Rethinking Level of Service in Eugene, OR

Analytical Memo Assignment prepared for PPPM 510 (Transportation Planning)

Prepared by Catherine Rohan and Garth Warr

Submitted 04/20/2020

Executive Summary

Level of service (LOS) is a metric used to evaluate how well roadways are working for a particular mode of transportation. Traditionally applied to vehicles, the metric has more recently been modified and expanded to evaluate roadways from the perspective of pedestrians, bicyclist, and public transportation users. The usefulness of this expansion, termed multi-modal level of service (MMLOS), is up for debate. In this memo we analyze two intersections in Eugene Oregon using vehicle, bicycle, and pedestrian LOS metrics. We found that the metrics were able to capture the experiences of multiple users well, but also identified numerous limitations related to use of MMLOS, chiefly the technocracy the metric entails as compared to complete streets policies. Our recommendation to the city of Eugene is to pair tradition vehicle LOS with a complete streets policy, instead of using a MMLOS metric.

Introduction

Level of Service (LOS) is a performance metric for roadways. It is a technical method of measuring a street's ability to facilitate automobile travel. LOS has been the subject of criticism since the 1980's because it fails to account for other modes of transportation. Some municipalities have piloted multi-modal level of service (MMLOS) metrics to measure roadway performance in a more holistic manner. Do these MMLOS metrics succeed in capturing what LOS does not, and are these holistic measures necessary to achieve the results that municipalities desire? To answer these questions, we evaluate two intersections in Eugene, Oregon using both traditional vehicle LOS and MMLOS metrics. We conclude the paper with a summary of findings and recommendations regarding Eugene's adoption of an MMLOS metric.

Overview of LOS and MMLOS

Traditional LOS

"Level of service" describes the quality of roadway operating conditions based on factors like speed, travel time, and delay. LOS can be calculated in different ways, but usually involves calculating a ratio between traffic volume for a segment of roadway and the capacity of that segment. Volumes are variable, based on a count of vehicles per hour per lane/segment. The capacity is static, calculated by multiplying a constant (e.g. X-number of vehicles per hour per lane) by the number of lanes in a segment. The result of this calculation is a letter grade from A to F, where A represents conditions of completely unimpeded travel, and F is an almost complete lack of travel.

The Highway Capacity Manual, first published in 1950 by the Transportation Research Board of the National Academies of Science, set this standard for assessing road performance. It has since gone through six iterations, the most recent being published in 2010. More recent iterations of the Highway

Capacity Manual have included guidance on incorporating multiple modes (cars, bicycles, buses, pedestrians), but its core performance measures focus on the impedance of automobile traffic.[1]

Since the performance standards in determining LOS revolve around automobile traffic, it ensures that traffic engineers are optimizing for automobiles. This perpetuates the North American norm of the automobile as the primary mode of transportation. Furthermore, the focus on LOS can run counter to other city goals of reducing vehicle miles traveled and green house gas emissions. For those who do not drive, the LOS performance measure also falls short because it doesn't account for non-automobile modes of transportation, including walking, bicycling, and public transportation.

Multimodal LOS

Since the early 2000s, transportation planners and engineers have increasingly begun to recognize that use of traditional LOS metrics prioritize vehicle travel to the exclusion and often detriment of other modes of transportation. To holistically evaluate roadways that serve a multitude of users, professionals have begun developing and implementing a new metric: multimodal level of service (MMLOS).

MMLOS metrics evaluate a roadway from the perspective of bicyclists, pedestrians, and public transportation users. Like LOS, MMLOS generates a score and/or letter grade for each travel mode. However, calculating MMLOS is not straightforward, in part because the goal of the measurement is not clear. While LOS uses a singular measure, vehicle delay time, to evaluate roadways, MMLOS may juggle multiple goals of safety, comfort, and aesthetic appeal.[2] As more variables are added, MMLOS calculations become increasingly unwieldy and subjective. See Table 1 for examples of variables used in MMLOS calculations. MMLOS evaluation is further complicated and distinguished from traditional vehicle LOS by its acknowledgment of tradeoffs between modes. For example, increasing the vehicle

---

[1] Milam, Transportation Impact Analysis Gets A Failing Grade When It Comes to Climate Change & Smart Growth, p.3-5
[2] Brozen, M., Black, T., and Liggett, R., Comparing Measures and Variables in Multimodal Street Performance Calculations: What's a Passing Grade?, p.1

speed limit along a roadway is beneficial to the vehicle and transit scores but detrimental to the bicycle score.

