THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Multimodal Level of Service Methodologies: Evaluation of the Multimodal Performance of Arterial Corridors

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Natalia Zuniga-Garcia, M.Sc.
Heidi W. Ross, M.Sc.
Randy B. Machemehl, Ph.D.

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Outline

- Introduction
- Multimodal Level of Service Methodologies
- Case Study: Austin, Texas
- Results and Discussion
- Conclusions

Introduction

- Level of service (LOS) has been expanded beyond automobiles (MMLOS).
- No nationally accepted method for a unique performance measure.
- Limitation for planning projects that consider all modes.

Introduction

Objective

Evaluate the multimodal performance of arterial corridors using currently available MMLOS methodologies.

Contributions

(1) Comprehensive review of available MMLOS methodologies.

(2) Evaluation and contrasting of MMLOS approaches with a case study.

(3) Insights on the multimodal evaluation procedures for arterial corridors.

MMLOS Methodologies

Highway Capacity Manual (HCM)

Transit Capacity and Quality of Service Manual (TCQSM)

Charlotte's *Urban Streets Design Guide (USDG)*

Pedestrian & Bicycle Environmental Quality Indices (PEQI & BEQI)

Level of Traffic Stress (LTS)

Bicycle Compatibility Index (BCI)

Deficiency Index (DI)

Walk Score®, Bike Score®, and Transit Score®

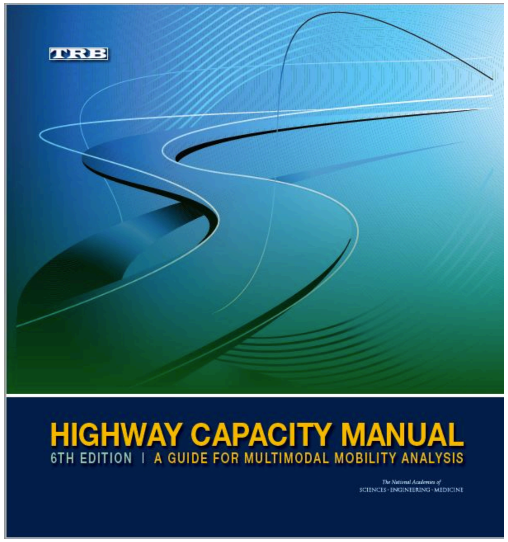
Method	**Mode***		
	Pedestrian	**Bicycle**	**Transit**
HCM	X	X	
TCQSM			X
Charlotte's *USDG*	X	X	
PEQI & BEQI	X	X	
BCI		X	
LTS		X	
DI	X	X	X
Walk Score® Bike Score® Transit Score®	X	X	X

*Automobile LOS is the most developed methodology and has uniform acceptance. Therefore, it is not included above.

MMLOS Methodologies

HCM

- 2010 (5th) edition includes multimodal analysis framework using information about demand, control, and geometry
- Letter score range: A to F



TCQSM

(Transit counterpart to the *HCM)*

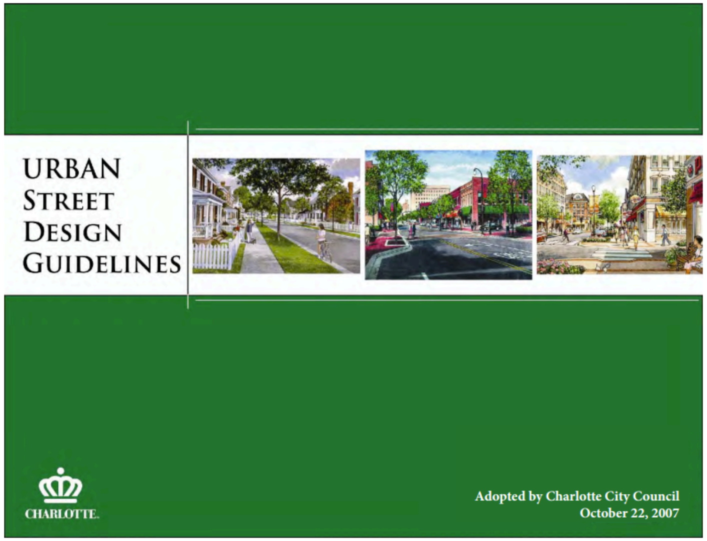
- Distinguishes between demand-responsive and fixed-route
- Applied at a street-segment level
- Letter score range: A to F

