- **More robust determination of improvements**



Case Study
General Plan

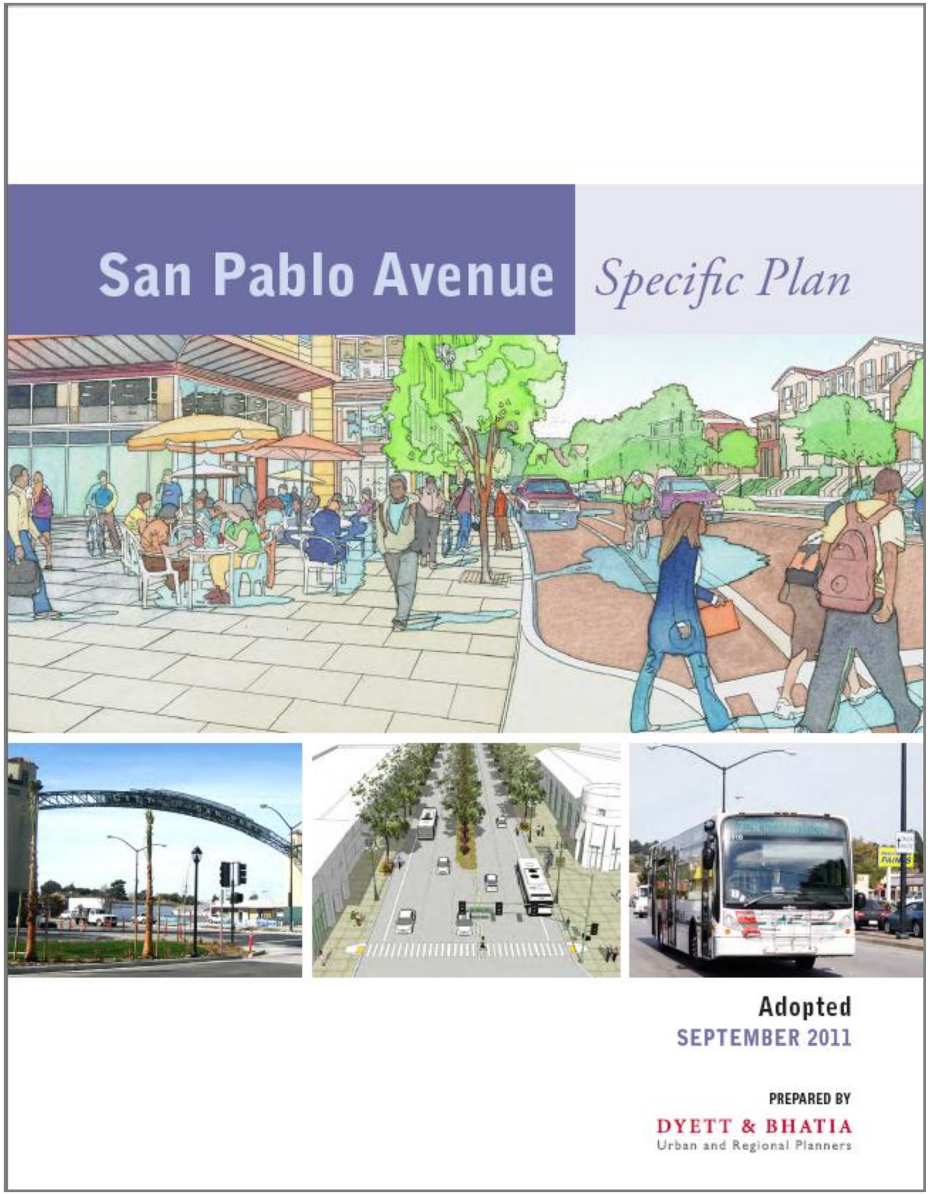
- **MMLOS summary of factors for each mode**

Table 5.2-4 Definition of Multi-modal Level of Service Indicators

LOS	*Transit*	*Bicycle*	*Pedestrian*
A	(Good walk access to bus stops, frequent service, good bus stop amenities.)	(Few driveway and cross street conflicts, good pavement condition, ample width of outside lane, including parking and bike lanes.)	(Low traffic volumes, wide buffer separating sidewalk from traffic, numerous street trees, and high parking occupancy.)
B			
C			
D			
E			
F	(Poor walk access to bus stops, infrequent service, poor schedule adherence, no bus stop amenities.)	(Poor pavement condition, narrow width of outside lane, frequent driveways and cross streets.)	(High traffic volumes, limited buffer separating sidewalk from traffic, few street trees, low parking occupancy.)

Source: Dowling Associates, 2010.

Case Study
Specific Plan



- **Adopted 2011**
- **Guide to revitalize in a sustainable manner**
- **MMLOS analysis**
  - Existing
  - 2030 No Project
  - 2030 Specific Plan

Case Study Specific Plan

▪ MMLOS Analysis

AM Peak-Hour													
		Northbound						*Southbound*					
		Transit Passenger		*Bicyclist*		*Pedestrian*		*Transit Passenger*		*Bicyclist*		*Pedestrian*	
Corridor Section	*Scenario*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*
North	Existing	1.67	A	3.45	C	2.98	C	1.65	A	3.55	D	3.07	C
	2030 No Project	2.11	B	3.49	C	3.08	C	1.78	A	3.61	D	3.19	C
	2030 Specific Plan	2.07	B	3.18	C	2.84	C	1.76	A	3.29	C	3.04	C
Central	Existing	1.08	A	3.50	C	3.06	C	1.10	A	3.49	C	2.96	C
	2030 No Project	1.22	A	3.54	D	3.15	C	1.27	A	3.55	D	3.07	C
	2030 Specific Plan	1.20	A	3.48	C	3.03	C	1.23	A	2.95	C	2.83	C
South	Existing	0.91	A	4.13	D	2.87	C	0.80	A	3.60	D	2.83	C
	2030 No Project	1.07	A	4.22	D	2.99	C	1.06	A	3.65	D	2.96	C
	2030 Specific Plan	1.04	A	3.69	D	2.81	C	1.05	A	3.57	D	2.85	C

Dowling Associates, Inc., Multi-Modal Level of Service analysis using CompleteStreetsLOS version 2.1.8, November 2010

Legend

(red)	Worse than existing
(light pink)	Worse than existing but better than 2030 No Project
(green)	Better than existing

Case Study Specific Plan

- **MMLOS Analysis**

PM Peak-Hour													
		Northbound						*Southbound*					
		Transit Passenger		*Bicyclist*		*Pedestrian*		*Transit Passenger*		*Bicyclist*		*Pedestrian*	
Corridor Section	*Scenario*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*	*Score*	*LOS*
North	Existing	1.71	A	3.61	D	3.26	C	1.64	A	3.53	D	3.03	C
	2030 No Project	1.79	A	3.70	D	3.43	C	2.08	B	3.63	D	3.23	C
	2030 Specific Plan	1.76	A	3.35	C	3.20	C	2.05	B	3.30	C	3.08	C
Central	Existing	1.10	A	3.57	D	3.20	C	1.08	A	3.44	C	2.84	C
	2030 No Project	1.14	A	3.70	D	3.47	C	2.50	B	3.50	C	3.06	C
	2030 Specific Plan	1.12	A	3.62	D	3.35	C	2.46	B	2.90	C	2.82	C
South	Existing	0.95	A	4.36	E	3.10	C	0.79	A	3.58	D	2.76	C
	2030 No Project	0.99	A	4.78	E	3.37	C	1.30	A	3.69	D	2.99	C
	2030 Specific Plan	0.96	A	3.90	D	3.21	C	1.29	A	3.60	D	2.89	C