Table 1: Examples non-vehicle MMLOS variables

Pedestrian	Bicyclists	Transit
Presence of buffer (+)	Traffic volume and speed (-)	Service frequency (+)
Sidewalks width (+)	Heavy vehicle percentage (-)	Bus stop amenities (+)
Intersection crossing length (-)	Bike lane presence (+)	On-board crowding (-)
Permitted right-turn-on-red (-)	Bike lane width (+)	Bus travel speed (+)

Note: "+" indicates a positive relationship, so the wider a sidewalk the better a pedestrian score. Likewise, "-" indicates a negative relationship, so the higher the automobile volume and speed the lower the bicyclist score.

Despite, or perhaps because of, these difficulties, numerous MMLOS metrics have been created. Examples of MMLOS metrics from the U.S. include the 2010 Highway Capacity Manual MMLOS; Charlotte, NC's Urban Street Design Guidelines; San Francisco's Pedestrian and Bicycle Environmental Quality Index; and Fort Collins, CO's MMLOS Guidelines. Different MMLOS metrics have different goals, variables, scoring systems, and required level of technical knowledge; all of which must be considered before use.[3]

One of the earliest established and better known MMLOS metrics is that of Charlotte, NC's, as found in their Urban Street Design Guidelines. First adopted in 2007, the MMLOS metric evaluates intersections for both pedestrians and bicyclists using a range of readily available data such as number of lanes and type of signal display.[4] Charlotte has received wide recognition for their MMLOS, which won the 2009 U.S. Environmental Protection Agency Award for Smart Growth Achievement.[5] The metric is featured in

---

[3] Zuniga-Garcia, N., Ross, H., and Machemehl, R., Multimodal Level of Service Methodologies: Evaluation of the Multimodal Performance of Arterial Corridors, p.10

[4] Charlotte Department of Transportation, Urban Street Design Guidelines

[5] U.S. Environmental Protection Agency, Award for Smart Growth Achievement. U.S. Environmental Protection Agency

the American Planning Association Report *Complete Streets: Best Policy and Implementation Practices* and has been adopted by a variety of other jurisdictions, including Hillsborough County, Florida and Middleton, Wisconsin. [6]

In Eugene, a MMLOS metric would evaluate a roadway from the perspective of multiple users. The city may adopt an existing MMLOS metric, tweaking methodology and goals where needed, or create their own MMLOS metric. Under either option, the city would need to establish thresholds for acceptable MMLOS scores by mode. Acceptable mode thresholds could vary by geographical location or roadway typology.

LOS and MMLOS of select Eugene Intersections

To better understand how the adoption of a MMLOS metric in Eugene may affect roadway assessment, we evaluate two intersections using Charlotte's bicycle and pedestrian MMLOS and the traditional HCM2010 vehicle LOS. We chose to use Charlotte's MMLOS because of its ease of application and good reputation.

Calculating traditional LOS for intersections exceeds our abilities, so we use existing vehicle LOS scores from the Eugene 2035 Transportation System Plan (TSP) in our study. The TSP evaluates a number of intersections throughout Eugene, we choose two intersections from the twenty under Eugene's jurisdiction; one that we felt would perform well under MMLOS (Chambers Street & W 13th Avenue) and one that we felt would perform poorly (Hilyard Street & Amazon Parkway - 30th Avenue). Aerial photos of both intersections can be found in Appendix A. MMLOS data for the intersections were obtained from Google Street View. A summary of LOS scores is shown in Table 2.

[6] McCann, B. and Rynne, S., Complete Streets: Best Policy and Implementation Practices

What follows is a discussion of intersection specific vehicle, bicycle, and pedestrian MMLOS. We also touch on our experience calculating LOS scores and limitations we identified over the course of our analysis.

Table 2: LOS Scores

Intersection	Vehicle LOS	Bicycle LOS	Pedestrian LOS
Chambers St. & W 13th	C	B (90)	A (109)
Hilyard St. & Amazon Pkwy. - 30th Ave.	D	E (33.75)	B (76.25)

Sources: Eugene 2035 Transportation System Plan and original research

Vehicle LOS

Calculating vehicle LOS for signalized intersections is beyond our technical ability, but an understanding of the variables used to calculate the measure is important for critical discussions about LOS and MMLOS; we devote space to that here in lieu of actual calculations. LOS for signalized intersections is defined by the weighted average control delay for the entire intersection.[7] Control delay quantifies the additional travel time (per vehicle in seconds) added by a traffic signal, it includes delay associated with vehicles slowing before the intersection, time spent stopped at the intersection, time spent moving up in the queue, and time needed for vehicles to accelerate to their desired speed.[8]

Control delay is the sum of three specific delay measures; delay calculated by assuming uniform arrival, delay due to random arrivals, and delay due to initial queue. Associated delay measure variables used in calculating overall control delay include cycle length, effective green time, volume/capacity ratio, and delay adjustment factor.[9] Such variables are typically collected during “peak” traffic times.

