NCHRP 17-87

Peer Exchange Workshop

Welcome

- William Rogers
  - Senior Program Officer, National Cooperative Highway Research Program (NCHRP)
- Kirk Zeringue
  - Special Studies Research Administrator, Louisiana DOTD
  - Panel Chair
- Paul Ryus
  - Principal Engineer, Kittelson & Associates, Inc.
  - Principal Investigator, NCHRP Project 17-87

Workshop Goals

- Present NCHRP 17-87 research results to professionals at the forefront of pedestrian planning
- Obtain feedback on:
  - First-draft guidebook
  - Quality-of-service evaluation methods being developed for the *Highway Capacity Manual* (HCM)
- Provide opportunities to network with fellow professionals

Workshop Agenda

- NCHRP 17-87 purpose and research results
- Guidebook
  - Pedestrian volume counting
  - Pedestrian operations analysis
- Lunch
- Guidebook
  - Pedestrian quality of service analysis
  - Test of proposed HCM uncontrolled crossing method
  - Pedestrian safety analysis
- Slides e-mailed following workshop

Desired Feedback

- Usefulness of Guide content as a resource for professionals
- Identifying missing/incomplete/unnecessary content
- Possible photos/figures to incorporate
- Future research needs
- Implementation ideas

Project Background

Project Genesis

- Research problem statements developed separately by two TRB committees
  - Pedestrians
  - Highway Capacity & Quality of Service
- Statements sponsored by state DOTs and submitted for funding through the NCHRP program
- NCHRP merged the two statements into one project
  - NCHRP 17-87, Enhancing Pedestrian Volume Estimation and Developing HCM Pedestrian Methodologies for Safe and Sustainable Communities

Project Objectives

- Identify techniques for efficient and accurate estimation of pedestrian volume and exposure
- Determine field-observed factors affecting pedestrian flow at the facility level, and integrate these factors into the HCM pedestrian LOS methodology
- Determine how pedestrian safety improvements on the roadway and in signal timing designs should be reflected in the HCM pedestrian LOS methodology
- Recommend corresponding enhancements to the current HCM methodology

Project Team

- Kittelson & Associates, Inc.
  - **Paul Ryus** (PI), **Anusha Musunuru**, Bastian Schroeder, Kelly Laustsen
- Highway Safety Research Center at University of North Carolina
  - Krista Nordback, **Seth LaJeunesse**, Wesley Kumfer
- Portland State University
  - **Sirisha Kothuri**, Nathan McNeil, Chris Monsere
- Pennsylvania State University
  - S. Ilgin Guler

Project Panel

- Kirk Zeringue, Louisiana DOTD (chair)
- George Branyon, District of Columbia DOT
- DeWayne Carver, Florida DOT
- Casey-Marie Claude, Boston Region MPO
- Richard Cunard, Transportation Research Board
- Jacqueline DeWolfe, Massachusetts DOT
- Carissa McQuiston, Michigan DOT
- Barbara Ostrom, Wood Technical Consulting Solutions
- Jeremy Raw, FHWA
- Keith Robinson, Gray Bowen Scott
- Yiyi Wang, San Francisco State University
- Joyce Yassin, WSP

Project Phases

- Phase 1: Fact-finding & interim report (Tasks 1–5)
  - May–November 2018
- Phase 2: Original research (Task 6)
  - December 2018–September 2019
- Phase 3: Report findings (Tasks 7–12)
  - Task 7: Draft guidebook
  - Task 8: Draft HCM chapter updates
  - Task 9: Implementation materials
  - Task 10: Outreach
  - Tasks 11, 12: Draft & final deliverables (by April 20, 2020)

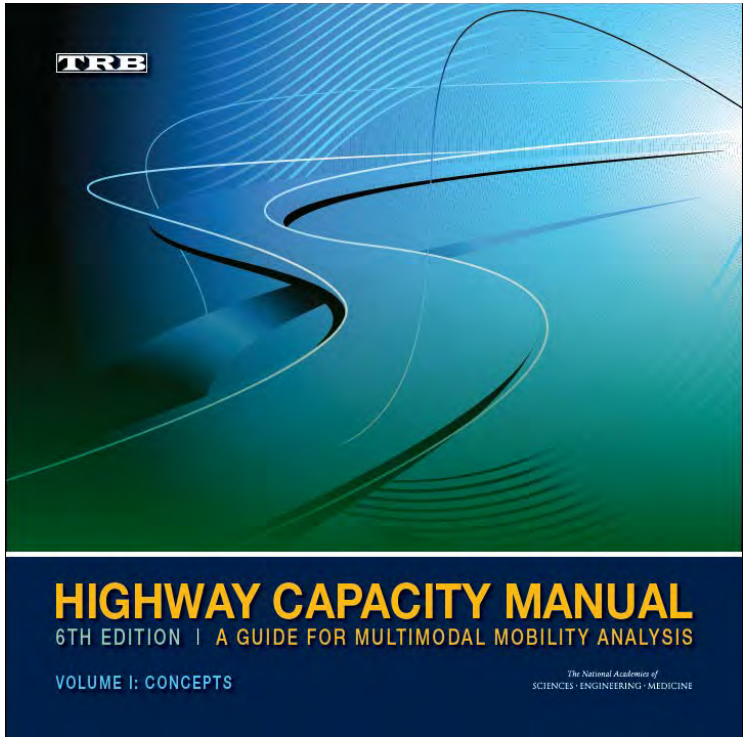
Phase 1 Results

Task 1: Literature Review (1)

- Reviewed over 300 documents relevant to the project
  - Pedestrian counting methods and practices
  - Performance measures for evaluating pedestrian safety, operations, mobility, and satisfaction
  - Effects of pedestrian safety countermeasures on pedestrian safety, operations, and quality of service (QOS)