MMLOS Methodologies

Charlotte's *USDG*

(Developed by the City Council of Charlotte, North Carolina)

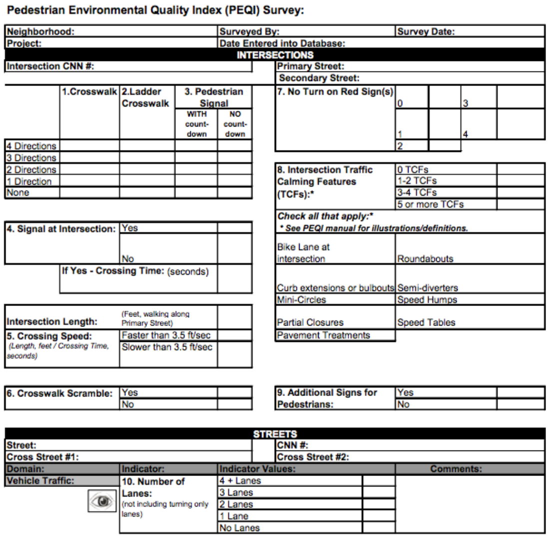
- Adds or subtracts points for the presence or absence of features
- Scores range from 0 to 100 and then converted into an A to F range



PEQI & BEQI

(Developed by The San Francisco Department of Public Health)

- Relies on observational surveys using checklists
- Scored on a scale from 0 to 100



Pedestrian Environmental Quality Index (PEQI) Survey:

Neighborhood:	Surveyed By:	Survey Date:
Project:	Date Entered into Database:	

INTERSECTIONS

Intersection CNN #:
Primary Street:
Secondary Street:

	1.Crosswalk	2.Ladder Crosswalk	3. Pedestrian Signal WITH count-down	3. Pedestrian Signal NO count-down
4 Directions				
3 Directions				
2 Directions				
1 Direction				
None				

7. No Turn on Red Sign(s)	0	3
	1	4
	2	

8. Intersection Traffic Calming Features (TCFs):*	0 TCFs	
	1-2 TCFs	
	3-4 TCFs	
	5 or more TCFs	

*Check all that apply:**
** See PEQI manual for illustrations/definitions.*

Bike Lane at intersection	Roundabouts
Curb extensions or bulbouts	Semi-diverters
Mini-Circles	Speed Humps
Partial Closures	Speed Tables
Pavement Treatments	

4. Signal at Intersection:	Yes	
	No	
If Yes - Crossing Time: (seconds)		
Intersection Length:	(Feet, walking along Primary Street)	
5. Crossing Speed: (Length, feet / Crossing Time, seconds)	Faster than 3.5 ft/sec	
	Slower than 3.5 ft/sec	
6. Crosswalk Scramble:	Yes	
	No	
9. Additional Signs for Pedestrians:	Yes	
	No	

STREETS

Street:	CNN #:
Cross Street #1:	Cross Street #2:

Domain:	Indicator:	Indicator Values:		Comments:
Vehicle Traffic:	10. Number of Lanes: (not including turning only lanes)	4 + Lanes		
		3 Lanes		
		2 Lanes		
		1 Lane		
		No Lanes		

MMLOS Methodologies

Level of Traffic Stress (LTS)

(Developed by The Mineta Transportation Institute)

- Used by Oregon DOT and StreetScore+, among other agencies
- Score types: LTS1, LTS2, LTS3, and LTS4