[7] Transportation Research Board, 2010 Highway Capacity Manual, Chapter 4, p.4-17
[8] Ibid
[9] Pitera, Kelly, Signalized Intersections, slides 27-32

As is suggested by the input variables and Table 3, which relates control delay to LOS grades, traditional vehicle LOS is mainly a function of limiting vehicle delay to maximize the number of vehicles moving through an intersection given the existing roadway conditions. Chambers has a LOS of C (22.8 seconds/vehicle) while Hilyard has a LOS of D (38.8 seconds/vehicle), indicating that vehicles at Hilyard have an additional 16 second delay attributed to the traffic signal.[10] While Hilyard has nearly twice the number of vehicles moving through it over the course of a day than Chambers does, each vehicle is subject to a longer delay at Amazon than they would be at Chambers.[11]

Table 3: LOS Criteria for Signalized intersections from HWCM 2016

LOS	Control Delay per Vehicle (seconds/vehicle)	General Description of Vehicle Traffic Conditions
A	≤ 10	Free flow
B	> 10-20	Stable flow (slight delay)
C	> 20-35	Stable flow (acceptable delay)
D	> 35-55	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	> 55-80	Unstable flow (intolerable delay)
F	> 80	Forced flow (jammed)

Bicycle LOS

Bicycle LOS ratings are based on five variables (see Appendix B for completed intersection rating sheets). Most important to the bicycle LOS score is the type of travel lane bicycles must use. If bicycles are forced to share lanes with automobiles, the intersection receives fewer points than if there are dedicated bike

[10] City of Eugene Oregon, Eugene 2035 Transportation System Plan Volume 2, p.59
[11] City of Eugene Oregon Public Works - Transportation Division, City of Eugene 2013 Traffic Flow Map

lanes. Hilyard suffers most from the lack of any dedicated bike lanes. Two of the approaches allow cars to turn on either the arrow or a green ball, reducing its score. Finally, the five-lane crossing distance incurs a slight score penalty. This adds up to an “E” rating for bicycle-LOS, a poor score overall.

Chambers has numerous features that make it a safer intersection for bicyclists. 13th is a one-way street, this immediately eliminates several potential points of potential conflict, particularly for vehicles turning into/in front of bicyclists. Every direction of travel has a bike lane that continues through the intersection. The combination of contiguous bicycle lanes and the lack of turn conflicts earns Chambers a high “B” rating (score of 90; a 93 or higher is an “A” rating). Although the lack of turn conflicts helps, it’s the presence of contiguous bike lanes that account for most of the score difference between Chambers and Hilyard.

Pedestrian LOS

Pedestrian LOS ratings are based on seven variables. The most influential variable is the number of travel lanes that a pedestrian must cross; more lanes contribute to a lower rating. The difference in scores between the two intersections is largely due to the different number of lanes each has; Hilyard’s five lane crossings scored a total of 220 while Chambers’ two and three lane crossings garnered 316. Corner radii were the second most differentiating factor between intersections. The much smaller corner radii of Chambers (average of 15 feet, score of 40) force vehicles to slow down, creating a safer pedestrian experience as compared to the larger radii of Hilyard (average of 32 feet, score of 10).

While the letter grade for each intersection indicates a minimal difference in pedestrian friendliness between Chambers and Hilyard (A and B, respectively), the scores are quite disparate. Chambers’ score of 109 places it well above the 93+ cut off for a letter grade of “A”, but Hilyard’s 76.25 score lands on the brink of the “B” range, 74-92.

Intersection Comparison

Chambers scored decently across all three LOS metrics, doing particularly well in the pedestrian category. Hilyard did not fare as well, scoring between one and four letter grades worse than Chambers across all LOS metrics, doing particularly poorly in the bicycle category. These scores align with our initial predictions that Chambers would have the better bicycle and pedestrian LOS.

As mentioned earlier, we chose our study intersections based on a cursory evaluation of their pedestrian and bicycle friendliness, not their vehicle LOS. Hence, it was somewhat surprising to us that Hilyard's much larger (and seemingly auto-centric) intersection has a worse vehicle LOS than Chambers. We did not observe either intersection at peak travel times, which may have altered our initial assumptions. However, this serves to underscore an important characteristic of vehicle LOS; it is not as readily identifiable as pedestrian and bicycle LOS. Hilyard's better scores across all three LOS metrics also highlight that it is possible to structure transportation such that it works well for multiple users; street design is not a zero-sum game.