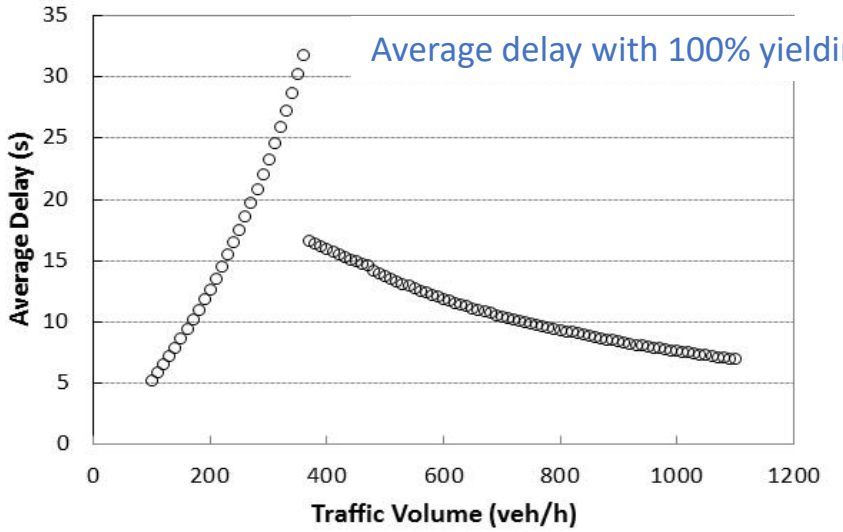
Task 1: Literature Review (2)

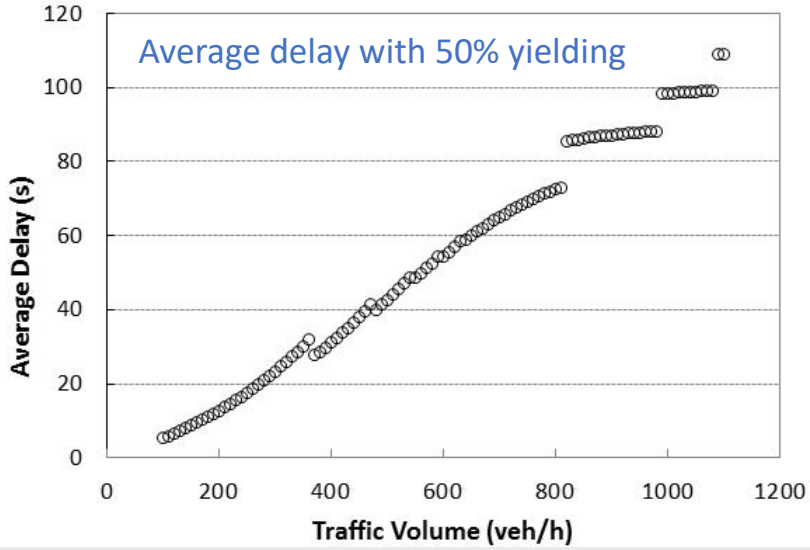
- HCM 6th Edition presents a suite of multimodal analysis methods for urban streets
  - Pedestrian, bicycle, transit, auto
- Current HCM pedestrian methods evaluated
  - Input data requirements
  - Result sensitivity to input variables
  - Applications and critiques in the literature
  - Known and newly identified limitations & issues



HCM Uncontrolled Crossing LOS

- Estimates pedestrian delay based on
  - Minimum gap needed to cross street
    - Function of traffic volume, crossing length
  - Motorist yielding rate
- Delay used to determine LOS
- Yielding portion of method found to produce unrealistic results in certain situations

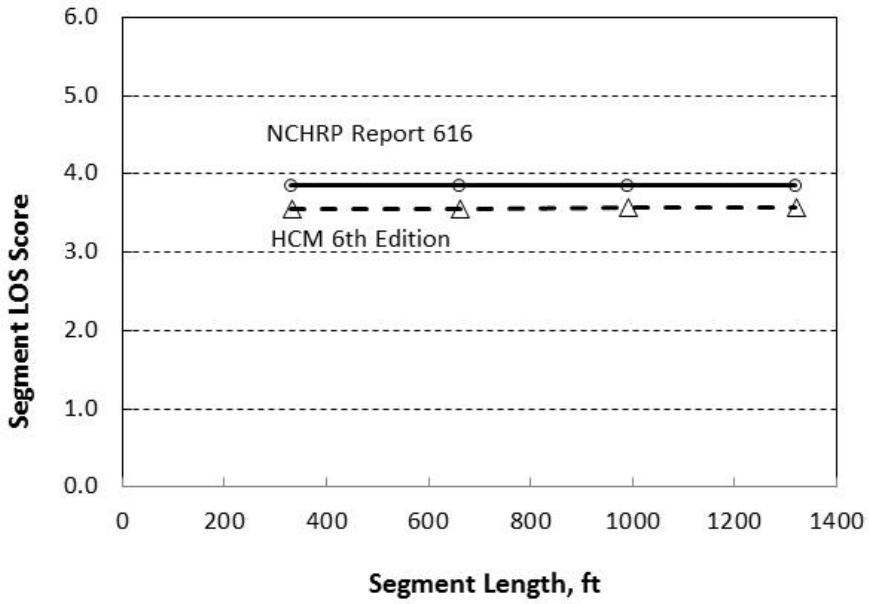




HCM Signalized Crossing LOS

- Estimates delay for randomly arriving pedestrians making a one-stage crossing at a pre-timed signal
- Does not address
  - Two-stage crossings of one intersection leg
  - Crossing more than one intersection leg
  - Semi- and fully actuated signals and hybrid beacons
  - Non-random pedestrian arrivals

HCM Midsegment Crossings



- Segment ped LOS score is insensitive to segment length for all but the shortest block lengths
  - Diversion delay exceeds crossing delay
- However, Baltes and Chu (2001) found that crossing difficulty is influenced by segment length