Configuration	Level of Traffic Stress
Single right-turn lane up to 150 ft. long, starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius such that turning speed is ≤ 15 mph.	LTS ≥ 2
Single right-turn lane longer than 150 ft. starting abruptly while the bike lane continues straight, and having an intersection angle and curb radius such that turning speed is ≤ 20 mph.	LTS ≥ 3
Single right-turn lane in which the bike lane shifts to the left but the intersection angle and curb radius are such that turning speed is ≤ 15 mph.	LTS ≥ 3
Single right-turn lane with any other configuration; dual right-turn lanes; or right-turn lane along with an option (through-right) lane.	LTS = 4

Speed Limit of Street Being Crossed	Width of Street Being Crossed		
	Up to 3 lanes	4 - 5 lanes	6+ lanes
Up to 25 mph	LTS 1	LTS 2	LTS 4
30 mph	LTS 1	LTS 2	LTS 4
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4

Speed Limit of Street Being Crossed	Width of Street Being Crossed		
	Up to 3 lanes	4 - 5 lanes	6+ lanes
Up to 25 mph	LTS 1	LTS 1	LTS 2
30 mph	LTS 1	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 4
40+	LTS 3	LTS 4	LTS 4

Bicycle Compatibility Index (BCI)

- Uses linear regression model
- Geometric and operational characteristics
- Score range: A to F

$$BCI = 3.67 - 0.966\mathbf{BL} - 0.410\mathbf{BLW} - 0.498\mathbf{CLW} + 0.002\mathbf{CLV} + 0.0004\mathbf{OLV} + 0.022\mathbf{SPD} + 0.506\mathbf{PKG} - 0.264\mathbf{AREA} + \mathbf{AF}$$

where:

BL = presence of a bicycle lane or paved shoulder ≥ 0.9 m
no = 0
yes = 1

BLW = bicycle lane (or paved shoulder) width
m (to the nearest tenth)

CLW = curb lane width
m (to the nearest tenth)

CLV = curb lane volume
vph in one direction

OLV = other lane(s) volume - same direction
vph

SPD = 85th percentile speed of traffic
km/h

PKG = presence of a parking lane with more than 30 percent occupancy
no = 0
yes = 1

AREA = type of roadside development
residential = 1
other type = 0

AF = $f_t + f_p + f_{rt}$

where:

f_t = adjustment factor for truck volumes (see below)

f_p = adjustment factor for parking turnover (see below)

f_{rt} = adjustment factor for right-turn volumes (see below)

MMLOS Methodologies

Deficiency Index (DI)

- Classifies features into physical, operational, and intermodal groups
- DI values are averaged per feature group, then per mode
- Score range: 0 to 18

Mode	Characteristics to Describe Physical Features	Characteristics to Describe Operational Features	Characteristics to Describe Intermodal Features
Auto	c_1: lane width (3.0) c_2: presence of parking (3.3) c_3: presence of median (3.1) c_4: frequency of median breaks (3.2) c_5: frequency of driveways (3.7)	c_1: vehicle volume/capacity ratio (4.2) c_2: average travel speed (3.7) c_3: signal progression (4.1) c_4: number of vehicle stops (4.1) c_5: travel time reliability (3.6) c_6: incident recovery time (3.6)	c_1: delay caused by transit (2.4) c_2: delay caused by pedestrians (2.4) c_3: delay caused by bicycles (2.0)
Transit	c_1: percent of transit stops with shelters (3.1) c_2: percent of transit stops with benches (2.9) c_3: maintenance quality of transit stops (3.0)	c_1: headway (4.2) c_2: transit travel time (3.7) c_3: headway variability (4.1) c_4: passenger crowding (3.4) c_5: hours of operation (3.9)	c_1: delay caused by auto mode (3.5) c_2: accessibility by pedestrians (3.8) c_3: accessibility by bicycles (2.8)
Pedestrian	c_1: existence of sidewalks (4.6) c_2: width of sidewalks (3.6) c_3: condition of sidewalks (3.5) c_4: distance from vehicular traffic (3.5) c_5: crossing conditions (4.3) c_6: ADA accessibility (3.5)	c_1: pedestrian volume/capacity ratio (2.8) c_2: midblock crossing delay (3.3) c_3: intersection crossing delay (3.8)	c_1: auto impact on pedestrians (4.1) c_2: transit impact on pedestrians (2.8) c_3: bicycle impact on pedestrians (2.2)
Bicycle	c_1: existence of bicycle lane (4.2) c_2: width of outside through lane (3.7) c_3: travel lane pavement quality (3.8) c_4: width of shoulder (3.9) c_5: shoulder pavement quality (3.8) c_6: presence of auto parking (3.7)	c_1: bicycle comfort (2.8) c_2: intersection crossing delay (3.3) c_3: bicycle speed (2.8)	c_1: auto impact on bicycles (4.4) c_2: transit impact on bicycles (2.9) c_3: pedestrian impact on bicycles (2.2)