Applying LOS and MMLOS

While we did not calculate vehicle LOS ourselves, the series of equations and input variables demanded by the metric do not appear overly complicated. The most difficult part of the calculation may simply be obtaining values for the variables themselves, a high barrier for most people. The vehicle LOS scores of the intersections we examined surprised us a bit, as mentioned under intersection comparison. However, it is difficult to relate vehicle LOS scores to the environment without having experienced peak travel time at those intersections.

We found the bicycle and pedestrian MMLOS metrics straight forward and easy to apply, even through Google Street View. The bicycle and pedestrian scores, in our opinions as frequent bicyclists and pedestrians, are representative of the physical environment, with that caveat that we are looking at the numerical score and not the letter grade.

Limitations

We identified several limitations in both traditional LOS and MMLOS over the course of our calculations and interpretations. To begin, the Charlotte MMLOS only analyses intersections, not roadway links (vehicle LOS analyzes both). While intersections are often the most stressful area for users because of the mixing of modes that takes place, they do not capture the full extent of the travel experience.

Next, the letter grades assigned by traditional LOS and MMLOS metrics do not tell the full story of an intersection or allow for nuanced comparisons. Because letter grades are based on a range of numerical scores, intersections could have very different scores but receive similar grades, by the same token, they could have very similar scores but receive different grades. These grade thresholds could be especially relevant if LOS grades are being used to set priority or allocate funds. Related to grade thresholds is the ability of a total score to hide poorly-scoring variables. Without looking directly at the calculations, it can be difficult to tell why an intersection received a particular score. This can be countered to some extent by placing more weight on the most important variables but cannot be totally removed. For this same reason, the aggregation or averaging of mode scores is not advisable.

Lastly, bicycle and pedestrian LOS do not take the surrounding physical context into account. Off-street bicycle and pedestrian paths, while not making an intersection itself better, reduce the need for pedestrian and bicycle related intersection treatments by providing alternative routes. Funding an extensive retrofit of an intersection to make it more bike friendly when a parallel off-street bike path is readily available would not be an inefficient use of tax dollars.

Conclusion and Recommendations

Our final thoughts on adoption of a MMLOS metric in Eugene are mixed; although we appreciate the intent behind MMLOS to quantify road service for multiple users, we do not believe implementation of these metrics is the best way to measure and promote multi-modal street design.

LOS works well for vehicles because much of the travel experience for motorists can be boiled down to a single variable, delay time. The same cannot be done for the experience of pedestrians and bicyclists, as evidenced by the multitude of variables attempting to quantify their perception of the intersection. This point is brought into sharper focus when you consider that the MMLOS we chose was intentionally simple to apply, but this is certainly not the case for all MMLOS metrics.

Given this, we believe that Eugene would be better off trading a potentially burdensome MMLOS methodology from a complete streets policy. Many of the variables that make a roadway more conducive to pedestrians and bicyclists are known and do not require a detailed assessment to establish their level of performance (unlike vehicle LOS). Complete streets policies capture the essence of MMLOS-efforts without unnecessary technocracy. Complete streets policies have the additional benefit of being easier to apply and understood by the public. We recommend that Eugene steer away from adoption of a MMLOS metric and instead explore a complete streets policy. The complete streets policy can be paired with the traditional LOS metric, as LOS does work well for vehicles.

Our recommendation coincides and further supports the MMLOS discussion that the Eugene Planning Commission took up in 2015. Using the example of South Willamette Street improvements, they too, found that while MMLOS was able to quantify scores for different modes of transportation, it did not contribute to the discussion of alternate designs beyond suggesting that one design was best for cars, one was best for bikes, and one was best pedestrians, all of which was clear from the designs themselves.[12] Since this discussion, Eugene has created a complete streets design guide, it is currently in draft form.

[12] City of Eugene Oregon, Eugene Planning Commission Meeting of August 31 2015, p.11

Bibliography

Brozen, M., Black, T., & Liggett, R. (2014). Comparing Measures and Variables in Multimodal Street Performance Calculations: What's a Passing Grade? *Transportation Research Record: Journal of the Transportation Research Board*, (2420), 1-14.

Brozen, M. (2015). *Moving Ahead for Multimodal Performance Measures: Applying the Charlotte, NC Bicycle and Pedestrian Level of Service Tool in Santa Monica, CA*. Institute of Transportation Engineers Journal, 36-40.