Dowling Associates, Inc., Multi-Modal Level of Service analysis using CompleteStreetsLOS version 2.1.8, November 2010

Legend

(dark pink)	Worse than existing
(light pink)	Worse than existing but better than 2030 No Project
(green)	Better than existing

Case Study
General and Specific Plan

- **Benefits of MMLOS**
  - Provided baseline LOS for all travel modes
    - Reasonableness of LOS standards
  - Tested MMLOS for Specific Plan scenario
  - Multimodal roadway designations
    - Provides guidelines for improvements
    - Informs mitigation requirements
    - Provides an analysis tool

Case Study
General and Specific Plan

- **Lessons Learned**
  - MMLOS works well analyzing fixed right-of-way
    - How to allocate space
    - Quantifies trade-offs between modes
  - Developing policy standards
    - Establish baseline
    - Conduct sketch what-if scenarios
    - May lead to prioritizing specific modes on streets

Overview

- **What’s New for HCM 2010?**
- **Brief history of HCM multimodal analysis**
- **Development of the HCM methodology**
    - Pedestrian LOS model
    - Bicycle LOS model
    - Transit LOS model
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- **Traffic Impact and Sensitivity Case Studies**
- **Q&A**

Traffic Impact and Sensitivity Case Studies

- **Worked with the City of Pasadena to analyze multimodal impacts of two projects**
  1. Road Diet Evaluation
  2. Development Impact Analysis

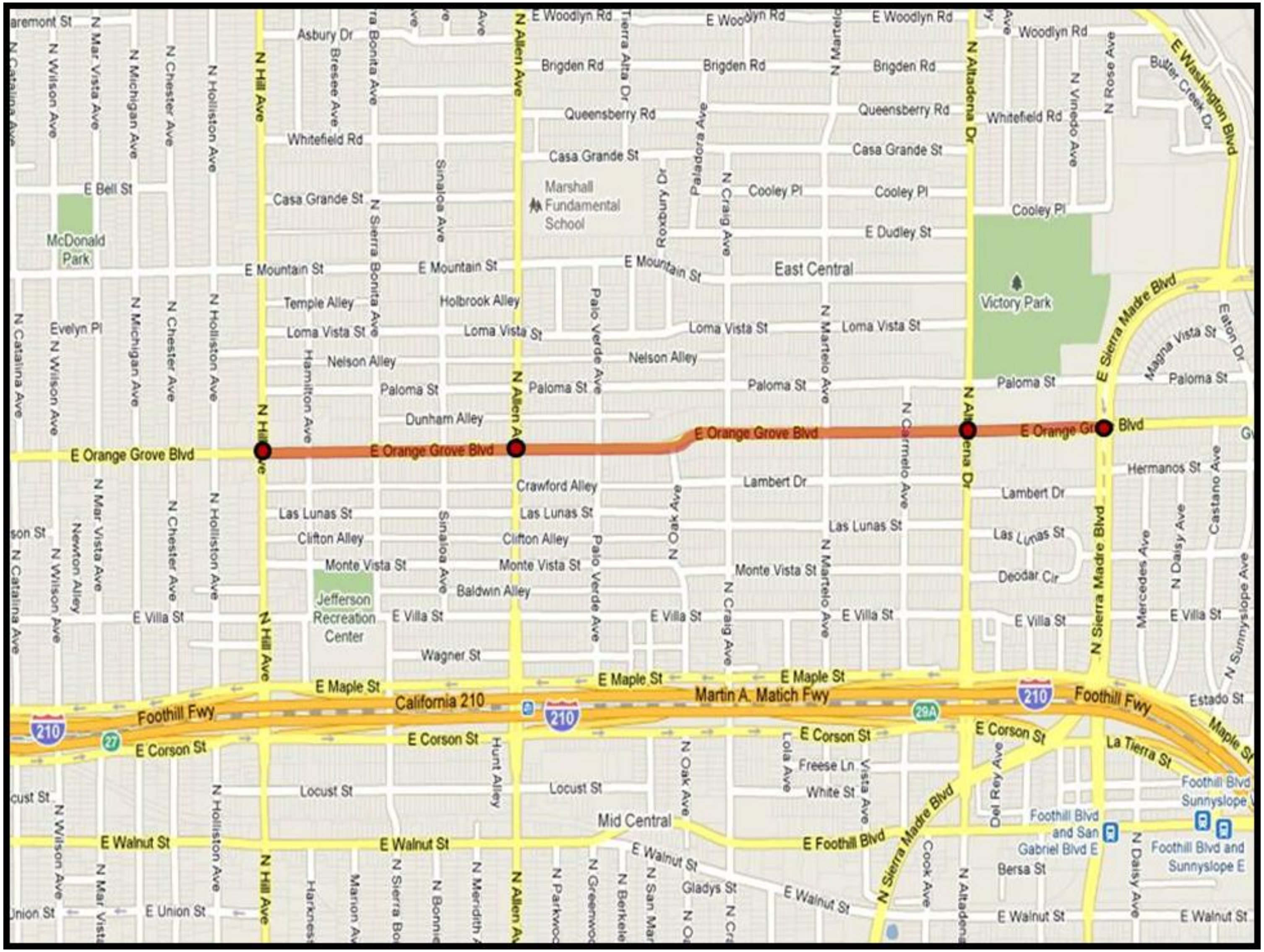
Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

- **When implementing a road diet, many concerns arise including:**
  - How will the lane reduction affect the auto mode?
  - Will transit operations be affected?
  - How much will the bicycle mode improve as a result of adding bike lanes?
  - Will there be any benefit to pedestrians?
- **Orange Grove Blvd. was analyzed using multimodal LOS to address these concerns**

Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

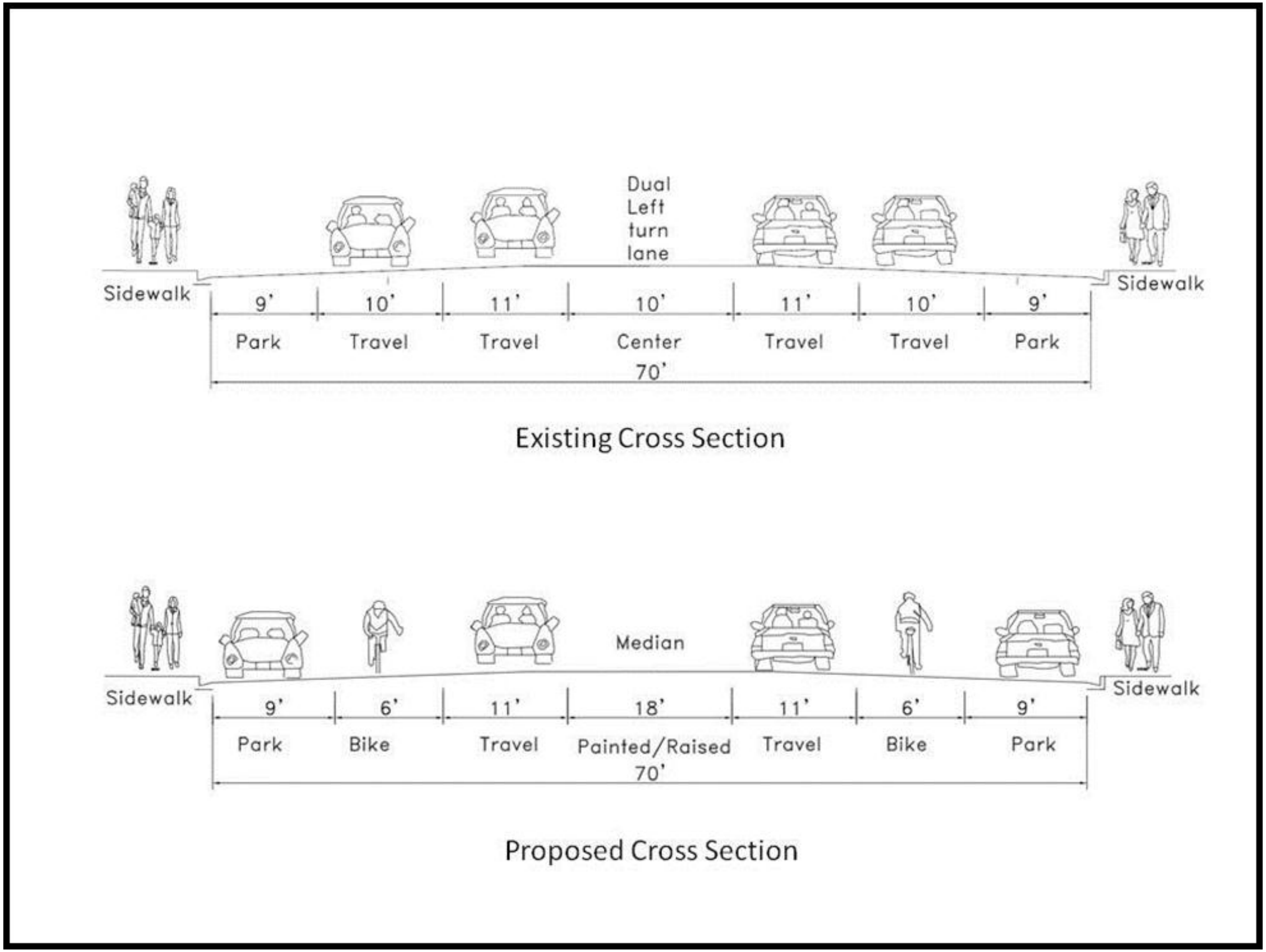


11,200 ADT

1.6 Miles

Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation



- **Issues with Current Cross Section**
  - No facilities for bicyclists
  - Light traffic volumes for a large right-of-way (ROW) roadway
  - Higher speeds and wider crossing width which detract from a neighborhood feel

Traffic Impact and Sensitivity Case Studies

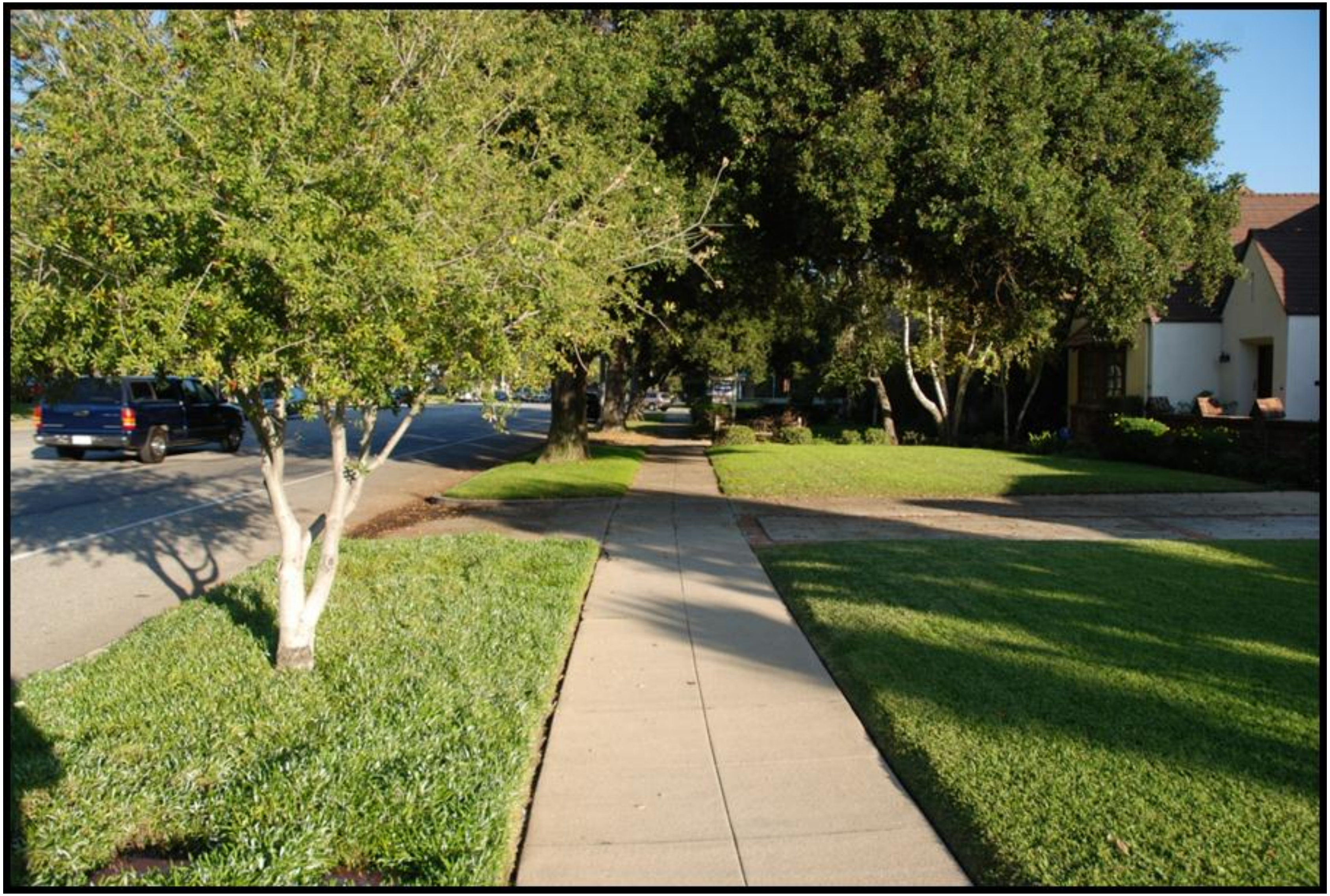
Road Diet Evaluation

Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation

Traffic Impact and Sensitivity Case Studies

Road Diet Evaluation



Traffic Impact and Sensitivity Case Studies
Road Diet Evaluation

The Result:

- *Analysis showed that the road diet will result in minor changes to the transit and auto mode*
- *The pedestrian and bicycle modes will improve between 9% and 20% if the road diet is implemented on this corridor*