Walk , Bike, and Transit Score®

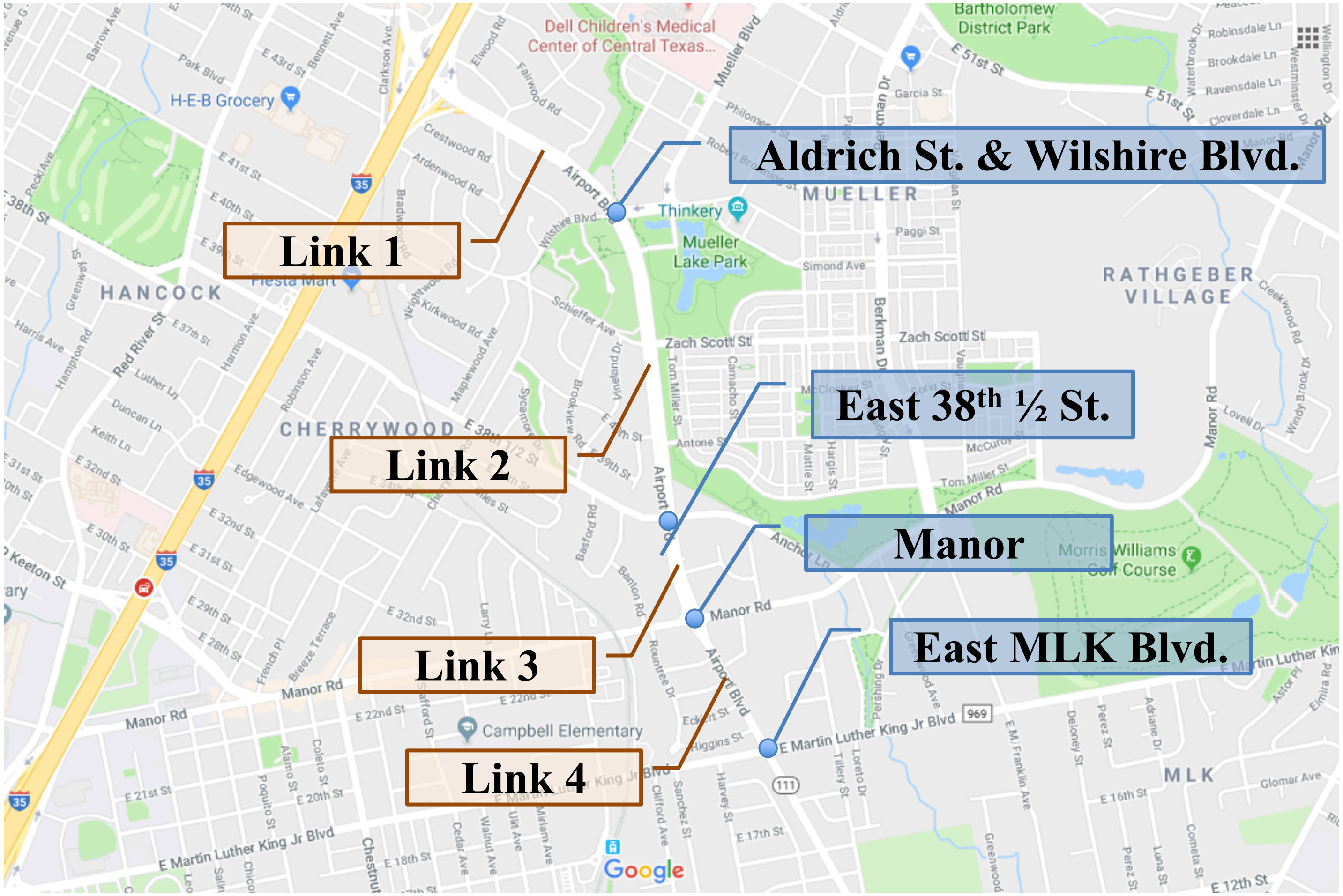
(Developed by Front Seat Management)