Charlotte Department of Transportation. (2007). Urban Street Design Guidelines. Retrieved from https://charlottenc.gov/Transportation/PlansProjects/Documents/USDG%20Full%20Document.pdf

City of Eugene Oregon Planning Commission. (2015). Meeting of August 31, 2015. Retrieved from https://www.eugene-or.gov/AgendaCenter/ViewFile/Agenda/08312015-704

City of Eugene Oregon Public Works - Transportation Division. (2013). City of Eugene 2013 Traffic Flow Map. Retrieved from https://www.eugene-or.gov/DocumentCenter/View/3426/TrafficFlowMap2013?bidId=

City of Eugene Oregon. (2017). Eugene 2035 Transportation System Plan Volume 2. Retrieved from https://www.eugene-or.gov/DocumentCenter/View/40991/ETSP-Volume2-Appendices

McCann, B., & Rynne, S., (2010). *Complete streets: Best policy and implementation practices* (Report (American Planning Association. Planning Advisory Service) ; no. 559). Chicago: American Planning Association.

Milam, Ronald. *Transportation Impact Analysis Gets A Failing Grade When It Comes to Climate Change & Smart Growth*. Fehr & Peers. Roseville, CA.

Pitera, Kelly. (2009). Signalized Intersections - Transportation Engineering I. University of Washington. Retrieved from http://courses.washington.edu/cee320ag/Lecture/Signalized%20Intersections_student%20notes_part2.pdf

Transportation Research Board. (2010). Highway Capacity Manual, Chapter 4 Traffic Flow and Capacity Concepts.

U.S. Environmental Protection Agency (EPA). (2009). 2009 National Award for Smart Growth. Retrieved from https://www.epa.gov/sites/production/files/2014-04/documents/sg_awards_2009.pdf

Zuniga-Garcia, N., Ross, H., & Machemehl, R. (2018). Multimodal Level of Service Methodologies: Evaluation of the Multimodal Performance of Arterial Corridors. *Transportation Research Record, 2672*(15), 142-154.

Appendix A: Intersection Aerial Photos

Chambers Street & W 13th Avenue (North orientation)