Orange Grove Boulevard - Facility PM					
	Mode	**Existing Score (LOS)**	**Road Diet Score (LOS)**	**Difference**	**% Change**
EB	Auto	2.33 (B)	2.57 (B)	0.24	10.3%
	Transit	3.23 (C)	3.19 (C)	-0.04	-1.2%
	Bicycle	3.44 (C)	2.73 (B)	-0.71	-20.6%
	Pedestrian	2.89 (C)	2.63 (B)	-0.26	-9.0%
WB	Auto	2.32 (B)	2.45 (B)	0.13	5.6%
	Transit	3.09 (C)	3.05 (C)	-0.04	-1.3%
	Bicycle	3.33 (C)	2.66 (B)	-0.67	-20.1%
	Pedestrian	2.84 (C)	2.58 (B)	-0.26	-9.2%

Traffic Impact and Sensitivity Case Studies
Road Diet Evaluation

- **Transit**
  - Auto speed decreased (-)
  - Pedestrian LOS improved (+)
- **Bicycle**
  - Slower auto speeds (+)
  - Fewer through lanes for same volume (-)
  - Exclusive bike lane (+)
- **Pedestrian**
  - More vehicles in lane nearest pedestrians (-)
  - Increased space between auto and ped (+)
  - Slower auto speeds (+)

Development Impact Analysis

Traffic Impact and Sensitivity Case Studies

Development Impact Analysis

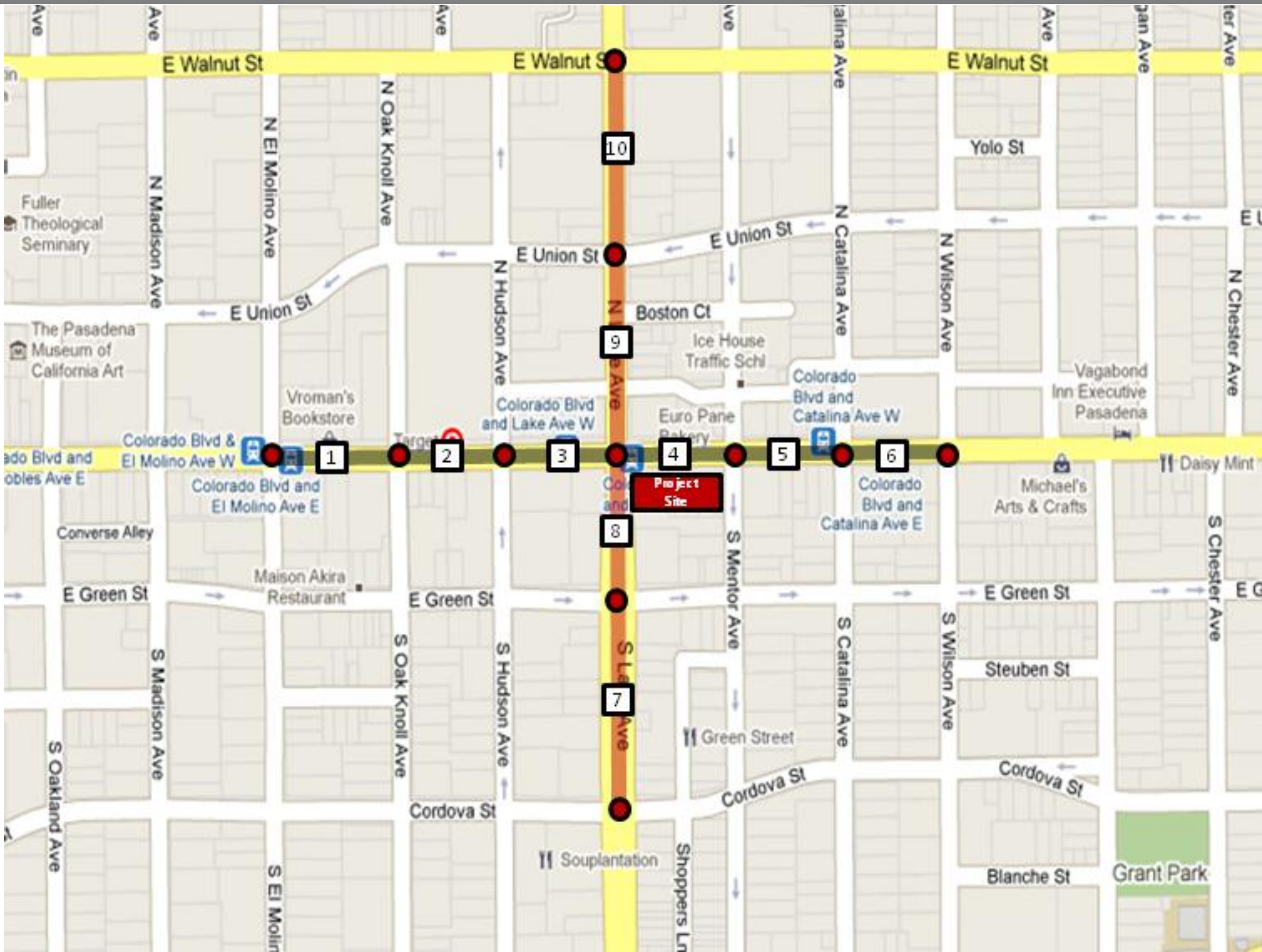
- Impact studies generally only consider auto
- Pasadena finding it difficult to mitigate certain areas
- How might MMLOS provide another tool
- A recent development project was selected to test multimodal LOS

Traffic Impact and Sensitivity Case Studies
Development Impact Analysis

- **Project consisted of:**
  - **156 room hotel**
  - **38,000 ft^2 of dining**
  - **14,000 ft^2 retail**
  - **103,000 ft^2 office**
  - **8,000 ft^2 of bank**
- **Generated 4,900 daily trips**
- **289 trips in the AM peak hour**
- **488 trips in the PM peak hour**

Traffic Impact and Sensitivity Case Studies

Development Impact Analysis



Facility Level Results for Colorado Blvd.

Direction	Mode	AM Peak			PM Peak		
		Existing	2015	2015 + Proj	Existing	2015	2015 + Proj
Eastbound	Auto	2.97 (C)	2.99 (C)	2.99 (C)	3.04 (C)	3.08 (C)	3.09 (C)
	Transit	1.29 (A)	1.32 (A)	1.32 (A)	1.36 (A)	1.43 (A)	1.44 (A)
	Pedestrian	2.46 (B)	2.52 (B)	2.54 (B)	2.65 (B)	2.77 (C)	2.79 (C)
	Bicycle	3.39 (C)	3.42 (C)	3.42 (C)	3.47 (C)	3.50 (C)	3.51 (D)
	Overall	2.53 (B)	2.56 (B)	2.57 (B)	2.63 (B)	2.70 (B)	2.71 (B)
Westbound	Auto	3.02 (C)	3.05 (C)	3.05 (C)	3.02 (C)	3.06 (C)	3.06 (C)
	Transit	1.26 (A)	1.32 (A)	1.33 (A)	1.47 (A)	1.54 (A)	1.54 (A)
	Pedestrian	2.58 (B)	2.67 (B)	2.68 (B)	2.61 (B)	2.71 (B)	2.72 (B)
	Bicycle	3.29 (C)	3.32 (C)	3.32 (C)	3.30 (C)	3.33 (C)	3.33 (C)
	Overall	2.54 (B)	2.59 (B)	2.60 (B)	2.60 (B)	2.66 (B)	2.66 (B)