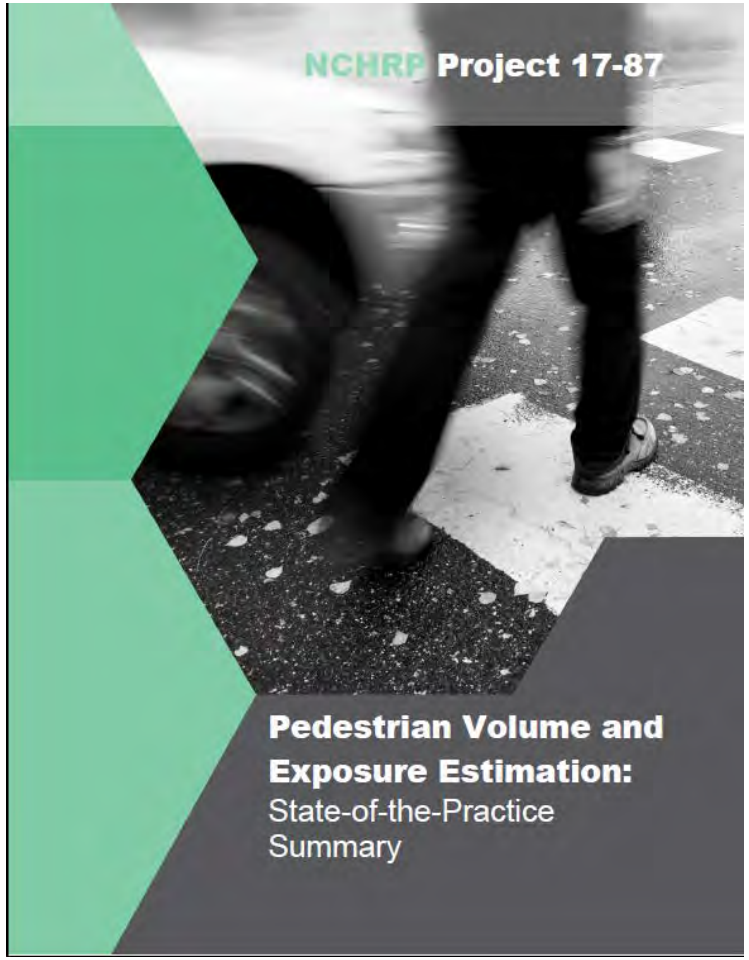
Task 2: Interviews

- Practitioners from leading organizations interviewed to
  - Identify current usage of pedestrian QOS and operations methods (not necessarily HCM methods)
  - Obtain input on research topics of greatest interest to a broad range of practitioners
- Organization types included
  - State DOTs
  - MPOs
  - Cities and counties
  - TRB committees

Stakeholder Input: Research Needs

Topic	Overall	State DOTs	MPOs	Local	HCQS Committee	Pedestrian Committees
n	*36*	*10*	*8*	*7*	*6*	*5*
Effects of signal timing changes on ped QOS	4.1 (13)	3.9 (2)	4.5 (4)	4.1 (3)	4.0 (1)	4.1 (3)
Effects of physical safety improvements on ped QOS	4.4 (21)	4.3 (5)	4.3 (5)	4.0 (3)	4.3 (3)	5.0 (5)
Evaluating pedestrian quality of service crossing a street	3.9 (16)	3.9 (4)	4.1 (4)	3.8 (3)	3.7 (2)	4.4 (3)
Evaluating pedestrian quality of service walking along a street	3.1 (3)	3.3 (1)	3.3 (1)	3.2 (0)	2.7 (0)	3.2 (1)
Determining the pedestrian volume at which pedestrians start walking out of the intended pedestrian path	2.7 (5)	2.4 (2)	3.0 (1)	3.1 (1)	2.5 (1)	2.6 (0)
Determining the required usable pedestrian sidewalk or path width for a given pedestrian volume	2.9 (3)	2.3 (1)	3.3 (0)	3.6 (1)	2.7 (1)	2.8 (0)
Determining the required crosswalk width for a given pedestrian volume	2.8 (3)	2.6 (1)	3.3 (1)	2.7 (0)	3.2 (1)	2.4 (0)
Determining how crosswalk configurations and motorist behaviors affect pedestrian quality of service	3.7 (11)	4.3 (4)	3.9 (3)	4.2 (2)	2.7 (0)	3.5 (2)
Extending current HCM pedestrian LOS methods to cover missing intersection types	3.6 (9)	3.8 (3)	3.6 (1)	3.0 (0)	4.8 (5)	2.4 (0)
Systemwide pedestrian connectivity and its relationship to pedestrian QOS	4.0 (18)	4.1 (5)	4.6 (7)	3.0 (1)	4.2 (3)	3.8 (2)

Task 3: State-of-the-Practice Summary



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Task 4: Draft Work Plan

- Candidate research activities identified for Phase 2
  - Group 0: Research design and pilot testing
  - Group 1: Pedestrian safety countermeasures satisfaction
  - Group 2: Sidewalk and intersection QOS
  - Group 3: Operations measures
- Research approach, cost developed for 17 potential research activities
  - Some activities could be repeated (e.g., different countermeasures, different intersection control types)

Task 5: Panel Meeting — Selected Research Topics

- 6A: Detailed work scopes & IRB approval
- 6B: Pilot testing
- 6C: Naturalistic walking study
- 6D: Pedestrian safety countermeasure LOS
  - Rectangular rapid-flashing beacon (RRFB)
  - Median refuge islands
  - Leading pedestrian intervals
- 6E: Pedestrian network connectivity LOS
- 6F: Improvements to HCM pedestrian delay methods
- 6G: Progress reporting

Phase 2 Research

Task 6D: Pedestrian Safety Countermeasures (1)

- Three-pronged approach:
  - Field surveys of pedestrians + video to identify the conditions experienced by surveyed pedestrians
    - Relate pedestrian satisfaction to crosswalk-related factors
  - Longer-duration video observations of pedestrian–vehicle interactions at same crosswalks on different days
    - Do countermeasures affect these interactions?
  - Data from naturalistic walking study at same crosswalks, when participants happened to pass through them
    - Measure participants' stress levels using biosensing wristbands