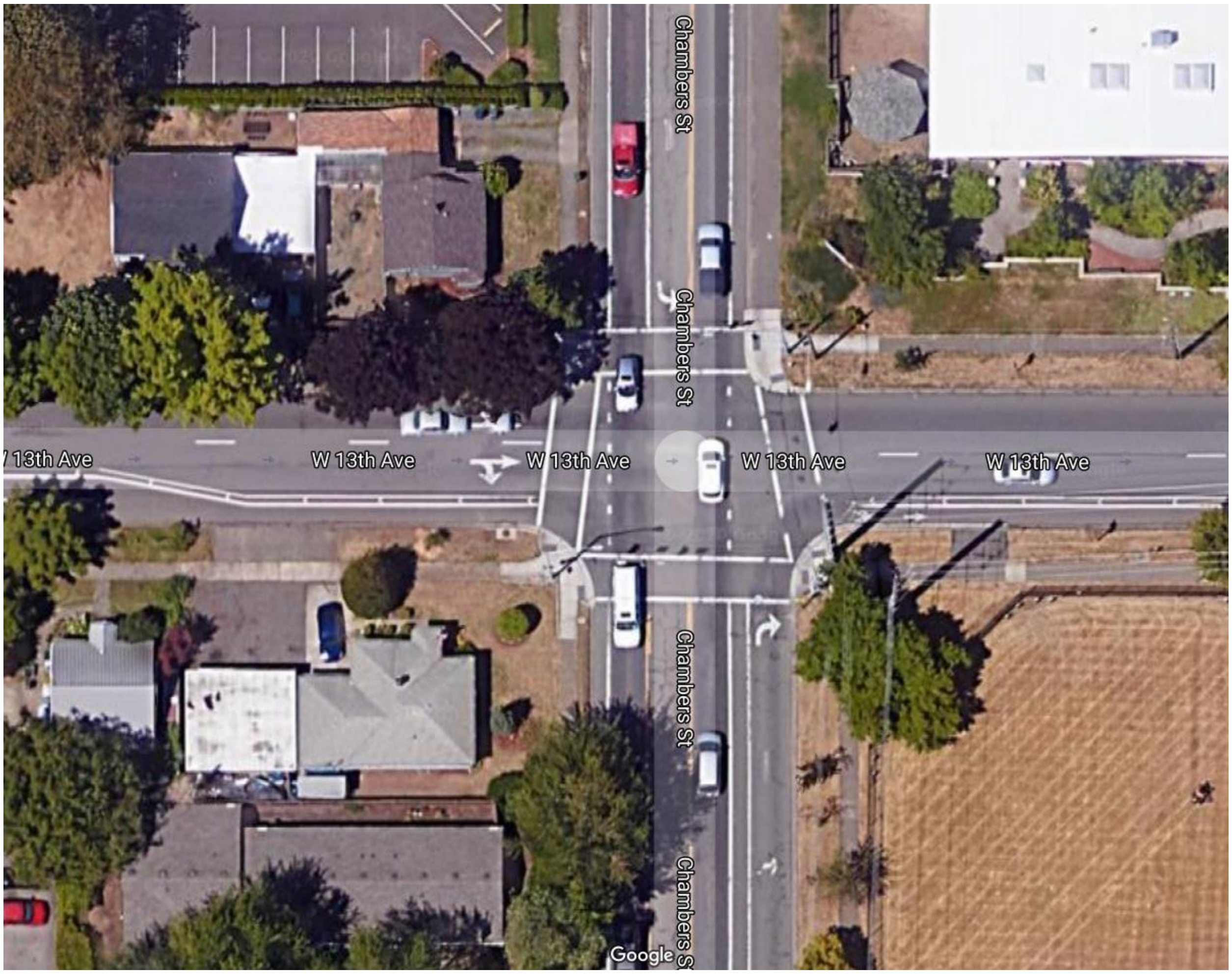

Image taken from Google Maps 4/18/2020

North/South speed limit: 30mph

Street Designations: Minor Arterial

Notes: West 13th Avenue is one way East bound

Hilyard Street & Amazon Parkway - 30th Avenue (North orientation)

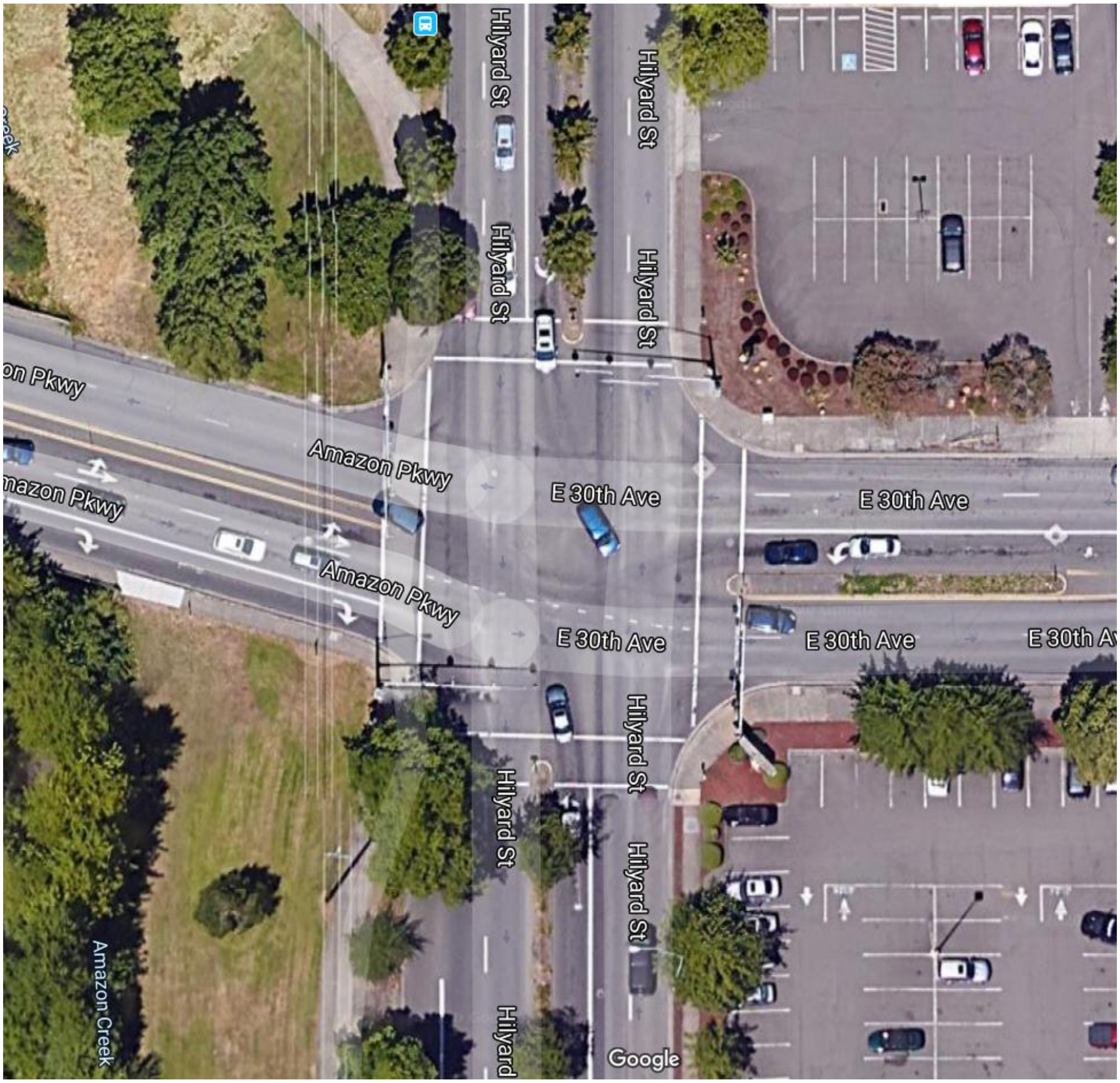

Image taken from Google Maps 4/18/2020

North/South speed limit: 30mph

Street Designations: Minor Arterial

Appendix B: Pedestrian and Bicycle MMLOS Scores

Pedestrian LOS Calculations

Location:	Amazon Parkway - 30th Avenue & Hilyard Street			
	Crossing of Northbound Approach (cross Hilyard)	Crossing of Southbound Approach (cross Hilyard)	Crossing of Eastbound Approach (cross Amazon)	Crossing of Westbound Approach (cross 30th)
Pedestrian Crossing Distance	5 Lanes (6" median)	5 Lanes (6" median)	5 Lanes (6" median)	5 Lanes (6" median)
Score	**55**	**55**	**55**	**55**
Signal Features				
Left Turn Conflict (left turns into pedestrain path)	Single left turn lane on green arrow without conflicting pedestrian phase**	Shared thru-left turn lane on green ball without conflicting pedestrian phase**	Single left turn lane on green arrow without conflicting pedestrian phase**	Single left turn lane on green arrow without conflicting pedestrian phase**
Score	**15**	**0**	**15**	**15**
Right Turn Conflict (right turns into pedestrain path)	Single right turn lane on green arrow without conflicting pedestrian phase**	Shared thru-right turn lane on green ball without conflicting pedestrian phase**	Shared thru-right turn lane on green ball without conflicting pedestrian phase**	Shared thru-right turn lane on green ball without conflicting pedestrian phase**
Score	**10**	**0**	**0**	**0**
Pedestrian Display Signal	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*
Score	**5**	**5**	**5**	**5**
Corner Radius	24.5"	38"	27"	39"
Score	**5**	**0**	**5**	**0**
Right Turns on Red	Allowed	Allowed	Allowed	Allowed
Score	**0**	**0**	**0**	**0**
Crosswalks	Traverse Marking	Traverse Marking	Traverse Marking	Traverse Marking
Score	**0**	**0**	**0**	**0**
Adjustment for One-Way Street Crossings	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Score	//	//	//	//
Approach Total	**90**	**60**	**80**	**75**
Approach LOS	**A**	**A**	**A**	**A**
Intersection AVG.	**76.25**			
Intersection LOS	**B (74-92)**			

Notes: Pedestrian walk signals come on automatically (there are no buttoms to press). *Pedestrian Display Signal Score is based on the type of display and pedestrain walking speeds neecesary to cross the intersection in the time alloted by the display. Times allowed by displays were not recorded in person, we assumed displays accomadate a pedestrian walking speed of >3.5 ft/sec. ** Pedestrian displays at this intersection are activated by push buttons. The use of push buttons is indicative of more complex pedestrian display/traffic signal interplay, based on this we assumed turning traffic would not conflict with pedestrian displays.

Location:	Chambers & 13th Avenue			
	Crossing of Northbound Approach (cross Chambers)	Crossing of Southbound Approach (cross Chambers)	Crossing of Eastbound Approach (cross 13th)	Crossing of Westbound Approach (cross 13th)
Pedestrian Crossing Distance	3 Lanes	3 Lanes	2 Lanes	2 Lanes
Score	**78**	**78**	**80**	**80**
Signal Features				
Left Turn Conflict (left turns into pedestrain path)	No Left Turn Conflict	Shared thru-left lane turn lane on green ball with conflicting pedestrian phase	No Left Turn Conflict	Single left turn lane on green ball with conflicting pedestrian phase
Score	**15**	**-5**	**15**	**-5**
Right Turn Conflict (right turns into pedestrain path)	Shared thru-right turn lane on green ball with conflicting pedestrian phase	No Right Turn Conflict	No Right Turn Conflict	Single right turn lane on green ball with conflicting pedestrian phase
Score	**0**	**15**	**15**	**0**
Pedestrian Display Signal	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*	Countdown Display (>3.5 ft/sec)*
Score	**5**	**5**	**5**	**5**
Corner Radius	20"	9.5"	15"	16.5"
Score	**10**	**10**	**10**	**10**
Right Turns on Red	Allowed	Not applicable	Allowed	Not applicable
Score	**0**	**5**	**0**	**5**
Crosswalks	Traverse Marking	Traverse Marking	Traverse Marking	Traverse Marking
Score	**0**	**0**	**0**	**0**
Adjustment for One-Way Street Crossings	Not Applicable (does not meet lane departure lane minimum)	Not Applicable (does not meet lane departure lane minimum)	Not Applicable (does not meet lane departure lane minimum)	Not Applicable (does not meet lane departure lane minimum)
Score	//	//	//	//
Approach Total	**108**	**108**	**125**	**95**
Approach LOS	**B**	**C**	**B**	**B**
Intersection AVG.	**109**			
Intersection LOS	**A (92+)**			

Notes: Pedestrain walk signals come on automatically (there are no buttoms to press). *Pedestrain Display Signal Score is based on the type of display and pedestrain walking speeds neecesary to cross the intersectin in the time alloted by the display. Times allowed by displays were not recorded in person, we assumed displays accomadate a pedestrian walking speed of >3.5 ft/sec.

Bicycle LOS Calculations

Location:	**Amazon Parkway - 30th Avenue & Hilyard Street**			
	Crossing of Northbound Approach (cross Hilyard)	Crossing of Southbound Approach (cross Hilyard)	Crossing of Eastbound Approach (cross Amazon)	Crossing of Westbound Approach (cross 30th)
Bike Travels in:	Shared Auto Lane to Shared Auto Lane	Shared Auto Lane to Shared Auto Lane	Shared Auto Lane to Shared Auto Lane	Shared Auto Lane to Shared Auto Lane
Score	**30**	**30**	**30**	**30**
Vehicular Left Turn Phase	Made on Green Arrow Only	Made on Green Arrow Only	Made on Green Ball Only	Made on Green Ball/Arrow
Score	**15**	**15**	**0**	**5**
Stop Bar Location	Shared stop bar	Shared stop bar	Shared stop bar	Shared stop bar
Score	**0**	**0**	**0**	**0**
Right Turn Traffic Conflict	No Separate Right Turn Lane	No Separate Right Turn Lane	No Separate Right Turn Lane	No Separate Right Turn Lane
Score	**0**	**0**	**0**	**0**
Right Turns on Red	Allowed	Allowed	Allowed	Allowed
Score	**0**	**0**	**0**	**0**
Intersection Crossing Distance	4-5 motor vehicle lanes	4-5 motor vehicle lanes	4-5 motor vehicle lanes	4-5 motor vehicle lanes
Score	**-5**	**-5**	**-5**	**-5**
Approach Total	**40**	**40**	**25**	**30**
Approach LOS	**D**	**D**	**E**	**E**
Intersection Average	**33.75**			
Intersection LOS	**E (19-36)**			

Location:	Chambers & 13th Avenue			
	Crossing of Northbound Approach (cross 13th)	Crossing of Southbound Approach (cross 13th)	Crossing of Eastbound Approach (cross Chambers)	Crossing of Westbound Approach (cross Chambers)
Bike Travels in:	Bike Lane to Bike Lane (30mph)	Bike Lane to Bike Lane (30mph)	Bike Lane to Bike Lane (30mph)	No Westbound approach for bicycles due to one-way street
Score	**70**	**70**	**70**	
Vehicular Left Turn Phase	Made on Green Ball Only	No Left Turn Conflict	No Left Turn Conflict	
Score	**0**	**15**	**15**	
Stop Bar Location	Shared stop bar	Shared stop bar	Shared stop bar	
Score	**0**	**0**	**0**	
Right Turn Traffic Conflict	Bike lane LEFT of right turn	No right turn conflict	No separate right turn lane	
Score	**10**	**15**	**0**	
Right Turns on Red	Allowed	Prohibited	Allowed	
Score	**0**	**5**	**0**	
Intersection Crossing Distance	<3 motor vehicle travel lanes	<3 motor vehicle travel lanes	<3 motor vehicle travel lanes	
Score	**0**	**0**	**0**	
Approach Total	**80**	**105**	**85**	
Approach LOS	**B**	**A**	**B**	
Average of Scores	**90**			
BICYCLE Level of Service	**B (74-92)**			

Table 4: Score to Letter Grade Conversions for Pedestrian and Bicycle LOS

Points	**LOS**
93+	A
74-92	B
55-73	C
37-54	D
19-36	E
0-18	F