Traffic Impact and Sensitivity Case Studies

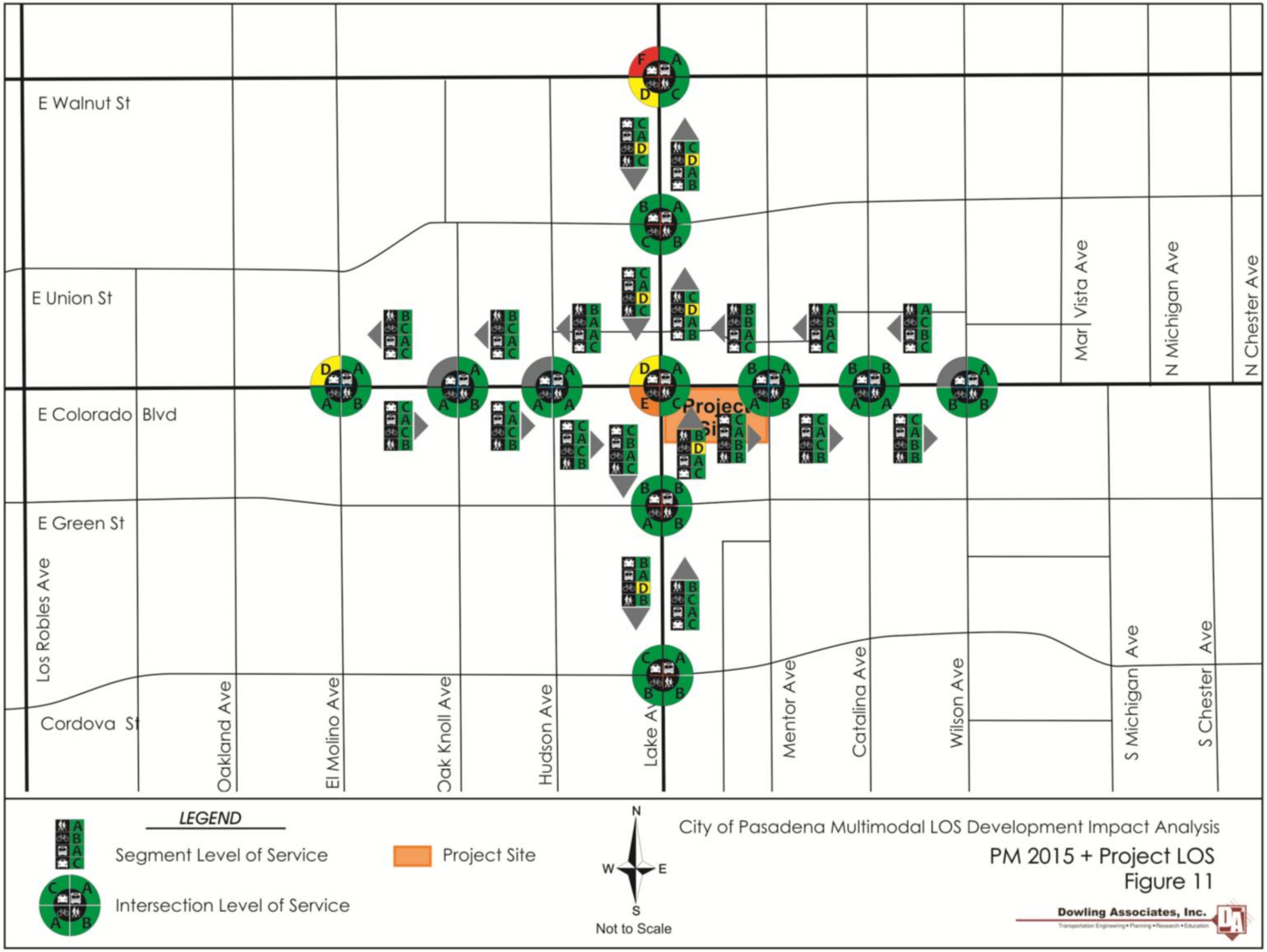
Development Impact Analysis

Link results for Colorado Blvd.

Colorado Boulevard - Worst Direction PM Segment LOS							
Segment	**Mode**	**Direction**	**Existing**	**2015**	**2015 + Proj**	**Diff.**	**% Change**
El Molino Ave to Oak Knoll Ave	Auto	EB	2.88 (C)	2.90 (C)	2.91 (C)	0.01	0.3%
	Transit	WB	1.54 (A)	1.61 (A)	1.61 (A)	0.00	0.0%
	Pedestrian	EB	1.80 (A)	2.16 (B)	2.21 (B)	0.05	2.3%
	Bicycle	EB	2.98 (C)	3.10 (C)	3.12 (C)	0.02	0.6%
Oak Knoll Ave to Hudson Ave	Auto	EB	3.10 (C)	3.17 (C)	3.19 (C)	0.02	0.6%
	Transit	EB	1.44 (A)	1.53 (A)	1.54 (A)	0.01	0.7%
	Pedestrian	EB	1.83 (A)	2.19 (B)	2.24 (B)	0.05	2.3%
	Bicycle	EB	2.68 (B)	2.80 (C)	2.81 (C)	0.01	0.4%

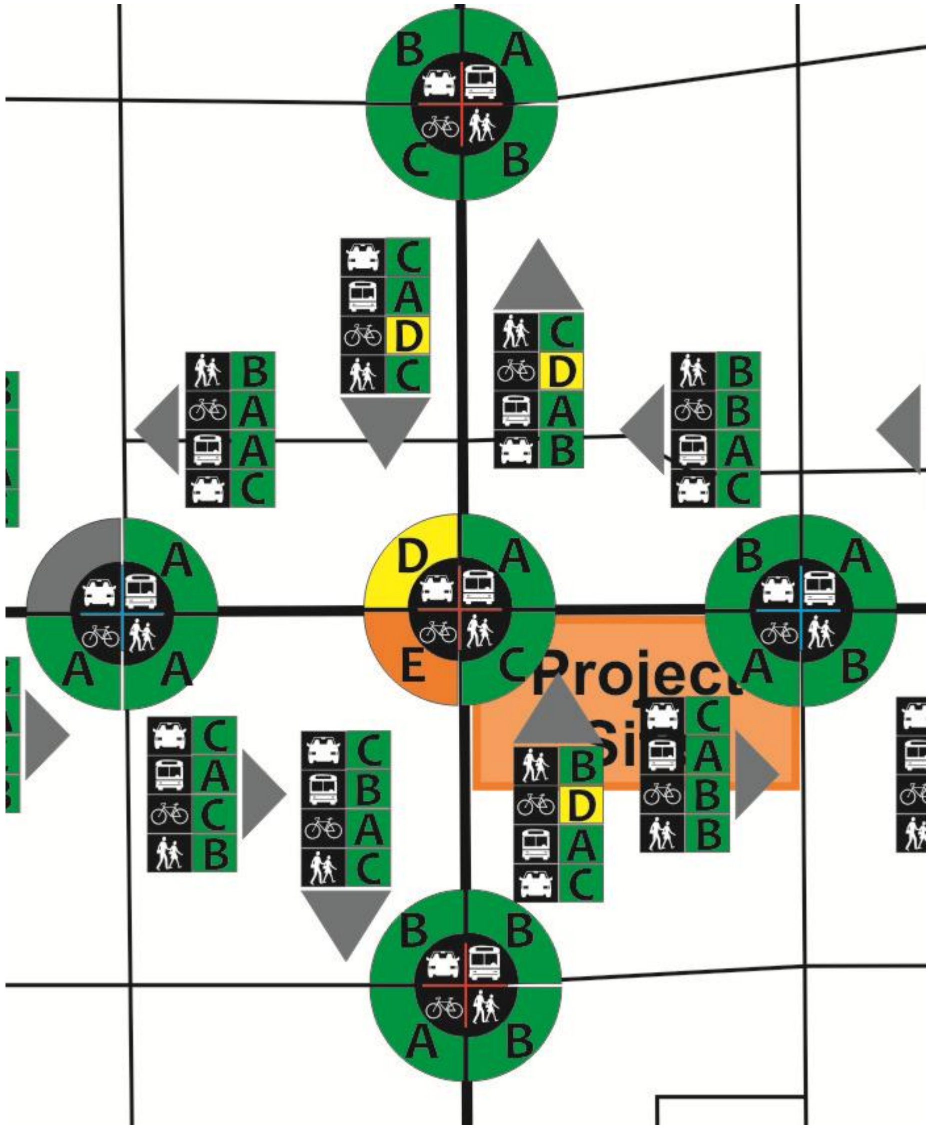
Traffic Impact and Sensitivity Case Studies