- Web-based tools
- Uses a variety of data sources (e.g. Google, Localeze, U.S. Census)
- Scored on a scale from 0 to 100

Case Study: Austin, Texas

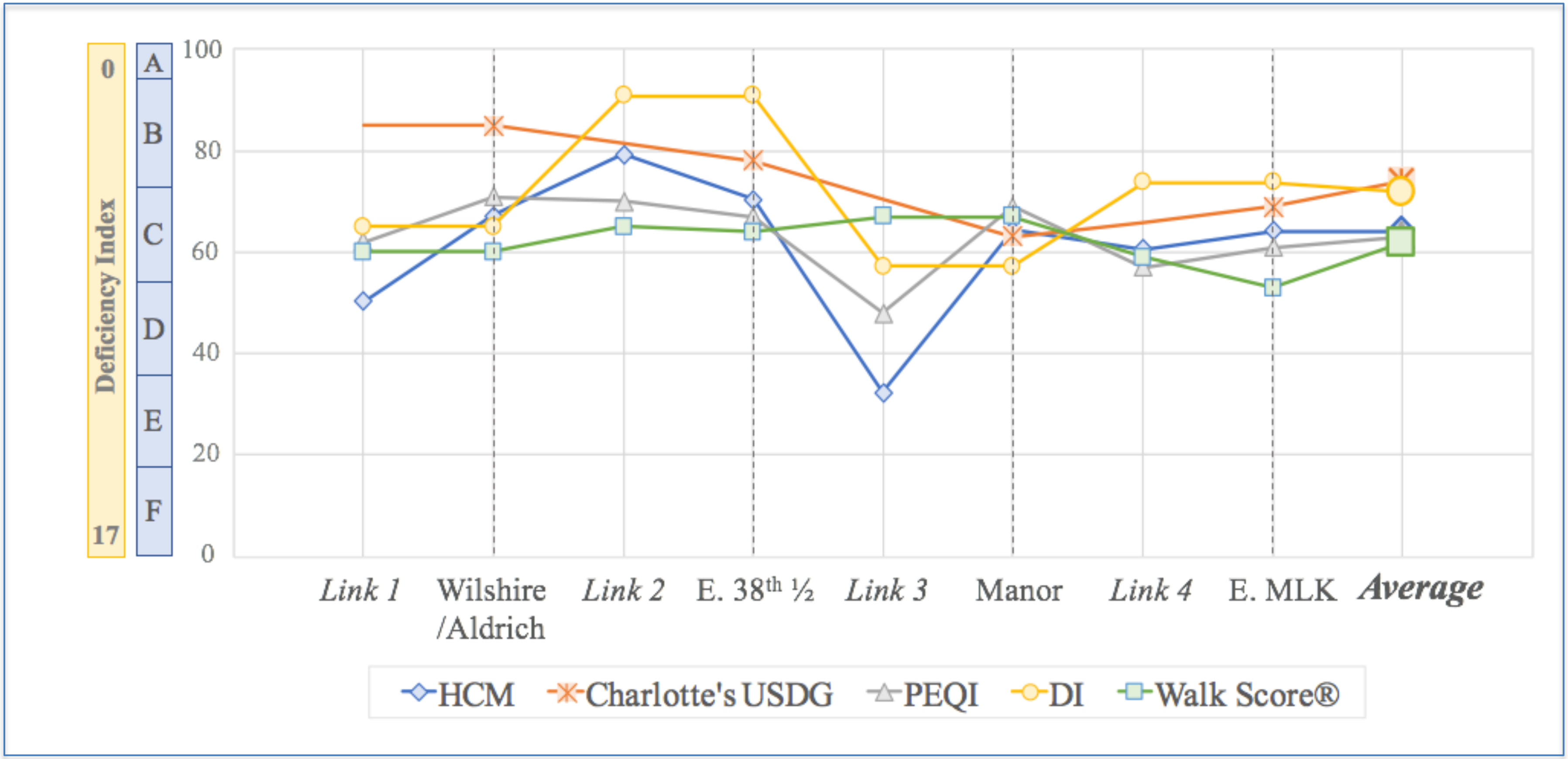
- Airport Boulevard (1.1-mile segment)
- Includes four major signalized-intersections:
  - Aldrich Street/Wilshire Boulevard
  - East 38^{th} ½ Street
  - Manor Road
  - East Martin Luther King Jr. (MLK) Boulevard
- Applied at intersection and street-segment level

Case Study: Austin, Texas



Results and Discussion

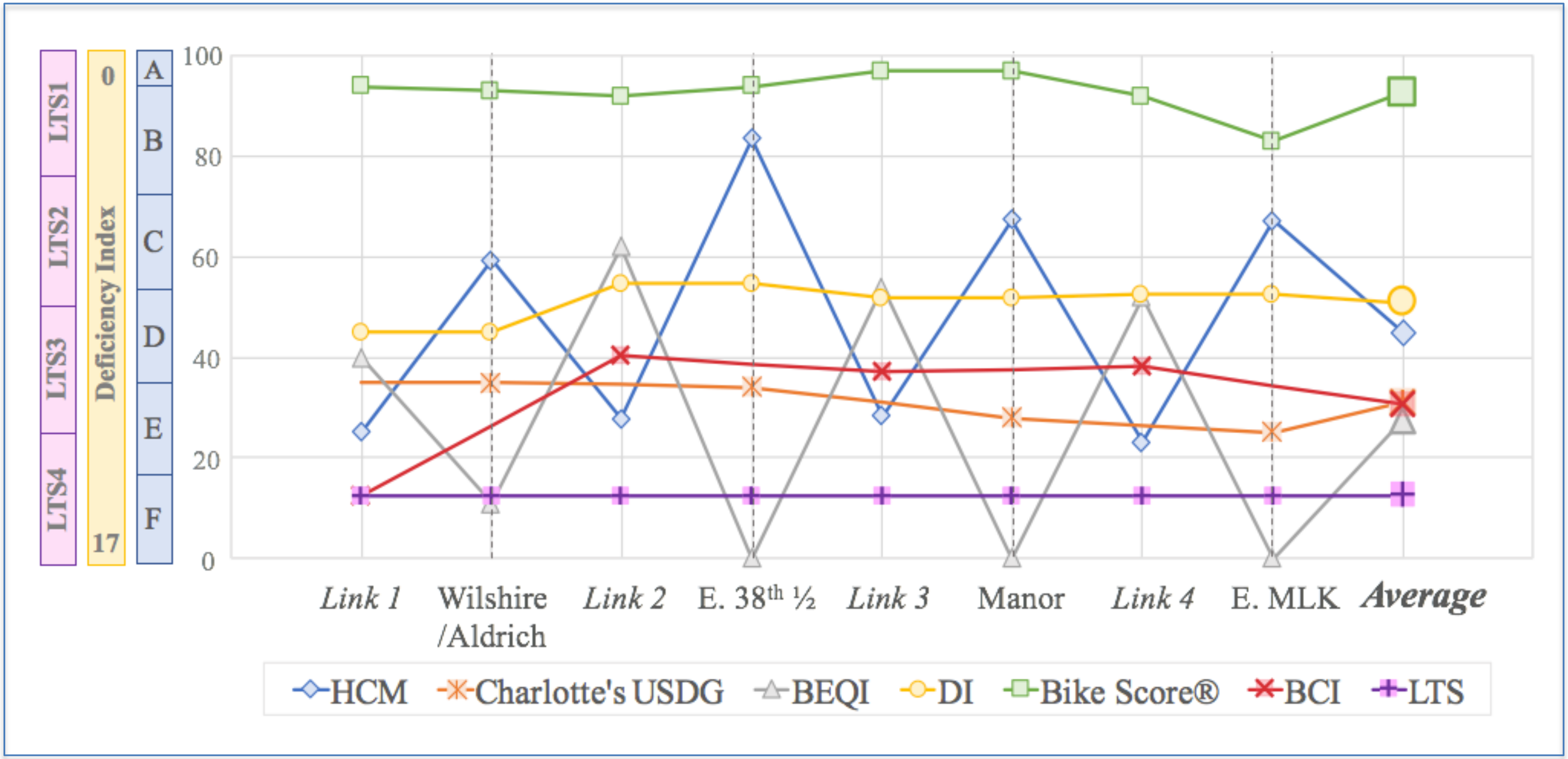
Pedestrian Level of Service



Note: The X-axis represents the corridor. Thus, links and intersections are intercalated.