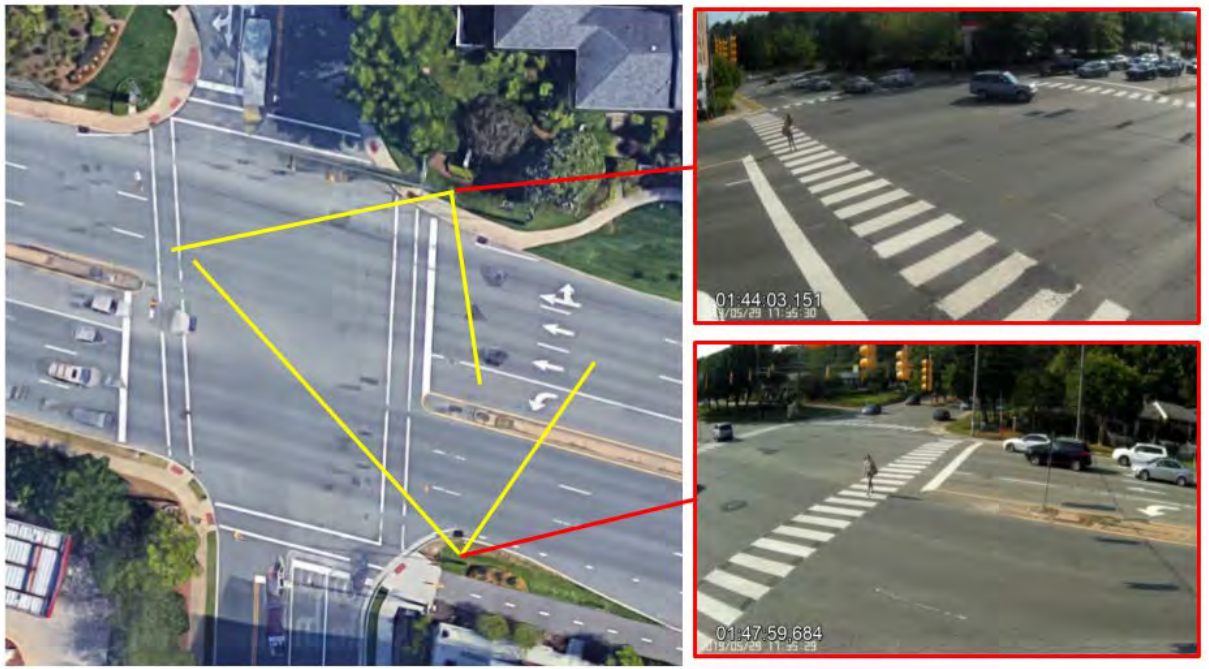
Task 6D: Pedestrian Safety Countermeasures (2)

- Data collection in 2 cities
  - Chapel Hill, NC (spring 2019)
  - Portland, OR (summer 2019)
- Three countermeasures (RRFBs, LPIs, median islands)
  - 10 treated sites & 10 control sites per countermeasure
  - Control sites matched to treated sites based on
    - Posted speed
    - AADT
    - Number of through lanes
    - Travel direction (one-way or two-way)
  - Control sites a mix of marked and unmarked crosswalks

Surveys (1)

- Pedestrians intercepted after making crossing
- Asked to rate satisfaction with crossing experience
  - Very satisfied, satisfied, dissatisfied, very dissatisfied
- Asked about trip purpose, trip length, familiarity with crossing, and if diverted to use the crossing
- Video observations of surveyed pedestrians
  - Delay, motorist yielding, avoidance maneuvers
- Field data collection about site characteristics
- Crossing ratings compared to crossing experiences

Surveys (2)



Surveys (3)

- 700 pedestrians interviewed
  - 0 to 50 per site (average 12 per site)
  - Unmarked crosswalks generally had the lowest volumes
- 57% response rate

Summary Survey Results (1)

Table B9. Survey respondent satisfaction by crossing type

Crossing Type	# of Pedestrians Interviewed	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
Signalized					
LPI	150	0%	14%	67%	19%
Marked Control	117	4%	19%	59%	18%
Unsignalized					
Median Island	167	2%	10%	53%	34%
RRFB	108	8%	8%	44%	39%
Marked Control	104	13%	24%	52%	12%
Unmarked Control	56	32%	30%	29%	9%

Table B11. Pedestrian satisfaction at unsignalized intersections by speed limit

Speed Limit (mph)	# of Pedestrians Interviewed	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
20	42	5%	10%	48%	38%
25	192	4%	15%	53%	28%
30	107	15%	21%	38%	26%
35	85	11%	15%	53%	21%
45	9	100%	0%	0%	0%

Summary Survey Results (2)

Table B14. Trip purpose

Trip Purpose	Number of Respondents	Percent of Respondents
Going home	193	32%
Running errands	150	25%
Going to work/school/the university	141	23%
Other	86	14%
Visiting friends/family	26	4%
Exercising	9	1%
TOTAL	**605**	**100%**

30% of trips transit-related

Table B16. Trip length

Trip Length	Number of Respondents	Percent of Respondents
<5 min	246	40%
5–10 min	152	25%
10–15 min	102	17%
>15 min	118	19%
TOTAL	**618**	**100%**

Table B17. Responses to frequency of crosswalk use

Frequency of Crosswalk Use	Number of Respondents	Percent of Respondents
4 or more days a week	317	51%
1–3 days a week	141	23%
1–3 days a month	66	11%
Less than one day a month	48	8%
First time	49	8%
TOTAL	**621**	**100%**

Level-of-Agreement Questions

Table B18. Level of agreement with statements

Topic	Level of Agreement Statement	Number of Respondents	1 = Strongly Disagree	2 = Disagree	3 = Agree	4 = Strongly Agree
Delay	LA1. Level of agreement: "I felt like I had to wait a long time to cross."	375	26%	54%	14%	5%
Delay	LA5. Level of agreement: "I felt delayed trying to cross this street."	372	20%	54%	21%	5%
Safety	LA2. Level of agreement: "I felt like I might get hit by a car when crossing here."	374	14%	37%	32%	16%
Safety	LA6. Level of agreement: "I felt safe crossing here."	373	12%	26%	47%	15%
Rushed	LA3. Level of agreement: "I had enough time to cross this street."	373	5%	18%	56%	21%
Rushed	LA7: Level of agreement: "I felt rushed trying to cross this street."	368	14%	42%	29%	14%
Route preference	LA4. Level of agreement: "I went out of my way to cross here."	373	18%	50%	24%	8%
Route preference	LA8: Level of agreement: "Crossing here was the most direct route to get to where I was going."	371	2%	11%	47%	40%