Development Impact Analysis



Traffic Impact and Sensitivity Case Studies

Development Impact Analysis



Traffic Impact and Sensitivity Case Studies
Development Impact Analysis

- **Transit**
  - Minimal effect, transit speed slightly slower (-)
  - Pedestrian LOS slightly worse (-)
- **Bicycle**
  - Slower auto speeds (+)
  - Increased volume (-)
- **Pedestrian**
  - More vehicles in lane nearest pedestrians (-)
  - Slower auto speeds (+)
- **All impacts minor, volume has only small effect on LOS for non-auto modes**

Traffic Impact and Sensitivity Case Studies
Conclusions

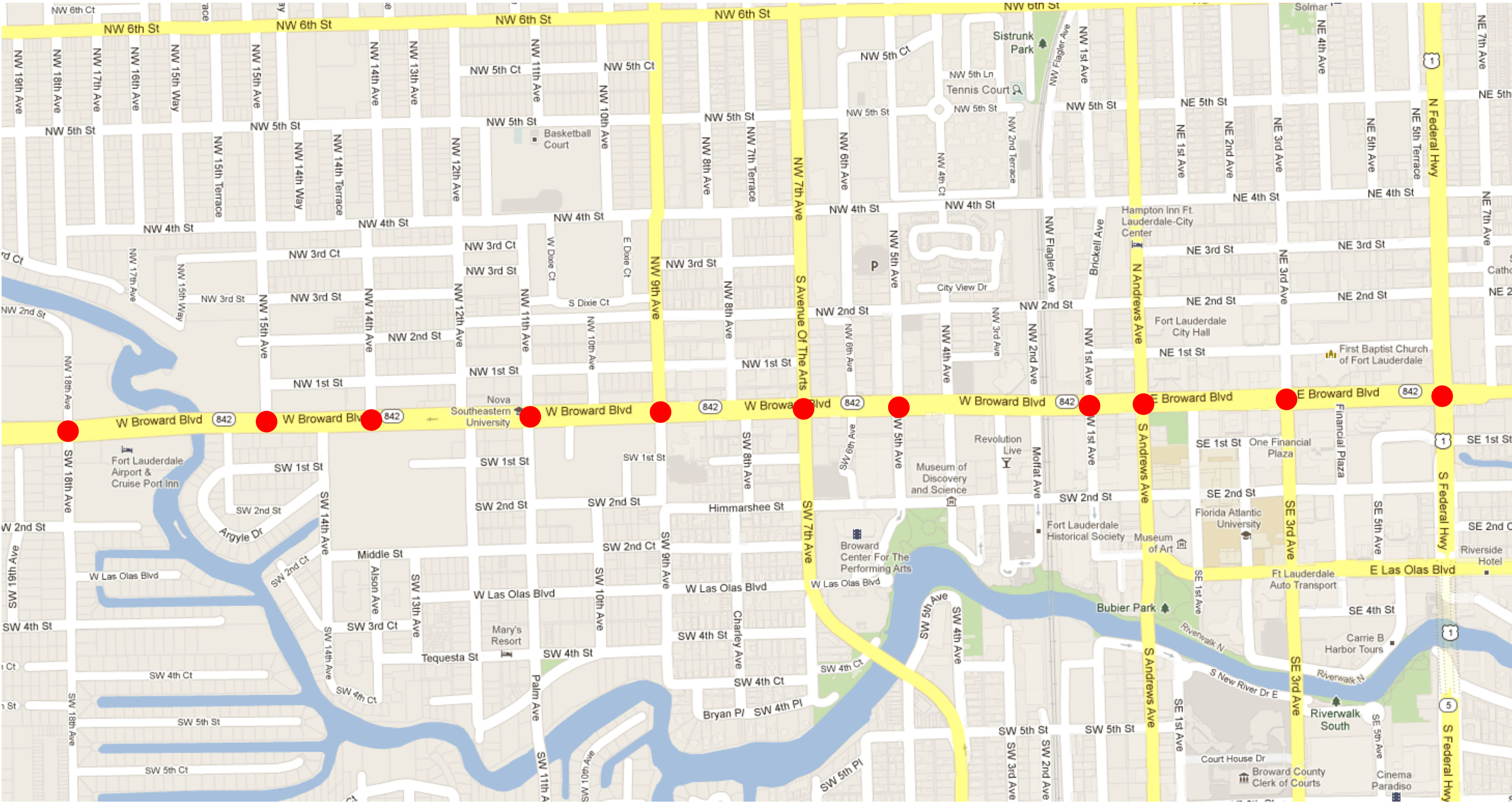
Lessons Learned:

- **Multimodal LOS not very sensitive to volume changes**
- **Methodology much better at quantitatively showing impacts to all four modes resulting from physical attributes such as:**
  - Cross section changes (Pedestrians/Bikes)
  - Trees or other buffers (Pedestrians)
  - Pavement condition (Bikes)