Results and Discussion

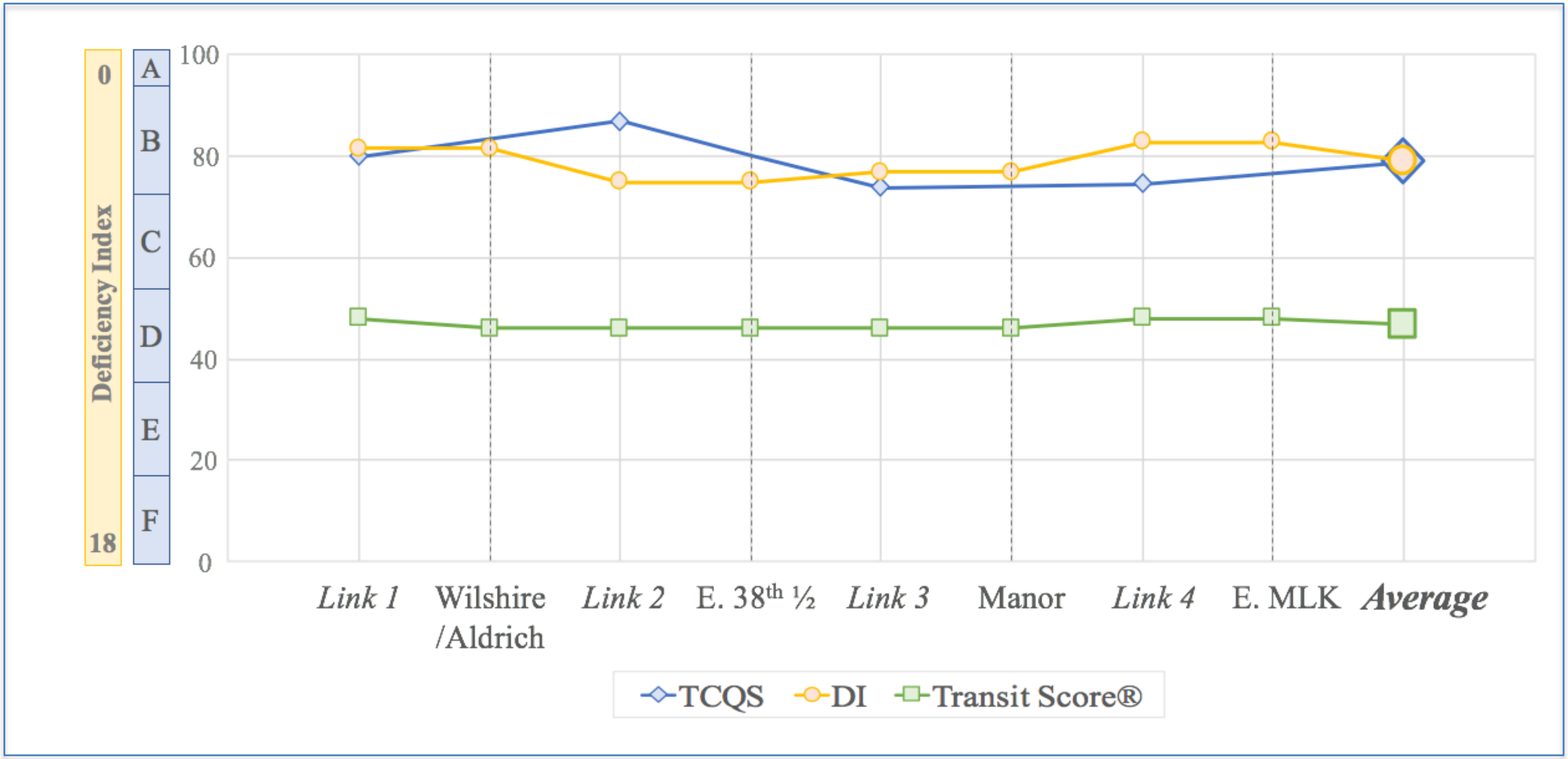
Bicycle Level of Service



Note: The X-axis represents the corridor. Thus, links and intersections are intercalated.

Results and Discussion

Transit Level of Service



Note: The X-axis represents the corridor. Thus, links and intersections are intercalated.

Results and Discussion

Method	Pros	Cons
HCM	· Evaluates both intersection and links	· **Not easy to apply**
	· Considers interaction of modes	· Requires training and technical knowledge
	· **Strong research background**	· Requires detailed data collection
TCQSM	· Easy to apply using the spreadsheet tool	· **Requires detailed data collection**
	· Considers interaction of modes	
	· **Strong research background**	
Charlotte's *USDG*	· Easy to apply using the spreadsheet tool	· **Does not evaluate link segments**
	· **Detailed intersection assessment**	
PEQI & BEQI	· Evaluates both intersection and links	· **Bicycle intersection assessment only considers three features**
	· Easy to apply	· Subjective scale of application
	· **Requires minimal basic training**	
LTS	· Easy to apply	· **Does not evaluate pedestrian and transit**
	· Evaluates both intersection and links	
	· **Does not requires intense data collection**	

Results and Discussion

Method	Pros	Cons
BCI	· Easy to apply	· **Does not evaluate intersections**
	· **Does not requires intense data collection**	· Does not evaluate pedestrian and transit
Deficiency Index (DI)	· Evaluates pedestrian, bicycle, and transit using comparable measures	· Requires technical knowledge
	· **Considers interaction of modes**	· **Subjective scale of application**
	· Can be used in conjunction with other methods	
Walk Score® Bike Score® Transit Score®	· Evaluates pedestrian, bicycle, and transit using comparable measures	· **Not sensitive to infrastructure deficiencies** (e.g. lack of bike lane or sidewalk)
	· **Easy to apply**	· Methodology not reproducible
	· Does not requires data collection process	
	· Evaluates both intersection and links	

Conclusions

- The multimodal analysis should be applied separately for each mode.
- Aggregation of results to one overall LOS requires judgement in terms of weighting modes, and therefore biases results.
- *HCM* and *TCQSM* allow a technical methodology that is replicable and comparable. Therefore, provide a MMLOS assessment that is suitable for a corridor evaluation.
- The DI is the most robust method. However, it requires technical knowledge and its application is subjective to user expertise. It is recommended to be used in combination with other methods.

Questions or Comments?

nzuniga@utexas.edu

THANKS