Motorist Interaction Results

Table B22 Satisfaction of pedestrians with motorist yielding at unsignalized crossings

Motorist Yielded to Pedestrian	Number of Respondents	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
Motorist yielded	309	5%	13%	50%	31%
Motorist did not yield	109	25%	21%	40%	14%

Table B1 Pedestrian crossing satisfaction when delayed due to motorist

Pedestrian Delayed Due to Motorist	Number of Respondents	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
Not delayed due to motorist	295	6%	15%	49%	31%
Delayed due to motorist	121	21%	18%	45%	16%

Table B24. Pedestrian crossing satisfaction as related to pedestrian delay

Pedestrian Delay	Number of Respondents	Very Dissatisfied	Dissatisfied	Satisfied	Very Satisfied
Unsignalized Crossing					
Delayed	129	22%	19%	45%	15%
Not Delayed	287	5%	14%	49%	31%
Signalized Crossing					
Delayed	124	3%	18%	65%	15%
Not Delayed	130	1%	15%	65%	19%

Multinomial Logistic Regression

Unsignalized

Variable	Response Level	Estimate	p-value	Odds Ratio
Aadt_s	Satisfied/Dissatisfied	-0.0438	0.0005	0.9570
Treatment_cat (RRFB/unmarked)	Satisfied/Dissatisfied	1.9572	<0.0001	7.0790
Treatment_cat (marked/unmarked)	Satisfied/Dissatisfied	0.9843	0.0143	2.6760
Treatment_cat (median islan/unmarked)	Satisfied/Dissatisfied	1.5496	0.0003	4.7100
Interaction_motorist_noyield (yes/no)	Satisfied/Dissatisfied	-0.6065	0.0313	0.5450
Interaction_ped_slowed (yes/no)	Satisfied/Dissatisfied	-1.2994	0.0039	0.2730
Intercept	Satisfied/Dissatisfied	0.9951	0.0157	-
All variables are statistically significant at the p=0.05 level				
AIC = 403.169; Chi-Square < 0.0001				
418 observations used				

Not significant: posted speed, # of through lanes

Signalized

Table B1. Logistic regression model for signalized sites without survey results

Variable	Response Level	Estimate	p-value	Odds Ratio	Lower Confidence Interval	Upper Confidence Interval
City (Chapel Hill/ Portland)	Satisfied/Dissatisfied	−1.027	0.0072	0.358	0.169	0.758
City (Chapel Hill/ Portland)	Very Satisfied/Dissatisfied	−1.519	0.0018	0.219	0.084	0.568
Volume_left_minor	Satisfied/Dissatisfied	−0.066	0.4855*	0.936	0.778	1.127
Volume_left_minor	Very Satisfied/Dissatisfied	−0.463	0.0033	0.629	0.462	0.857
Intercept	Satisfied/Dissatisfied	1.719	<0.0001	—	—	—
Intercept	Very Satisfied/Dissatisfied	2.256	0.0036	—	—	—

Note: *Lack of statistical significance for the given odds ratio.