BROWARD BOULEVARD:
ROAD DIET

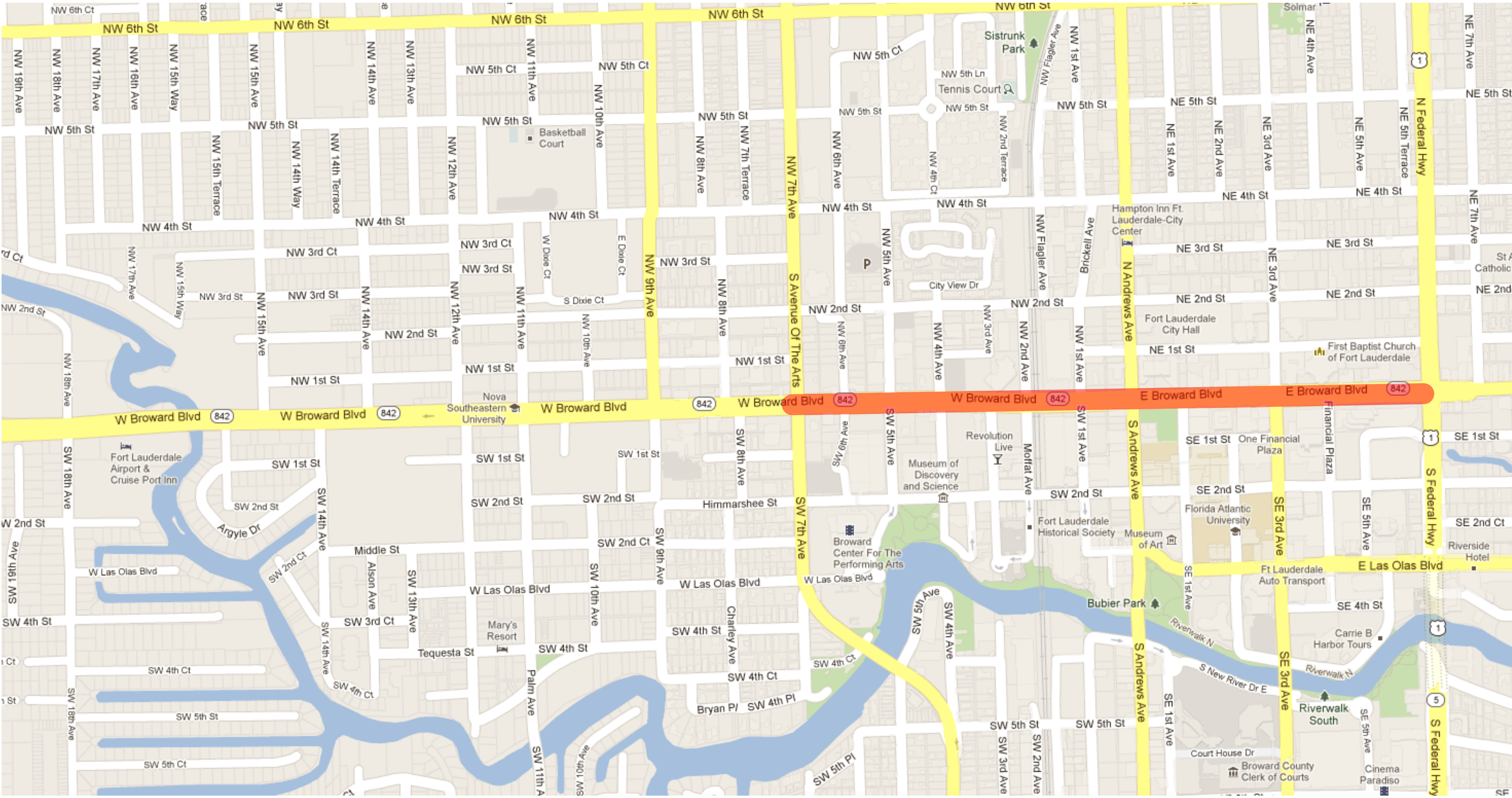
Analysis Corridor

Analysis Intersections



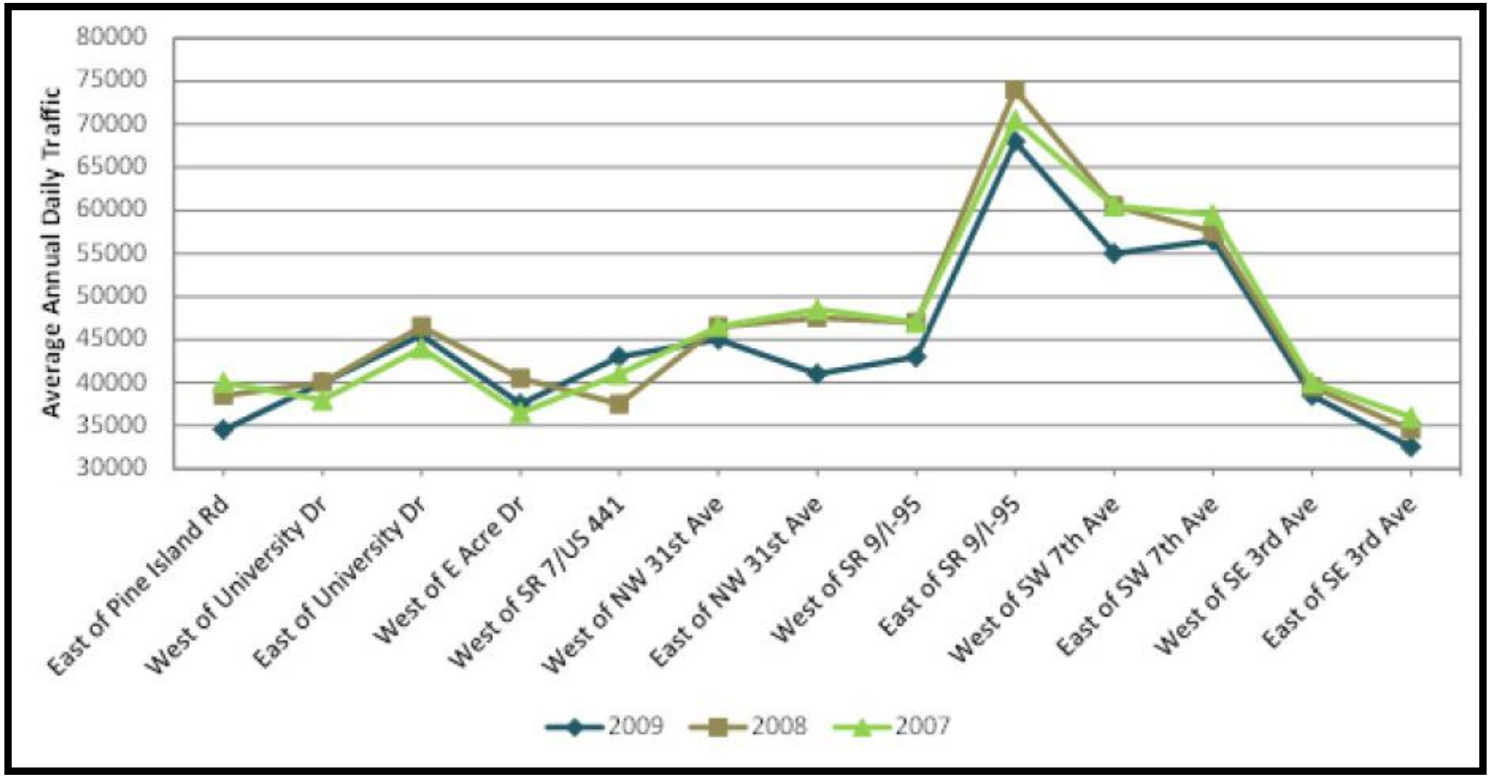
Analysis Corridor

Road Diet Portion



Existing Facility

- **Divided 6-Lane Facility**
- **Performed a MMLOS Analysis for WB Direction**



Existing Facility

Existing Facility

Existing LOS Results
Link LOS

WB Link LOS						
Segment	**From**	**To**	**Auto**	**Transit**	**Bike**	**Pedestrian**
1	US-1	NE 3rd	0.34 (E)	3.69 (D)	4.00 (D)	2.39 (B)
2	NE 3rd	Andrews	0.34 (E)	1.92 (A)	4.15 (D)	2.76 (C)
3	Andrews	NW 1st	0.38 (E)	1.92 (A)	3.39 (C)	2.87 (C)
4	NW 1st	NW 5th	0.39 (E)	1.77 (A)	4.35 (E)	3.50 (C)
5	NW 5th	NW 7th	0.36 (E)	2.30 (B)	4.16 (D)	3.42 (C)
6	NW 7th	NW 9th	0.65 (C)	2.22 (B)	4.44 (E)	3.90 (D)
7	NW 9th	NW 11th	0.50 (C)	1.10 (A)	4.38 (E)	3.70 (D)
8	NW 11th	NW 14th	0.73 (B)	2.22 (B)	4.51 (E)	3.98 (D)
9	NW 14th	NW 15th	0.72 (B)	3.52 (D)	3.65 (D)	3.77 (D)
10	NW 15th	NW 18th	0.56 (C)	1.99 (A)	4.55 (E)	4.19 (D)

Existing LOS Results
Segment LOS

WB Segment LOS						
Segment	From	To	Auto	Transit	Bike	Pedestrian
1	US-1	NE 3rd	0.34 (E)	3.69 (D)	3.85 (D)	3.60 (D)
2	NE 3rd	Andrews	0.34 (E)	1.92 (A)	3.71 (D)	3.71 (D)
3	Andrews	NW 1st	0.38 (E)	1.92 (A)	3.67 (D)	3.63 (D)
4	NW 1st	NW 5th	0.39 (E)	1.77 (A)	4.09 (D)	3.75 (D)
5	NW 5th	NW 7th	0.36 (E)	2.30 (B)	4.18 (D)	3.99 (D)
6	NW 7th	NW 9th	0.65 (C)	2.22 (B)	4.25 (D)	4.00 (D)
7	NW 9th	NW 11th	0.50 (C)	1.10 (A)	4.06 (D)	3.92 (D)
8	NW 11th	NW 14th	0.73 (B)	2.22 (B)	4.01 (D)	3.98 (D)
9	NW 14th	NW 15th	0.72 (B)	3.52 (D)	3.82 (D)	4.00 (D)
10	NW 15th	NW 18th	0.56 (C)	1.99 (A)	4.04 (D)	4.07 (D)

Future Conditions

- **Remove through lane along corridor**
- **Between US-1 and NW 7th, convert 1 through lane to parking and a bike lane**
- **Between NW 7th and I-95, convert 1 through lane to a transit only lane and bicycle lane**

SOFTWARE APPLICATION

COMPLETESTREETSLOS

Auto LOS

WB Segment Auto LOS						
Segment	**From**	**To**	**Existing**	**Road Diet**	**% Change**	**LOS**
1	US-1	NE 3rd	0.34	0.31	-10.3%	E >> E
2	NE 3rd	Andrews	0.34	0.23	-45.7%	E >> F
3	Andrews	NW 1st	0.38	0.34	-13.7%	E >> E
4	NW 1st	NW 5th	0.39	0.12	-227.7%	E >> F
5	NW 5th	NW 7th	0.36	0.17	-116.4%	E >> F
6	NW 7th	NW 9th	0.65	0.32	-102.5%	C >> E