Not significant: posted speed, # of through lanes, AADT, LPI presence

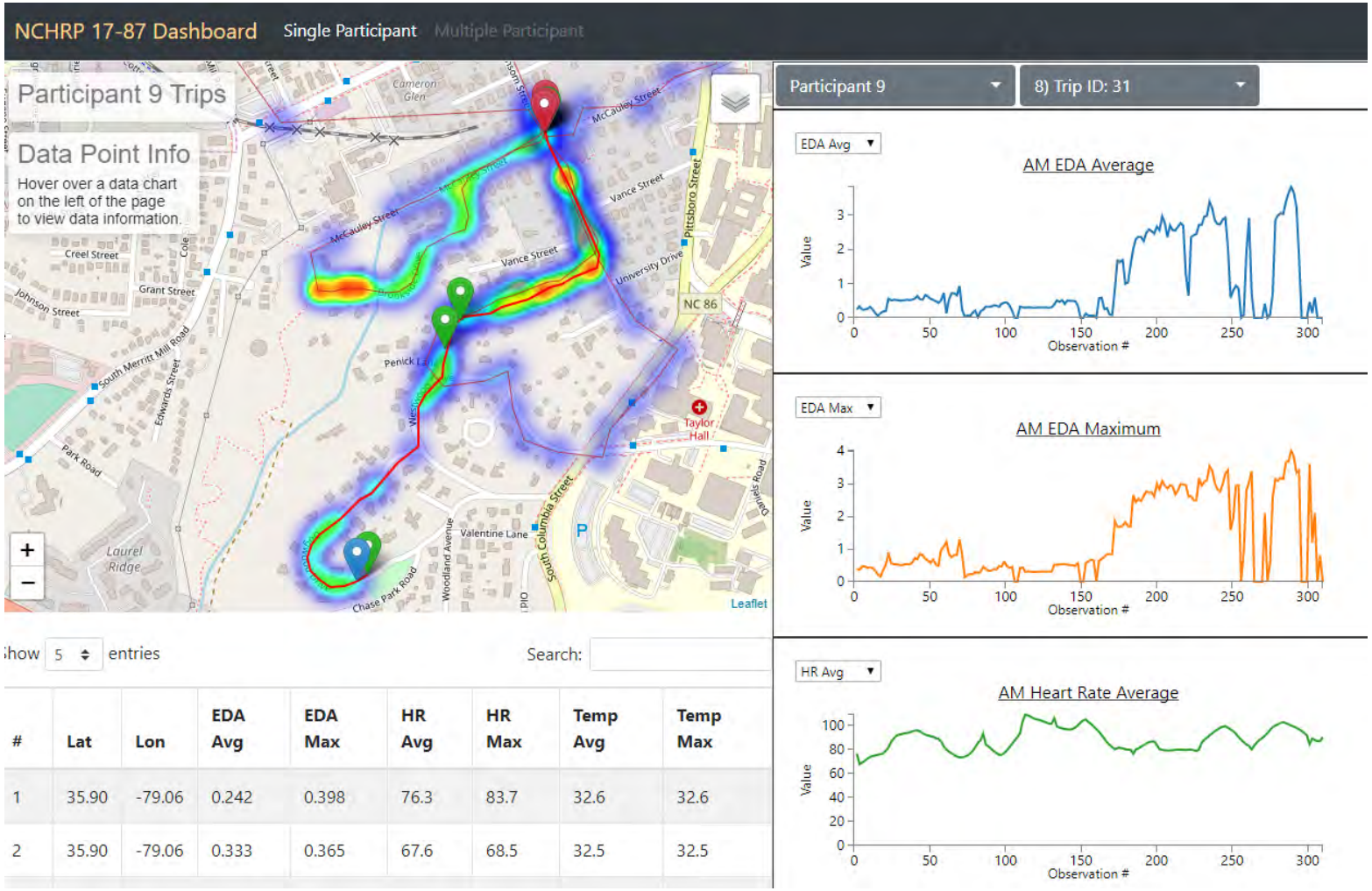
Video Observation Results

- Looked at pedestrian delay, crossing time, percent yielding, percent crossings with no vehicle interaction, percent legal crossers, percent 2-stage crossers
- Uncontrolled crossings
  - Motorist yielding rates higher at treated (RFFB, median island) sites than at untreated (marked/unmarked xwalk) sites
- Signalized crossings
  - Pedestrian signal compliance better at LPI sites than at control sites

Task 6C: Naturalistic Walking Study

- Purposes:
  - Compare survey and video observations with pedestrian stress readings at study crosswalks
  - Evaluate variations in pedestrian stress during trip
- 15 recruited participants made normal walking trips over the course of a week
- Wore Empatica E4 biosensing wristband
  - Measures skin conductance (stress), heart rate
- Carried GPS unit
  - Provides location to match to wristband data

Physiological Data



Data Collection Issues

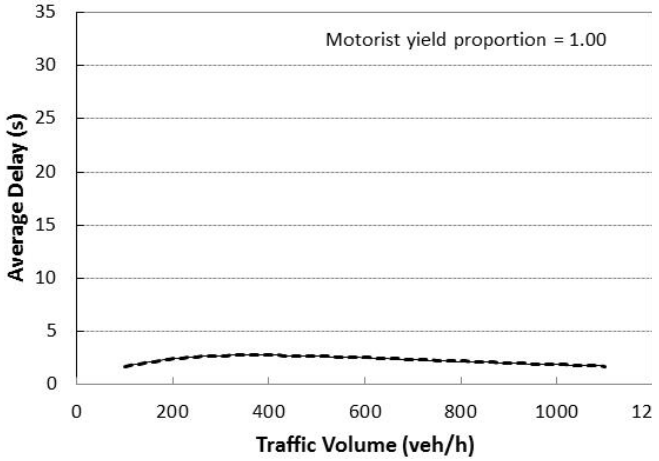
- Participants forgetting to start wristband sessions or carry GPS units
- Battery life on 3 GPS units (3 days vs. 1 week)
- GPS vendor not setting location interval to 5 seconds from default 1 minute when activating devices
- Obtained useful data for 21 out of expected 60 trips

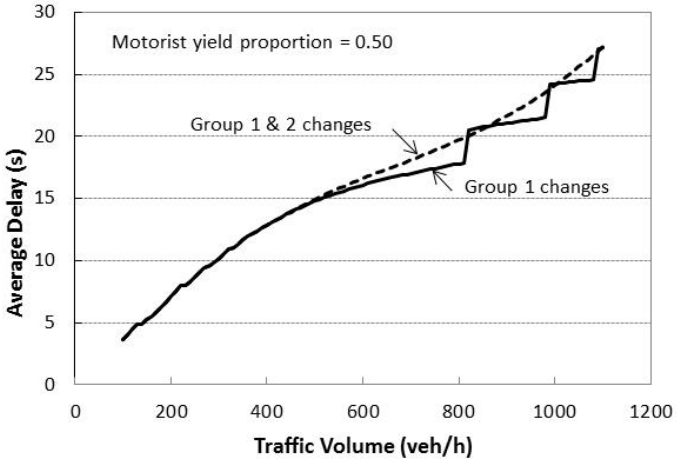
Naturalistic Study Results

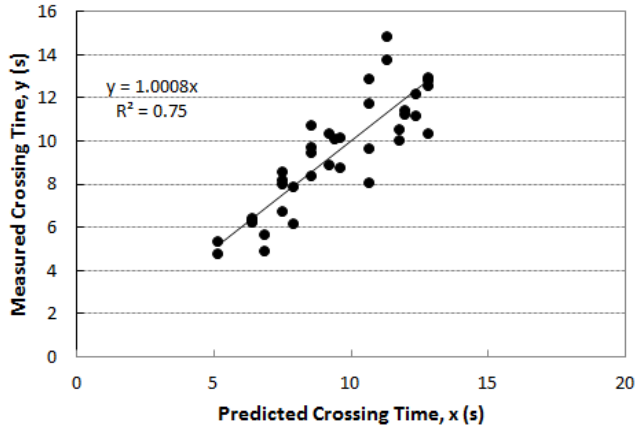
- No significant relationship found between stress and
  - Crossings at study sites
  - Crossings generally
- Stress level
  - Higher on collector & arterial roadways
  - Higher in industrial and mixed-use environments
  - Lower in low-density residential, forest, park, and university campus settings
- Heart rate
  - Higher on collectors & in industrial, mixed-use settings
  - Lower on paths & in environments with AADT < 4,000

Task 6F: HCM Pedestrian Delay

- Uncontrolled crossings:
  - Fixed yielding rate issues
  - Modeled delay compared to Task 6D field data
    - Can reliably predict delay
    - More spread in the data when turn lanes present at crossing
  - Reliability of delay estimate highly dependent on
    - Pedestrian crossing speed (4.3 ft/s HCM, 4.7 ft/s field)
    - Start-up and end clearance time (3.0 s HCM, 0.0 s field)



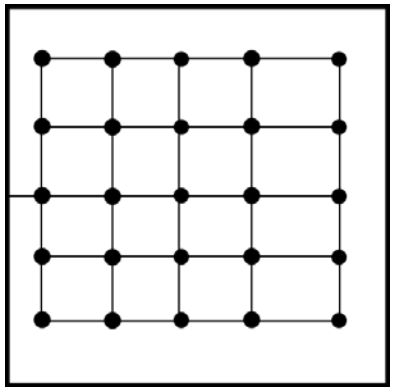




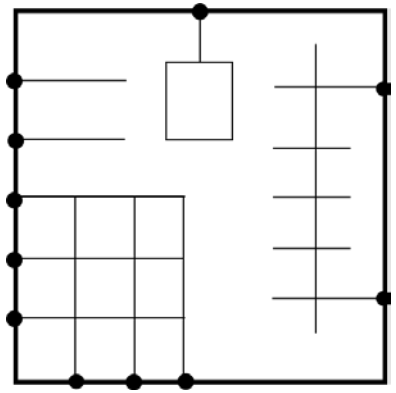
Task 6E: Network Connectivity LOS

- Develop and test develop and test a method for evaluating the quality of service (QOS) for a pedestrian network covering a large area, ranging in size from a neighborhood or campus to an entire city
- FHWA's *Guidebook on Measuring Multimodal Network Connectivity* identifies these factors:
  - Network quality
  - Network completeness
  - Network density
  - Route directness
  - Access to destinations

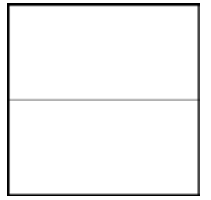
Challenges with Existing Measures



- Generally small block sizes
- High intersection density, high street density
- High internal connectivity, low external connectivity



- Range of block sizes
- Moderate intersection density, moderate street density
- Low internal connectivity, Relatively high external connectivity

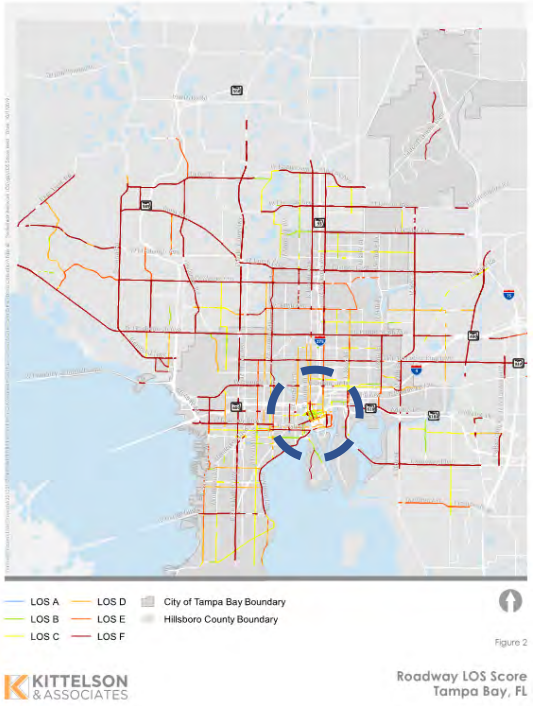


- Low intersection density, low street density
- Moderate block sizes
- Few choices of routes, but network is complete and connected

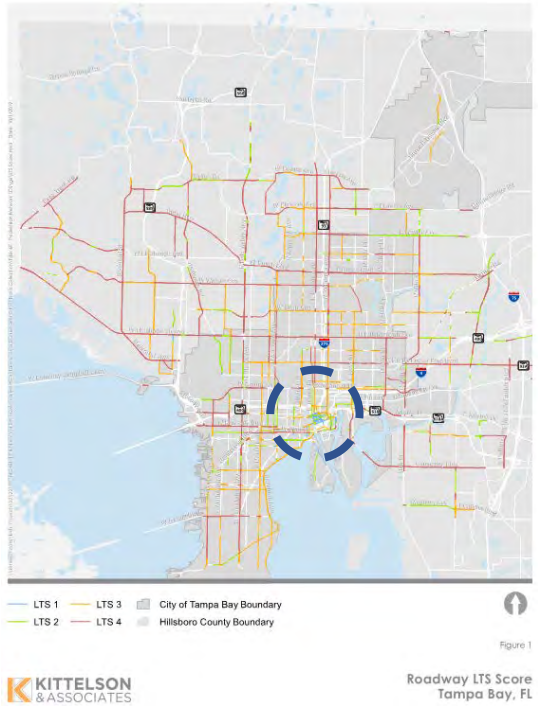
Network Quality

- Investigated two planning-level measures of pedestrian facility quality
  - 2009 Florida Pedestrian LOS
  - Oregon DOT Pedestrian Level of Traffic Stress
- Tested measures on a pedestrian facility dataset covering all Florida arterials and collectors

PLOS – Tampa



PLTS – Tampa



Connectivity Island Mapping (1)

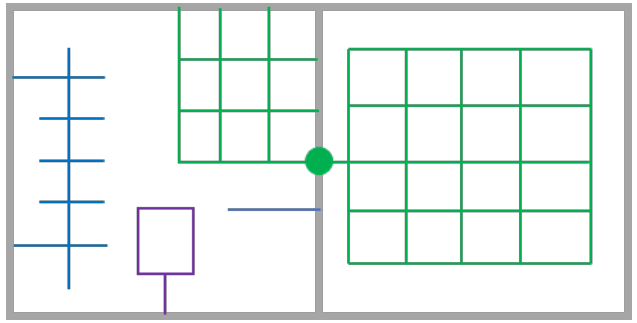
- Use GIS to identify all streets connected at a user-defined PLTS
  - ODOT PLTS method for links
  - Planning-level version of NCHRP 17-87 xing satisfaction method for intersections

Figure D4. Connectivity Island Mapping (Fort Collins, CO)

Source: FHWA *Guidebook on Measuring Multimodal Network Connectivity*

Connectivity Island Mapping (2)

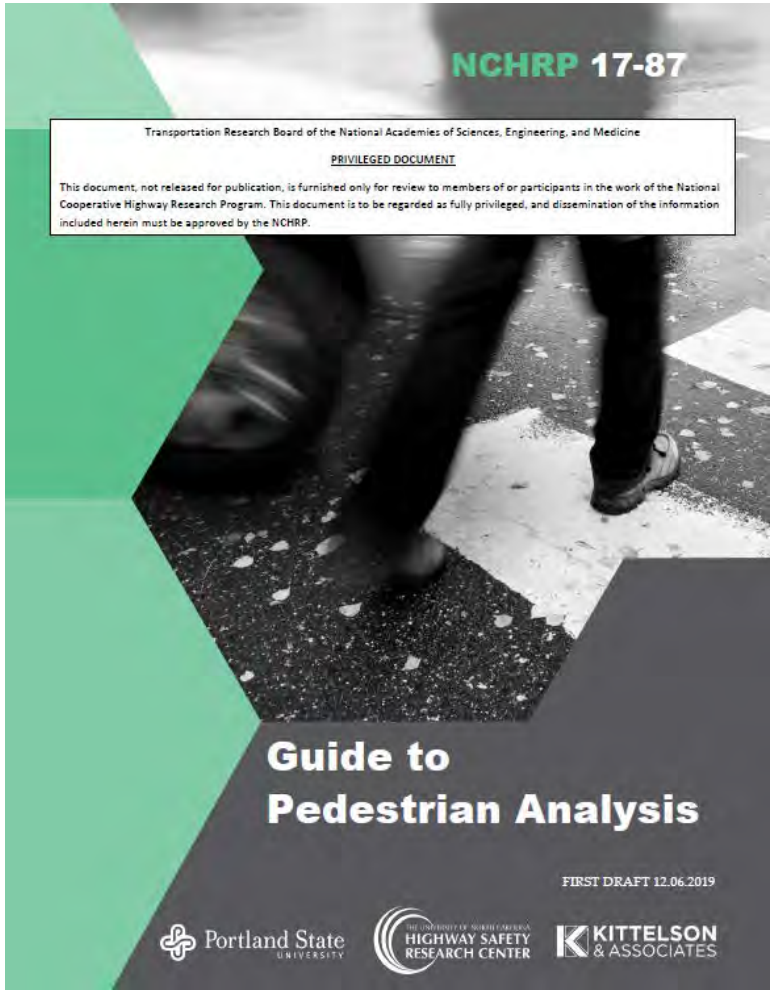
- Network quality
  - Miles/% of network at a given PLTS
- Network completeness
- Network density
  - Average miles per island at a given PLTS



- Route directness
  - Shortest path at a given PLTS vs. straight-line (air) distance for given O-D
- Access to destinations
  - % destinations accessible at a given PLTS for a given origin

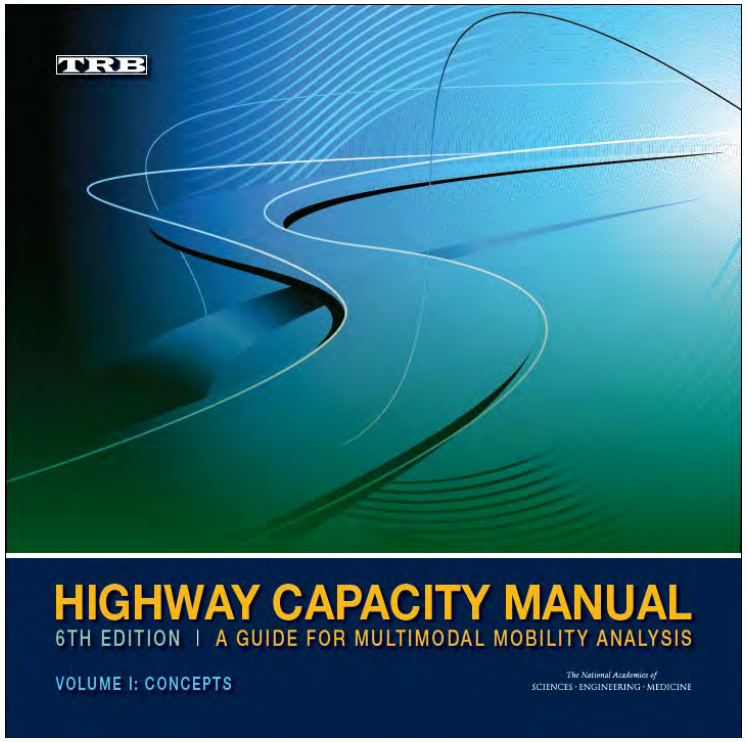
Phase 3 Products

Task 7: Guide to Pedestrian Analysis



Task 8: HCM Chapter Updates

- Major revisions to ped material in
  - Chapter 19 (signalized intersections)
  - Chapter 20 (two-way stop-control)
  - Chapters 31, 32 (example problems)
- Smaller revisions to
  - Chapter 18 (midblock xing difficulty factor)
  - Chapter 9 (glossary & symbols)
- Updates to ped section of HCM Planning Guide (NCHRP Report 825)
- Computational engines



Task 9: Implementation Materials

- Webinar slides
- Short video about the Guide
- Implementation plan

Task 10: Outreach

- Peer exchange workshop
- Webinar (spring 2020 requested)
- Updates to TRB committees

Tasks 11 &12:
Draft & Final Deliverables

- Project scheduled completion date: April 20, 2020

Questions
Discussion
Feedback