7	NW 9th	NW 11th	0.50	0.13	-299.2%	C >> F
8	NW 11th	NW 14th	0.73	0.17	-332.5%	B >> F
9	NW 14th	NW 15th	0.72	0.49	-46.9%	B >> F
10	NW 15th	NW 18th	0.56	0.05	-1002.0%	C >> F

Transit LOS

WB Segment Transit LOS						
Segment	From	To	Existing	Road Diet	% Change	LOS
1	US-1	NE 3rd	3.69	3.23	-14.2%	D >> C
2	NE 3rd	Andrews	1.93	1.23	-56.9%	A >> A
3	Andrews	NW 1st	1.92	1.09	-76.1%	A >> A
4	NW 1st	NW 5th	1.77	1.15	-53.9%	A >> A
5	NW 5th	NW 7th	2.30	1.83	-25.7%	B >> A
6	NW 7th	NW 9th	2.22	2.30	3.5%	B >> B
7	NW 9th	NW 11th	1.10	1.69	34.9%	A >> A
8	NW 11th	NW 14th	2.22	2.48	10.5%	B >> B
9	NW 14th	NW 15th	3.52	3.36	-4.8%	D >> C
10	NW 15th	NW 18th	1.99	1.95	-2.1%	A >> A

Bicycle LOS

WB Segment Bike LOS						
Segment	**From**	**To**	**Existing**	**Road Diet**	**% Change**	**LOS**
1	US-1	NE 3rd	3.85	3.63	-6.1%	D >> D
2	NE 3rd	Andrews	3.71	3.50	-6.0%	D >> D
3	Andrews	NW 1st	3.67	3.45	-6.4%	D >> C
4	NW 1st	NW 5th	4.09	3.81	-7.3%	D >> D
5	NW 5th	NW 7th	4.18	3.88	-7.7%	D >> D
6	NW 7th	NW 9th	4.25	2.69	-58.0%	D >> B
7	NW 9th	NW 11th	4.06	2.65	-53.2%	D >> B
8	NW 11th	NW 14th	4.01	2.70	-48.5%	D >> B
9	NW 14th	NW 15th	3.82	2.48	-54.0%	D >> B
10	NW 15th	NW 18th	4.04	2.64	-53.0%	D >> B

Pedestrian LOS

WB Segment Pedestrian LOS						
Segment	From	To	Existing	Road Diet	% Change	LOS
1	US-1	NE 3rd	3.61	3.54	-2.0%	D >> D
2	NE 3rd	Andrews	3.75	3.72	-0.8%	D >> D
3	Andrews	NW 1st	3.63	3.62	-0.3%	D >> D
4	NW 1st	NW 5th	3.75	3.71	-1.1%	D >> D
5	NW 5th	NW 7th	3.99	3.99	0.0%	D >> D
6	NW 7th	NW 9th	4.00	4.12	2.9%	D >> D
7	NW 9th	NW 11th	3.92	4.02	2.5%	D >> D
8	NW 11th	NW 14th	3.77	4.46	15.5%	D >> E
9	NW 14th	NW 15th	4.00	4.26	6.1%	D >> E
10	NW 15th	NW 18th	4.07	4.33	6.0%	D >> E

Overview

- **What's New for HCM 2010?**
- **Brief history of HCM multimodal analysis**
- **Development of the HCM methodology**
  - Pedestrian LOS model
  - Bicycle LOS model
  - Transit LOS model
- **FDOT Q/LOS versus HCM 2010**
- **Complete Streets and General Plan Case Studies**
- **Traffic Impact and Sensitivity Case Studies**
- **<u>Q&A</u>**

Aaron Elias

Engineering Associate

(510) 839-1742

aelias@kittelson.com

Kamala Parks

Senior Planner

(510) 839-1742

kparks@kittelson.com

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING