NCHRP Project 20-123 (02)

Research Roadmap *for the* AASHTO Council on Active Transportation

APBP Webinar
February 2, 2022

Portland State UNIVERSITY

TOOLE DESIGN

Roadmap for my presentation

- **Process for developing the Roadmap**
- What's in the Roadmap?
- How can you use the Roadmap and get involved in research?

Our Team

Portland State UNIVERSITY

Jennifer Dill, PI

Nathan McNeil

Christopher Monsere

Sirisha Kothuri

Kyuri Kim

Ana Maria Navia Pelaez

Our Team

TOOLE DESIGN

Stefanie Brodie
co-PI

Jessica Schoner
(former)

Belinda Judelman

Dan Goodman

Frank Proulx
(former)

Project Panel

Patrick D. Adams, Maine Department of Transportation
Rob Bedenbaugh, South Carolina Department of Transportation
Marshall R. Elizer, Washington State Department of Transportation
Donna Lewandowski, Arizona Department of Transportation
Susan Peithman, Oregon Department of Transportation
Phillip Burgoyne-Allen, AASHTO Liaison
Phillip M. Peevy, AASHTO Liaison
Darren Buck, FHWA Liaison

Ann Hartell, NCHRP Senior Program Officer

Project Tasks

Prioritizing Research Needs

110 needs placed into 3 priority levels using survey & workshop input and team's knowledge

Top 15 needs reviewed by Panel and CAT Steering Committee. Their input + survey of CAT members used to select top 6.

6 Highest priority (Research Problem Statements)

9 High priority (Research Need Briefs)

31 Medium priority (Research Need Briefs)

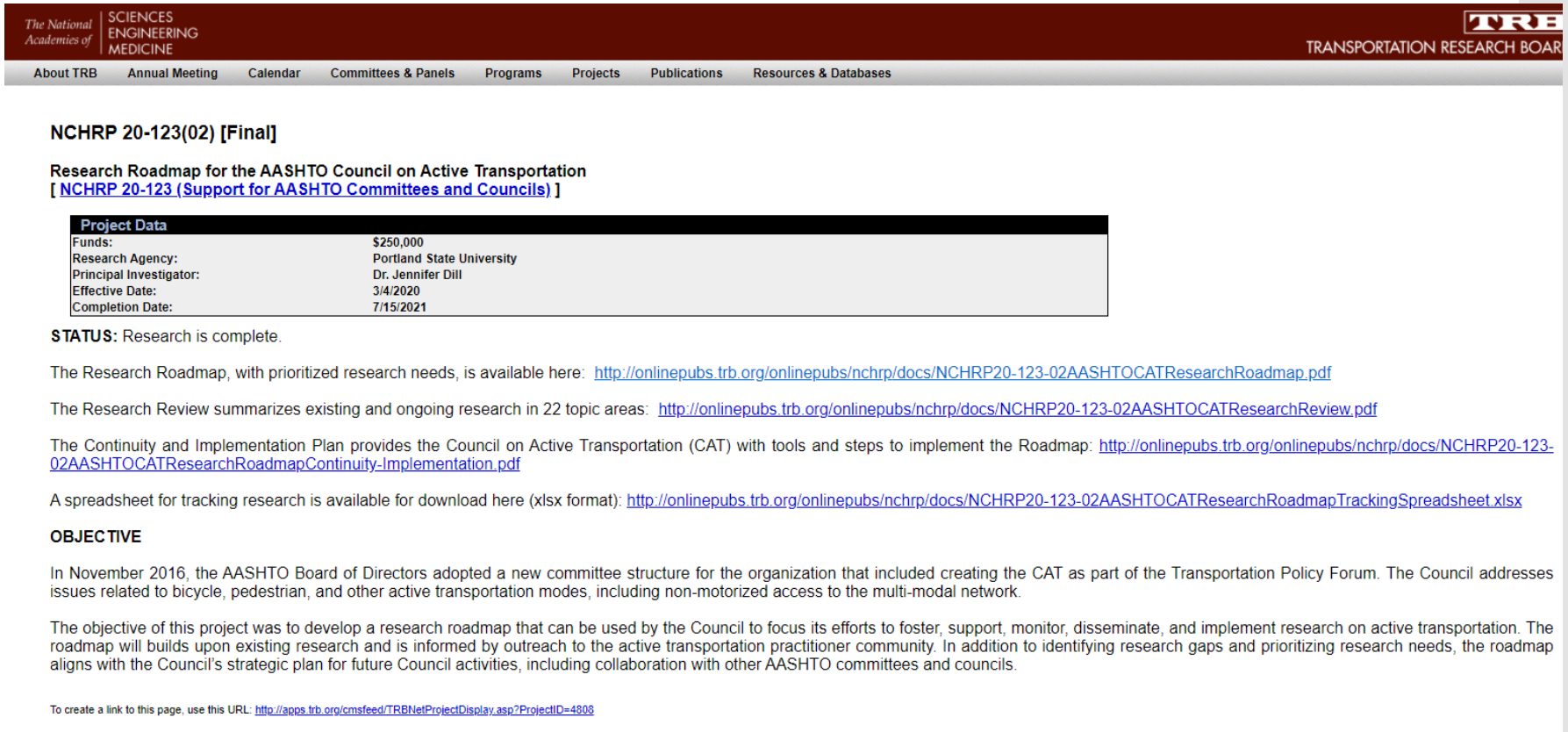
64 Lower priority

Roadmap for my presentation

- Process for developing the Roadmap
- **What's in the Roadmap?**
- How can you use the Roadmap and get involved in research?

Where to find the final documents

- https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4808
  - Or search *research roadmap AASHTO council active transportation*



The National Academies of SCIENCES ENGINEERING MEDICINE

TRB TRANSPORTATION RESEARCH BOARD

About TRB | Annual Meeting | Calendar | Committees & Panels | Programs | Projects | Publications | Resources & Databases

NCHRP 20-123(02) [Final]

Research Roadmap for the AASHTO Council on Active Transportation
[NCHRP 20-123 (Support for AASHTO Committees and Councils)]

Project Data	
Funds:	$250,000
Research Agency:	Portland State University
Principal Investigator:	Dr. Jennifer Dill
Effective Date:	3/4/2020
Completion Date:	7/15/2021

STATUS: Research is complete.

The Research Roadmap, with prioritized research needs, is available here: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-123-02AASHTOCATResearchRoadmap.pdf

The Research Review summarizes existing and ongoing research in 22 topic areas: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-123-02AASHTOCATResearchReview.pdf

The Continuity and Implementation Plan provides the Council on Active Transportation (CAT) with tools and steps to implement the Roadmap: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-123-02AASHTOCATResearchRoadmapContinuity-Implementation.pdf

A spreadsheet for tracking research is available for download here (xlsx format): http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-123-02AASHTOCATResearchRoadmapTrackingSpreadsheet.xlsx

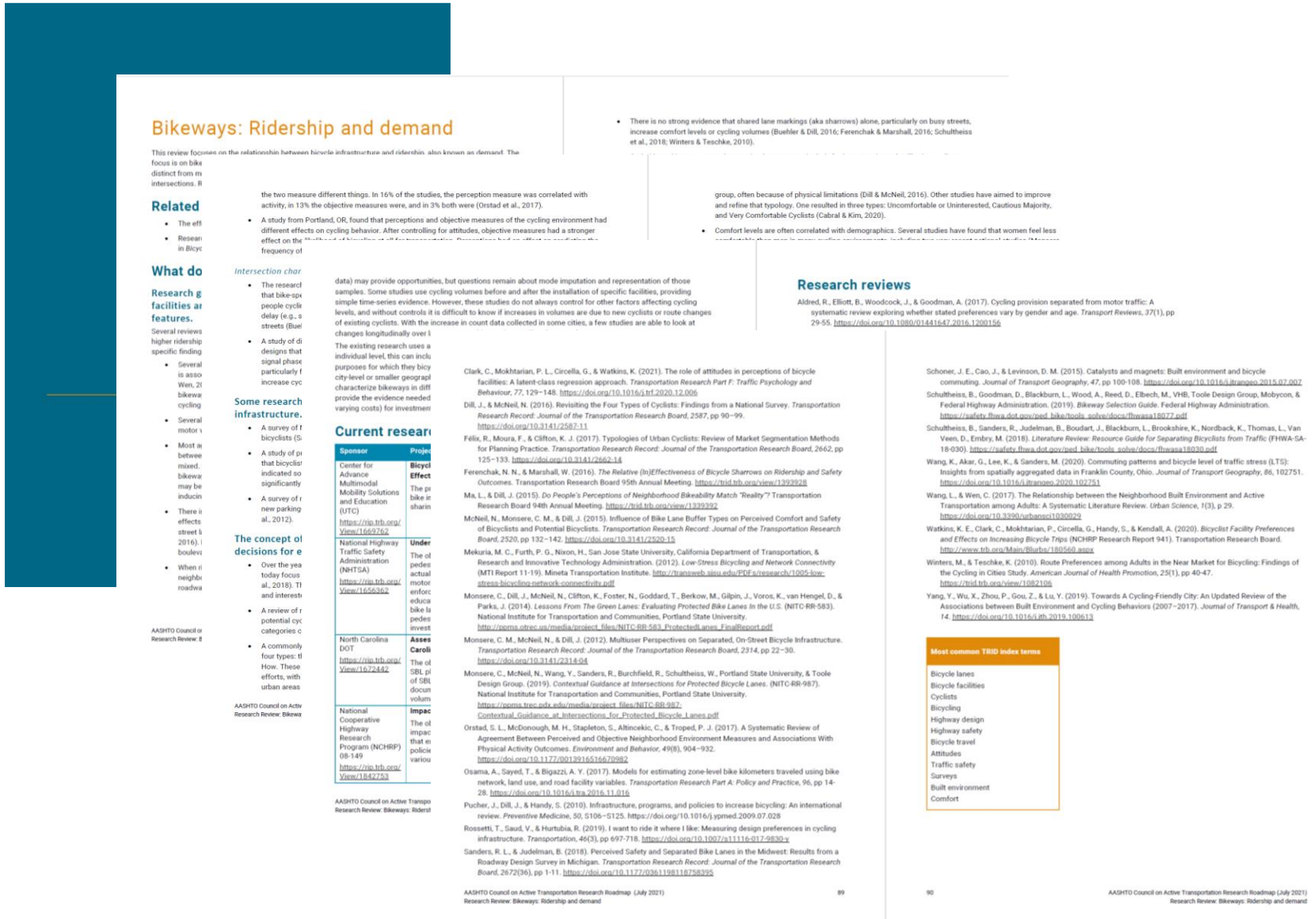
OBJECTIVE

In November 2016, the AASHTO Board of Directors adopted a new committee structure for the organization that included creating the CAT as part of the Transportation Policy Forum. The Council addresses issues related to bicycle, pedestrian, and other active transportation modes, including non-motorized access to the multi-modal network.

The objective of this project was to develop a research roadmap that can be used by the Council to focus its efforts to foster, support, monitor, disseminate, and implement research on active transportation. The roadmap will builds upon existing research and is informed by outreach to the active transportation practitioner community. In addition to identifying research gaps and prioritizing research needs, the roadmap aligns with the Council's strategic plan for future Council activities, including collaboration with other AASHTO committees and councils.

To create a link to this page, use this URL: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4808

Research Review



Bikeways: Ridership and demand

Related

What do

Some research infrastructure.

The concept of decisions for e

Current researc

Sponsor	Projec
Center for Advance Multimodal Mobility Solutions and Education (UTC) https://rip.trb.org/View/1669762	Bicycl Effect
National Highway Traffic Safety Administration (NHTSA) https://rip.trb.org/View/1656362	Under
North Carolina DOT https://rip.trb.org/View/1672442	Asses Caroli
National Cooperative Highway Research Program (NCHRP) 08-149 https://rip.trb.org/View/1842753	Impac

the two measure different things. In 16% of the studies, the perception measure was correlated with activity, in 13% the objective measures were, and in 3% both were (Orstad et al., 2017).

- A study from Portland, OR, found that perceptions and objective measures of the cycling environment had different effects on cycling behavior. After controlling for attitudes, objective measures had a stronger effect on the

Intersection char

data) may provide opportunities, but questions remain about mode imputation and representation of those samples. Some studies use cycling volumes before and after the installation of specific facilities, providing simple time-series evidence. However, these studies do not always control for other factors affecting cycling levels, and without controls it is difficult to know if increases in volumes are due to new cyclists or route changes of existing cyclists. With the increase in count data collected in some cities, a few studies are able to look at changes longitudinally over

The existing research uses a individual level, this can inclu purposes for which they bicy city-level or smaller geograp characterize bikeways in diff provide the evidence needed varying costs) for investmen

- There is no strong evidence that shared lane markings (aka sharrows) alone, particularly on busy streets, increase comfort levels or cycling volumes (Buehler & Dill, 2016; Ferenchak & Marshall, 2016; Schultheiss et al., 2018; Winters & Teschke, 2010).

group, often because of physical limitations (Dill & McNeil, 2016). Other studies have aimed to improve and refine that typology. One resulted in three types: Uncomfortable or Uninterested, Cautious Majority, and Very Comfortable Cyclists (Cabral & Kim, 2020).

- Comfort levels are often correlated with demographics. Several studies have found that women feel less

Research reviews

Aldred, R., Elliott, B., Woodcock, J., & Goodman, A. (2017). Cycling provision separated from motor traffic: A systematic review exploring whether stated preferences vary by gender and age. *Transport Reviews, 37*(1), pp 29-55. https://doi.org/10.1080/01441647.2016.1200156

Clark, C., Mokhtarian, P. L., Circella, G., & Watkins, K. (2021). The role of attitudes in perceptions of bicycle facilities: A latent-class regression approach. *Transportation Research Part F: Traffic Psychology and Behaviour, 77*, 129–148. https://doi.org/10.1016/j.trf.2020.12.006

Dill, J., & McNeil, N. (2016). Revisiting the Four Types of Cyclists: Findings from a National Survey. *Transportation Research Record: Journal of the Transportation Research Board, 2587*, pp 90–99. https://doi.org/10.3141/2587-11

Félix, R., Moura, F., & Clifton, K. J. (2017). Typologies of Urban Cyclists: Review of Market Segmentation Methods for Planning Practice. *Transportation Research Record: Journal of the Transportation Research Board, 2662*, pp 125–133. https://doi.org/10.3141/2662-14

Ferenchak, N. N., & Marshall, W. (2016). *The Relative (In)Effectiveness of Bicycle Sharrows on Ridership and Safety Outcomes*. Transportation Research Board 95th Annual Meeting. https://trid.trb.org/view/1393928

Ma, L., & Dill, J. (2015). *Do People's Perceptions of Neighborhood Bikeability Match "Reality"?* Transportation Research Board 94th Annual Meeting. https://trid.trb.org/view/1339392

McNeil, N., Monsere, C. M., & Dill, J. (2015). Influence of Bike Lane Buffer Types on Perceived Comfort and Safety of Bicyclists and Potential Bicyclists. *Transportation Research Record: Journal of the Transportation Research Board, 2520*, pp 132–142. https://doi.org/10.3141/2520-15

Mekuria, M. C., Furth, P. G., Nixon, H., San Jose State University, California Department of Transportation, & Research and Innovative Technology Administration. (2012). *Low-Stress Bicycling and Network Connectivity* (MTI Report 11-19). Mineta Transportation Institute. http://transweb.sjsu.edu/PDFs/research/1005-low-stress-bicycling-network-connectivity.pdf

Monsere, C., Dill, J., McNeil, N., Clifton, K., Foster, N., Goddard, T., Berkow, M., Gilpin, J., Voros, K., van Hengel, D., & Parks, J. (2014). *Lessons From The Green Lanes: Evaluating Protected Bike Lanes In the U.S.* (NITC-RR-583). National Institute for Transportation and Communities, Portland State University. http://ppms.otrec.us/media/project_files/NITC-RR-583_ProtectedLanes_FinalReport.pdf

Monsere, C. M., McNeil, N., & Dill, J. (2012). Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure. *Transportation Research Record: Journal of the Transportation Research Board, 2314*, pp 22–30. https://doi.org/10.3141/2314-04

Monsere, C., McNeil, N., Wang, Y., Sanders, R., Burchfield, R., Schultheiss, W., Portland State University, & Toole Design Group. (2019). *Contextual Guidance at Intersections for Protected Bicycle Lanes*. (NITC-RR-987). National Institute for Transportation and Communities, Portland State University. https://ppms.trec.pdx.edu/media/project_files/NITC-RR-987-Contextual_Guidance_at_Intersections_for_Protected_Bicycle_Lanes.pdf

Orstad, S. L., McDonough, M. H., Stapleton, S., Altincekic, C., & Troped, P. J. (2017). A Systematic Review of Agreement Between Perceived and Objective Neighborhood Environment Measures and Associations With Physical Activity Outcomes. *Environment and Behavior, 49*(8), 904–932. https://doi.org/10.1177/0013916516670982

Osama, A., Sayed, T., & Bigazzi, A. Y. (2017). Models for estimating zone-level bike kilometers traveled using bike network, land use, and road facility variables. *Transportation Research Part A: Policy and Practice, 96*, pp 14-28. https://doi.org/10.1016/j.tra.2016.11.016

Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine, 50*, S106–S125. https://doi.org/10.1016/j.ypmed.2009.07.028

Rossetti, T., Saud, V., & Hurtubia, R. (2019). I want to ride it where I like: Measuring design preferences in cycling infrastructure. *Transportation, 46*(3), pp 697-718. https://doi.org/10.1007/s11116-017-9830-y

Sanders, R. L., & Judelman, B. (2018). Perceived Safety and Separated Bike Lanes in the Midwest: Results from a Roadway Design Survey in Michigan. *Transportation Research Record: Journal of the Transportation Research Board, 2672*(36), pp 1-11. https://doi.org/10.1177/0361198118758395

Schoner, J. E., Cao, J., & Levinson, D. M. (2015). Catalysts and magnets: Built environment and bicycle commuting. *Journal of Transport Geography, 47*, pp 100-108. https://doi.org/10.1016/j.jtrangeo.2015.07.007

Schultheiss, B., Goodman, D., Blackburn, L., Wood, A., Reed, D., Elbech, M., VHB, Toole Design Group, Mobycon, & Federal Highway Administration. (2019). *Bikeway Selection Guide*. Federal Highway Administration. https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf

Schultheiss, B., Sanders, R., Judelman, B., Boudart, J., Blackburn, L., Brookshire, K., Nordback, K., Thomas, L., Van Veen, D., Embry, M. (2018). *Literature Review: Resource Guide for Separating Bicyclists from Traffic* (FHWA-SA-18-030). https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18030.pdf

Wang, K., Akar, G., Lee, K., & Sanders, M. (2020). Commuting patterns and bicycle level of traffic stress (LTS): Insights from spatially aggregated data in Franklin County, Ohio. *Journal of Transport Geography, 86*, 102751. https://doi.org/10.1016/j.jtrangeo.2020.102751

Wang, L., & Wen, C. (2017). The Relationship between the Neighborhood Built Environment and Active Transportation among Adults: A Systematic Literature Review. *Urban Science, 1*(3), p 29. https://doi.org/10.3390/urbansci1030029

Watkins, K. E., Clark, C., Mokhtarian, P., Circella, G., Handy, S., & Kendall, A. (2020). *Bicyclist Facility Preferences and Effects on Increasing Bicycle Trips* (NCHRP Research Report 941). Transportation Research Board. http://www.trb.org/Main/Blurbs/180560.aspx

Winters, M., & Teschke, K. (2010). Route Preferences among Adults in the Near Market for Bicycling: Findings of the Cycling in Cities Study. *American Journal of Health Promotion, 25*(1), pp 40-47. https://trid.trb.org/view/1082106

Yang, Y., Wu, X., Zhou, P., Gou, Z., & Lu, Y. (2019). Towards A Cycling-Friendly City: An Updated Review of the Associations between Built Environment and Cycling Behaviors (2007–2017). *Journal of Transport & Health, 14*. https://doi.org/10.1016/j.jth.2019.100613

Most common TRID index terms

- Bicycle lanes
- Bicycle facilities
- Cyclists
- Bicycling
- Highway design
- Highway safety
- Bicycle travel
- Attitudes
- Traffic safety
- Surveys
- Built environment
- Comfort

The Research Roadmap

Contents

Executive Summary vi

Overview vi

Research Needs vi

Introduction and Methods 1

Overview: Using the Roadmap 1

Background 1

Why is a Roadmap Important? 1

The Role of the AASHTO Council on Active Transportation 2

Methods 3

Overview 3

Existing Research Needs and Gaps 3

Outreach for the Roadmap 3

Roadmap Development 3

Research Needs 4

Introduction 4

Connections to the CAT Strategic Plan 4

Themes 5

Equity 5

Research on Practice and Policy 5

Some Older, Inadequate Research and Assumptions are Barriers 5

Crash Modification Factors 5

Walking and Bicycling Should Often be Considered Separately 5

What is Included: Highest-Priority Needs 6

What is Included: High- and Medium-Priority Needs 6

Overview and Research Objectives 6

Research Type 6

Research Review 6

Potential Funding Pathways 6

Research Timeline 6

Research Partners 6

Related Projects 6

Related RPSs and RNSs 6

What is Included: Lower-Priority Needs 6

Organization of the Needs 6

Research Needs Matrix 6

Research Needs: Data 6

A1: Applying and integrating active transportation data into planning and operatic

B6: Improving data on pedestrian and bicyclist fatalities and injuries .....

C2: Accuracy of new bicyclist and pedestrian counting technologies 33

C16: Improving consistency of regional, statewide and national active transportation data practices 35

C17: Improving travel surveys to collect better active travel data 37

C20: Methods to estimate pedestrian and bicycle travel from limited counts 39

C22: New pedestrian and bicyclist traffic data sources 41

C26: Refinement of pedestrian and bicyclist crash types 43

..... 45

..... 46

...s to increase active

..... 47

...d crosswalks 50

..... 53

..... 55

...f bicycles and pedestrians 57

...sign 59

...benefit from retrofits 61

...s: safety and operations 63

..... 65

..... 68

...safety 69

..... 75

...disabilities 77

...the built environment 79

...es for pedestrians with

..... 81

...s 83

...t decision points as

..... 85

...sportation use 87

...d policies 89

...r underserved populations 91

..... 93

..... 94

..... 95

..... 97

...eling 99

...tion impact studies 101

...in planning processes 103

..... 105

..... 106

...ughout planning and

..... 107

...ollaboration to improve

..... 112

..... 114

..... 116

..... 119

Research Needs Matrix

Research Need		COLLABORATORS						
		AASHTO				TRB		
Research Problem Statement (RPS) - Highest Priority High Priority Medium Priority Lower Priority		JNMTC & Design	Safety	Planning	Evnt & Sust.	TRB Bicycle (ACH20)	TRB Ped (ACH10)	OTHER COLLABORATORS
NEED	DESCRIPTION							
DATA								
A1	Applying and integrating active transportation data into planning and operations			■	■	■	■	AASHTO Data Management and Analytics
B6	Improving data on pedestrian and bicyclist fatalities and injuries		■			■	■	AASHTO Data Management and Analytics
C2	Accuracy of new bicyclist and pedestrian counting technologies					■	■	AASHTO Data Management and Analytics
C16	Improving consistency of regional, statewide and national non-motorized data practices		■	■	■	■	■	
C17	Improving travel surveys to collect better active travel data			■				
C20	Methods to estimate pedestrian and bicycle travel from limited counts					■	■	AASHTO Data Management and Analytics
C22	New pedestrian and bicyclist traffic data sources					■	■	AASHTO Data Management and Analytics
C26	Refinement of pedestrian and bicyclist crash types		■			■	■	
D11	Developing site selection criteria for continuous and short-duration pedestrian and bike count locations			■		■	■	
D31	Improving data on pedestrian and bicyclist crashes not involving motor vehicles, including on trails		■			■	■	
D42	QA/QC standards for pedestrian and bicycle count data, including in different contexts, volumes, etc.					■	■	
DESIGN								
A2	Using minimum accommodations vs. alternative approaches to increase active transportation	■		■	■	■		
A3	Determining context-driven optimal spacing between marked crosswalks	■		■			■	
B4	Designs to improve safety at shared-use path intersections	■	■			■	■	
C12	Guidance on bicycle signal timing and design	■				■		AASHTO Traffic Engineering
C15	Improved pavement markings to make road users aware of bicycles and pedestrians	■				■	■	
C23	Pedestrian crossing treatments and transit: safety and design	■	■	■			■	
C25	Quantifying the active transportation facilities that would benefit from retrofits	■		■	■	■	■	
C31	Spacing and types of separated bike lane vertical elements: safety and operations	■	■			■		
D2	Bicycle signals: face design, bicyclist and driver comprehension and compliance	■				■		AASHTO Traffic Engineering
D3	Bicycle signals: user comprehension and safety of permissive phasing	■				■		AASHTO Traffic Engineering
D8	Deployment and effectiveness of emerging urban street and intersection design guides	■		■		■	■	TRB Geometric Design (AKD10)

The Research Roadmap:

Highest Priority Needs (6)

Research Problem Statements

RPSs for the six highest-priority needs (not ranked):

A1. Applying and integrating active transportation data into planning and operations.

A2. Using minimum accommodations vs. alternative approaches to increase active transportation.

A3. Determining context-driven optimal spacing between marked crosswalks.

A4. Addressing barriers to integrating active transportation throughout planning and engineering practice.

A5. Racial and economic disparities in pedestrian and bicyclist safety.

A6. Speed management solutions and strategies to improve pedestrian and bicyclist safety on arterial roadways.

Follow the 2020 NCHRP problem statement format

The Research Roadmap:

High (9) & Medium (31) Priority Needs

Research Need Briefs

Research Topic	***B4: Designs to improve safety at shared-use path intersections***
Overview	Shared or multiuse paths invite a wide range of users, including pedestrians, bicyclists, and other wheeled users, with a range of transportation purposes such as commuting, exercise, and recreation. For rail-adjacent paths, the crossings may also include traversing railroad tracks. Absent adequate accommodations, shared-use path crossings can present users with complex tasks including gap selection, scanning for turning vehicles, and interacting with other path users. Ensuring safe crossings for all users at these locations is essential. There is a large body of research on the effectiveness of enhanced crossing features for pedestrian-only crossings. Pedestrian-activated yellow flashing beacons, usually in combination with high-visibility crossings or advance yield markings, refuge median islands, rapid rectangular flashing beacons (RRFBs), and pedestrian hybrid beacons (PHBs) have all been shown to increase driver yielding rates and pedestrian safety. Additional enhancements and design elements such as signing, markings, and geometry can also be used at these crossings. While some or all of these tools translate to shared-use path crossings, it is not clear how to integrate treatments for different types of path users, road classifications, land use contexts, and crossing geometries. Overall, there is limited guidance for treatment selection, particularly for paths next to railroads. Research is needed to identify contextually appropriate designs, and which design elements and tools practitioners should use in the shared-use path environment.
Research Objectives	Research in this area would likely include best practice scans, particularly to better document and understand how to safely implement shared-use path crossings in a wide variety of different state, land use, and roadway and path contexts. New empirical research may also be needed to confirm or validate typical designs and treatments. The research should seek to address the following: • Develop a design toolbox, including retrofit improvements, that is context sensitive and distinguishes how to assess and apply treatments at intersections of paths on all roads, including midblock crossings, and for different path user types. This toolbox would benefit from detailed case studies, including urban, suburban and rural, and guidance on appropriate performance measures for evaluating improvements (e.g., driver yielding, conflicts, crashes). • How best to design and accommodate people of all ages and abilities - ages, socioeconomic groups, mobility devices, types of bikes, visual acuity, and preferred speeds. • How to design intersections now to plan for changes in technology that can help mitigate conflicts with trail users.
Research Type	

Research Review	Bicycles at intersections: Design and safety		
Potential Funding Pathways	**TRB Cooperative Programs:** NCHRP regular process **Other:** FHWA		
Research Timeline	***2021 – 2022***	***2023 – 2026***	***2027 and later***
	Scope and initiate research Monitor and coordinate with NCHRP 03-141	Complete and implement research	Monitor application of research
Research Partners	**AASHTO Committees**: Design/JTCNMT; Safety **TRB Committees**: Pedestrians; Bicycle Transportation **US DOT**: FHWA **Other organizations**: Rails-to-Trails Conservancy		
Related Projects	***Description/Connection***		***Status***
	NCHRP 03-141: Midblock Pedestrian Signal Warrants and Operation		
	This research will focus on when signals are suitable for midblock crossings.		Start 2021
	NCHRP 17-97: Strategies to Improve Pedestrian Safety at Night		
	This research may touch on lighting for shared-use path intersections.		Anticipated 2021
	FHWA, Outreach and Awareness Program on Strategies to Enhance Pedestrian and Bicyclist Safety at Intersections		
	Research on this topic should coordinate with this project described in FHWA's *Pedestrian and Bicycle Safety Program Strategic Plan.*		Anticipated, 2021-2022
Related RNSs	Traffic Control at Shared-Use Path Road Crossings (ACH20, Bicycle Transportation) https://rns.trb.org/dproject.asp?n=38925 Intersection Sight Distance for Bicyclists (ACH20, Bicycle Transportation) https://rns.trb.org/details/dproject.aspx?n=43238 Evaluation of Pedestrian Crossing Design Practices Based on User Behavior and Psychology (ACH10, Pedestrians).		

The Research Roadmap:
High Priority Needs (9)

Nine high-priority needs (no ranking within):

- B6 Improving data on pedestrian and bicyclist fatalities and injuries
- B4 Designs to improve safety at shared-use path intersections.
- B5 Equitable representation in active transportation
- B2 Bicycle networks: measures and effects
- B3 Changes in bicycle ridership with innovative infrastructure
- B7 Incorporating active transportation into travel demand modeling
- B8 Safety and operations of separated bike lanes at intersections
- B9 Using crash records and surrogate measures to identify safety hotspots and plan bicycle/pedestrian improvements
- B1 Connected and autonomous vehicles and active transportation users

The Research Roadmap:

Lower Priority Needs (64)

Other design needs

Need	Relevant Research Reviews	Related Research Statements	Related Current Research
D2: Bicycle signals: face design, bicyclist and driver comprehension and compliance	Bicycles at intersections: Design and safety	Optimal Methods to Communicate Allowable Protected, or Permissive Movements to Bicyclists at Signalized Intersections (ACH20, Bicycle Transportation) https://rns.trb.org/dproject.asp?n=43256 Intuitively Understood Pedestrian Signal Indications (AND40, Visibility) https://rns.trb.org/details/dproject.aspx?n=38905	FHWA: Mainstreaming Best Practices for Nonmotorized Signal Timing Practice to Enhance Multimodal Safety (Anticipated, PBSP Strategic Plan)
D3: Bicycle signals: user comprehension and safety of permissive phasing	Bicycles at intersections: Design and safety	Optimal Methods to Communicate Allowable Protected, or Permissive Movements to Bicyclists at Signalized Intersections (ACH20, Bicycle Transportation) https://rns.trb.org/dproject.asp?n=43256 Intuitively Understood Pedestrian Signal Indications (AND40, Visibility) https://rns.trb.org/details/dproject.aspx?n=38905	FHWA: Mainstreaming Best Practices for Nonmotorized Signal Timing Practice to Enhance Multimodal Safety (Anticipated, PBSP Strategic Plan)
D8: Deployment and effectiveness of emerging urban street and intersection design guides	Bicycles at intersections: Design and safety Bikeways: Safety and design Bikeways: Ridership and demand Pedestrian crossings: Design and safety	Comprehensive Review and Synthesis of Emerging Urban Street and Intersection Design Guides (AFB10, Geometric Design) https://rns.trb.org/dproject.asp?n=41201	None identified
D9: Design and operations strategies to promote social/physical distancing of pedestrians during pandemics	None	None identified	None identified

Need	Relevant Research Reviews	Related Research Statements	Related Current Research
D10: Design of bicycle facilities to accommodate different bicycle types (e.g., cargo bikes, adult tricycles, etc.)	Accessibility for pedestrians and cyclists with disabilities Bikeways: Safety and design Equity and bicycling	None identified	None identified
D20: Guidance on adequate physical distancing for active transportation modes to reduce exposure to viruses	None	None identified	None identified
D36: Optimal bicycle wayfinding signs and pavement markings	Bicycles at intersections: Design and safety Bikeways: Safety and design Bikeways: Ridership and demand	None identified	MNDOT: Pavement Marking Patterns and Widths – Human Factors Study (Start 2019, End 2021)
D37: Optimal methods to communicate allowable, protected, or permissive movements to bicyclists at signalized intersections	Bicycles at intersections: Design and safety	Optimal Methods to Communicate Allowable Protected, or Permissive Movements to Bicyclists at Signalized Intersections (ACH20, Bicycle Transportation) https://rns.trb.org/dproject.asp?n=43256 Intuitively Understood Pedestrian Signal Indications (AND40, Visibility) https://rns.trb.org/details/dproject.aspx?n=38905	FHWA: Mainstreaming Best Practices for Nonmotorized Signal Timing Practice to Enhance Multimodal Safety (Anticipated, PBSP Strategic Plan)

The Research Roadmap:
Some themes

- Equity
- Research on practice and policy
- Some older, inadequate research and assumptions are barriers
- Need more crash modification factors
- Walking and bicycling should often be considered separately

Keep in mind…

- The Research Roadmap…
  - should be considered a starting point.
  - is not comprehensive.

Roadmap for my presentation

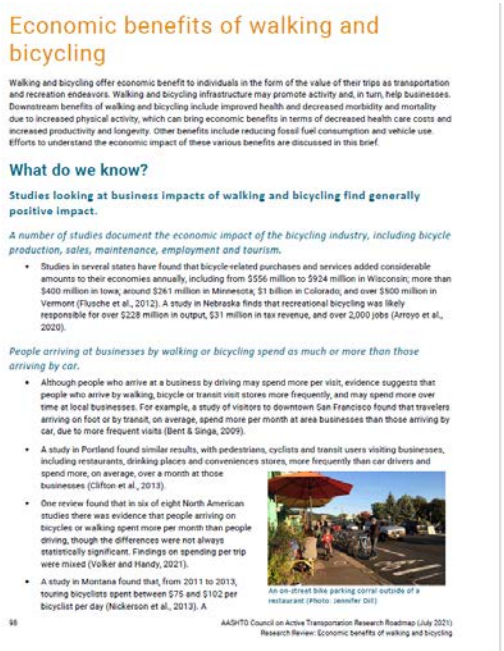
- Process for developing the Roadmap
- What's in the Roadmap?
- **How can you use the Roadmap and get involved in research?**

Use the Research Review as a reference

Is there any evidence that shared lane markings (sharrows) have a safety benefit?

- Studies of shared lane markings, or sharrows, indicate that they may influence cyclists' position on the road, but there is no evidence of a reduction in crashes or injuries (DiGioia et al., 2017). A more recent study found an increase in injury and crash rates in places with *only* sharrows as bicycle infrastructure (Ferenchak & Marshall, 2019). A review of research on the effect of sharrows on lateral passing distance found mixed results (Rubie et al., 2020).

What about economic impacts of active transportation infrastructure?



Economic benefits of walking and bicycling

Walking and bicycling offer economic benefit to individuals in the form of the value of their trips as transportation and recreation endeavors. Walking and bicycling infrastructure may promote activity and, in turn, help businesses. Downstream benefits of walking and bicycling include improved health and decreased morbidity and mortality due to increased physical activity, which can bring economic benefits in terms of decreased health care costs and increased productivity and longevity. Other benefits include reducing fossil fuel consumption and vehicle use. Efforts to understand the economic impact of these various benefits are discussed in this brief.

What do we know?

Studies looking at business impacts of walking and bicycling find generally positive impact.

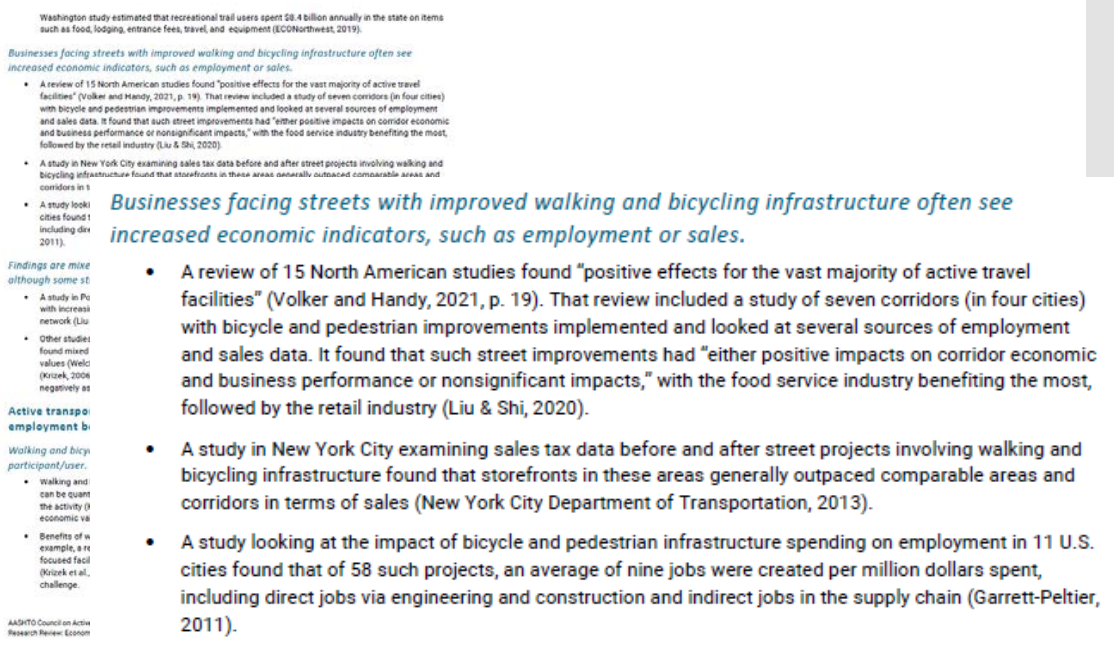
A number of studies document the economic impact of the bicycling industry, including bicycle production, sales, maintenance, employment and tourism.

- Studies in several states have found that bicycle-related purchases and services added considerable amounts to their economies annually, including from $556 million to $924 million in Wisconsin; more than $400 million in Iowa; around $261 million in Minnesota; $1 billion in Colorado; and over $500 million in Vermont (Flusche et al., 2012). A study in Nebraska finds that recreational bicycling was likely responsible for over $228 million in output, $31 million in tax revenue, and over 2,000 jobs (Arroyo et al., 2020).

People arriving at businesses by walking or bicycling spend as much or more than those arriving by car.

- Although people who arrive at a business by driving may spend more per visit, evidence suggests that people who arrive by walking, bicycle or transit visit stores more frequently, and may spend more over time at local businesses. For example, a study of visitors to downtown San Francisco found that travelers arriving on foot or by transit, on average, spend more per month at area businesses than those arriving by car, due to more frequent visits (Bent & Singa, 2009).
- A study in Portland found similar results, with pedestrians, cyclists and transit users visiting businesses, including restaurants, drinking places and convenience stores, more frequently than car drivers and spend more, on average, over a month at those businesses (Clifton et al., 2013).
- One review found that in six of eight North American studies there was evidence that people arriving on bicycles or walking spent more per month than people driving, though the differences were not always statistically significant. Findings on spending per trip were mixed (Volker and Handy, 2021).
- A study in Montana found that, from 2011 to 2013, touring bicyclists spent between $75 and $102 per bicyclist per day (Nickerson et al., 2013). A

An on-street bike parking corral outside of a restaurant (Photo: Jennifer Dill)



Washington study estimated that recreational trail users spent $8.4 billion annually in the state on items such as food, lodging, entrance fees, travel, and equipment (ECONorthwest, 2019).

Businesses facing streets with improved walking and bicycling infrastructure often see increased economic indicators, such as employment or sales.

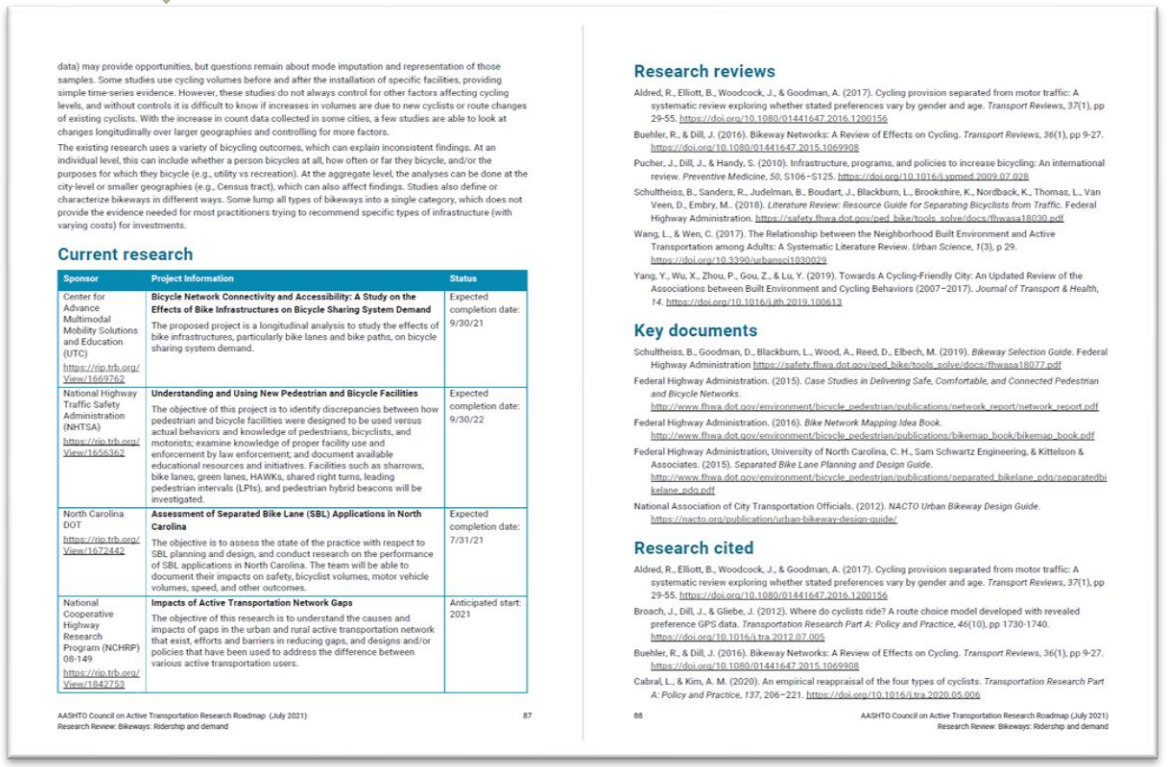
- A review of 15 North American studies found "positive effects for the vast majority of active travel facilities" (Volker and Handy, 2021, p. 19). That review included a study of seven corridors (in four cities) with bicycle and pedestrian improvements implemented and looked at several sources of employment and sales data. It found that such street improvements had "either positive impacts on corridor economic and business performance or nonsignificant impacts," with the food service industry benefiting the most, followed by the retail industry (Liu & Shi, 2020).
- A study in New York City examining sales tax data before and after street projects involving walking and bicycling infrastructure found that storefronts in these areas generally outpaced comparable areas and corridors in terms of sales (New York City Department of Transportation, 2013).
- A study looking at the impact of bicycle and pedestrian infrastructure spending on employment in 11 U.S. cities found that of 58 such projects, an average of nine jobs were created per million dollars spent, including direct jobs via engineering and construction and indirect jobs in the supply chain (Garrett-Peltier, 2011).

Businesses facing streets with improved walking and bicycling infrastructure often see increased economic indicators, such as employment or sales.

- A review of 15 North American studies found "positive effects for the vast majority of active travel facilities" (Volker and Handy, 2021, p. 19). That review included a study of seven corridors (in four cities) with bicycle and pedestrian improvements implemented and looked at several sources of employment and sales data. It found that such street improvements had "either positive impacts on corridor economic and business performance or nonsignificant impacts," with the food service industry benefiting the most, followed by the retail industry (Liu & Shi, 2020).
- A study in New York City examining sales tax data before and after street projects involving walking and bicycling infrastructure found that storefronts in these areas generally outpaced comparable areas and corridors in terms of sales (New York City Department of Transportation, 2013).
- A study looking at the impact of bicycle and pedestrian infrastructure spending on employment in 11 U.S. cities found that of 58 such projects, an average of nine jobs were created per million dollars spent, including direct jobs via engineering and construction and indirect jobs in the supply chain (Garrett-Peltier, 2011).

Okay, but what about new research?

- Check the status of on-going research listed in the Review



data) may provide opportunities, but questions remain about mode imputation and representation of those samples. Some studies use cycling volumes before and after the installation of specific facilities, providing simple time-series evidence. However, these studies do not always control for other factors affecting cycling levels, and without controls it is difficult to know if increases in volumes are due to new cyclists or route changes of existing cyclists. With the increase in count data collected in some cities, a few studies are able to look at changes longitudinally over larger geographies and controlling for more factors.

The existing research uses a variety of bicycling outcomes, which can explain inconsistent findings. At an individual level, this can include whether a person bicycles at all, how often or far they bicycle, and/or the purposes for which they bicycle (e.g., utility vs recreation). At the aggregate level, the analyses can be done at the city-level or smaller geographies (e.g., Census tract), which can also affect findings. Studies also define or characterize bikeways in different ways. Some lump all types of bikeways into a single category, which does not provide the evidence needed for most practitioners trying to recommend specific types of infrastructure (with varying costs) for investments.

Current research

Sponsor	Project Information	Status
Center for Advance Multimodal Mobility Solutions and Education (UTC) https://rip.trb.org/View/1669762	**Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand** The proposed project is a longitudinal analysis to study the effects of bike infrastructures, particularly bike lanes and bike paths, on bicycle sharing system demand.	Expected completion date: 9/30/21
National Highway Traffic Safety Administration (NHTSA) https://rip.trb.org/View/1656362	**Understanding and Using New Pedestrian and Bicycle Facilities** The objective of this project is to identify discrepancies between how pedestrian and bicycle facilities were designed to be used versus actual behaviors and knowledge of pedestrians, bicyclists, and motorists; examine knowledge of proper facility use and enforcement by law enforcement; and document available educational resources and initiatives. Facilities such as sharrows, bike lanes, green lanes, HAWKs, shared right turns, leading pedestrian intervals (LPIs), and pedestrian hybrid beacons will be investigated.	Expected completion date: 9/30/22
North Carolina DOT https://rip.trb.org/View/1672442	**Assessment of Separated Bike Lane (SBL) Applications in North Carolina** The objective is to assess the state of the practice with respect to SBL planning and design, and conduct research on the performance of SBL applications in North Carolina. The team will be able to document their impacts on safety, bicyclist volumes, motor vehicle volumes, speed, and other outcomes.	Expected completion date: 7/31/21
National Cooperative Highway Research Program (NCHRP) 08-149 https://rip.trb.org/View/1842753	**Impacts of Active Transportation Network Gaps** The objective of this research is to understand the causes and impacts of gaps in the urban and rural active transportation network that exist, efforts and barriers in reducing gaps, and designs and/or policies that have been used to address the difference between various active transportation users.	Anticipated start: 2021

Research reviews

Aldred, R., Elliott, B., Woodcock, J., & Goodman, A. (2017). Cycling provision separated from motor traffic: A systematic review exploring whether stated preferences vary by gender and age. *Transport Reviews*, 37(1), pp 29-55. https://doi.org/10.1080/01441647.2016.1200156

Buehler, R., & Dill, J. (2016). Bikeway Networks: A Review of Effects on Cycling. *Transport Reviews*, 36(1), pp 9-27. https://doi.org/10.1080/01441647.2015.1069908

Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine*, 50, S106–S125. https://doi.org/10.1016/j.ypmed.2009.07.028

Schultheiss, B., Sanders, R., Judelman, B., Boudart, J., Blackburn, L., Brookshire, K., Nordback, K., Thomas, L., Van Veen, D., Embry, M.. (2018). *Literature Review: Resource Guide for Separating Bicyclists from Traffic*. Federal Highway Administration. https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18030.pdf

Wang, L., & Wen, C. (2017). The Relationship between the Neighborhood Built Environment and Active Transportation among Adults: A Systematic Literature Review. *Urban Science*, 1(3), p 29. https://doi.org/10.3390/urbansci1030029

Yang, Y., Wu, X., Zhou, P., Gou, Z., & Lu, Y. (2019). Towards A Cycling-Friendly City: An Updated Review of the Associations between Built Environment and Cycling Behaviors (2007–2017). *Journal of Transport & Health*, *14*. https://doi.org/10.1016/j.jth.2019.100613

Key documents

Schultheiss, B., Goodman, D., Blackburn, L., Wood, A., Reed, D., Elbech, M. (2019). *Bikeway Selection Guide*. Federal Highway Administration https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf

Federal Highway Administration. (2015). *Case Studies in Delivering Safe, Comfortable, and Connected Pedestrian and Bicycle Networks*. http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/network_report/network_report.pdf

Federal Highway Administration. (2016). *Bike Network Mapping Idea Book*. http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/bikemap_book/bikemap_book.pdf

Federal Highway Administration, University of North Carolina, C. H., Sam Schwartz Engineering, & Kittelson & Associates. (2015). *Separated Bike Lane Planning and Design Guide*. http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

National Association of City Transportation Officials. (2012). *NACTO Urban Bikeway Design Guide*. https://nacto.org/publication/urban-bikeway-design-guide/

Research cited

Aldred, R., Elliott, B., Woodcock, J., & Goodman, A. (2017). Cycling provision separated from motor traffic: A systematic review exploring whether stated preferences vary by gender and age. *Transport Reviews*, 37(1), pp 29-55. https://doi.org/10.1080/01441647.2016.1200156

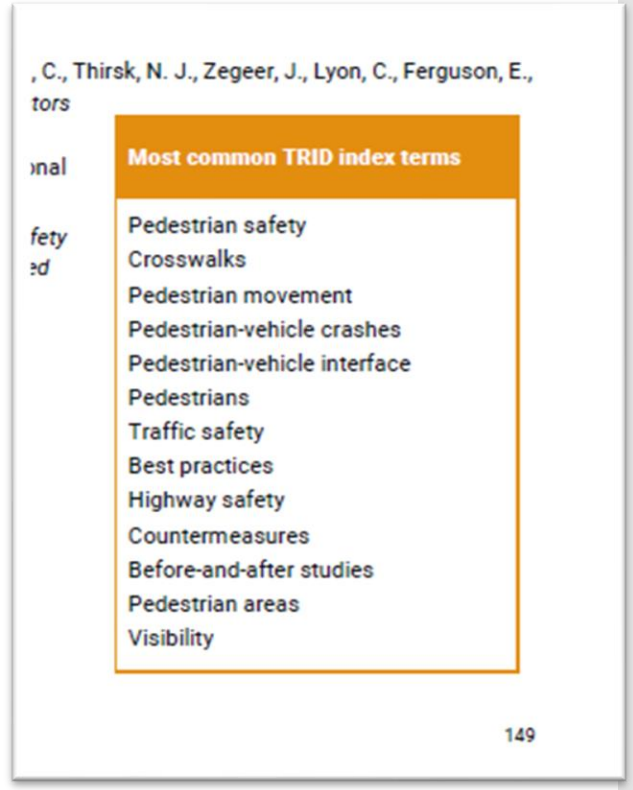
Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. *Transportation Research Part A: Policy and Practice*, 46(10), pp 1730-1740. https://doi.org/10.1016/j.tra.2012.07.005

Buehler, R., & Dill, J. (2016). Bikeway Networks: A Review of Effects on Cycling. *Transport Reviews*, 36(1), pp 9-27. https://doi.org/10.1080/01441647.2015.1069908

Cabral, L., & Kim, A. M. (2020). An empirical reappraisal of the four types of cyclists. *Transportation Research Part A: Policy and Practice*, *137*, 206–221. https://doi.org/10.1016/j.tra.2020.05.006

Okay, but what about new research?

- Use TRID to search! https://trid.trb.org/
- The Research Review includes the most common Index Terms for each research topic



New to using TRID?

The *Continuity & Implementation Plan* provides advice on searching TRID to keep up on new research & projects.

There is also a spreadsheet with some pre-populated searches for new Research in Progress

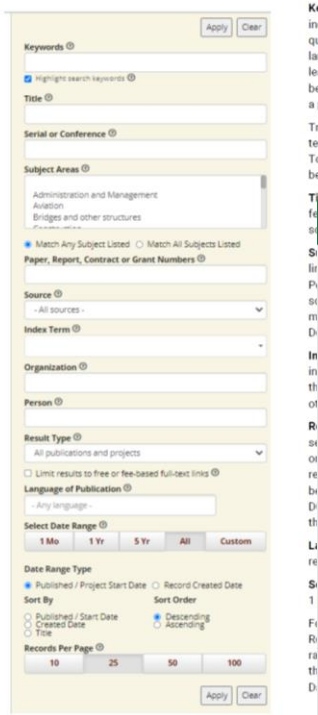


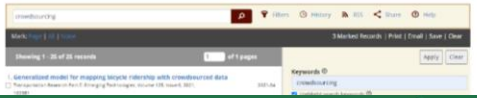
Figure 5: TRID Filters (Source: TRB and The National Academies)

AASHTO Council on Active Transportation Research Roadmap (July 2021)
Continuity and Implementation Plan

Keywords: This field searches many TRID data fields, including the abstract. It is useful to put phrases in quotes, such as "bicycle lane" rather than bicycle lane. The former yields about 300 results, while leaving the quotation marks out yields over 3,000 because it includes items with both words, but not as a phrase.

Try using one or more of the most common index terms listed in the Most Common Index Terms by Topic section that follows. Using the boolean "AND" between terms can narrow the search.

After entering search terms and selecting filters and clicking "Apply", the results will display. At this point, the user can add additional filters. For example, Figure 6 shows the results of a search using "crowdsourcing" as a key word and within the Pedestrians and Bicyclists subject area. This term was the most common TRT index term used in the review of emerging user-based data. This search was also limited to records created in the past year. There are 25 results. At this point, the user can apply additional filters (e.g. limiting it to projects or publications) or start using the records.



AutoSave Off — AASHTO CAT Research Roadmap Tracking Spreadsheet - Excel — Search

File Home Insert Draw Page Layout Formulas Data Review View Help

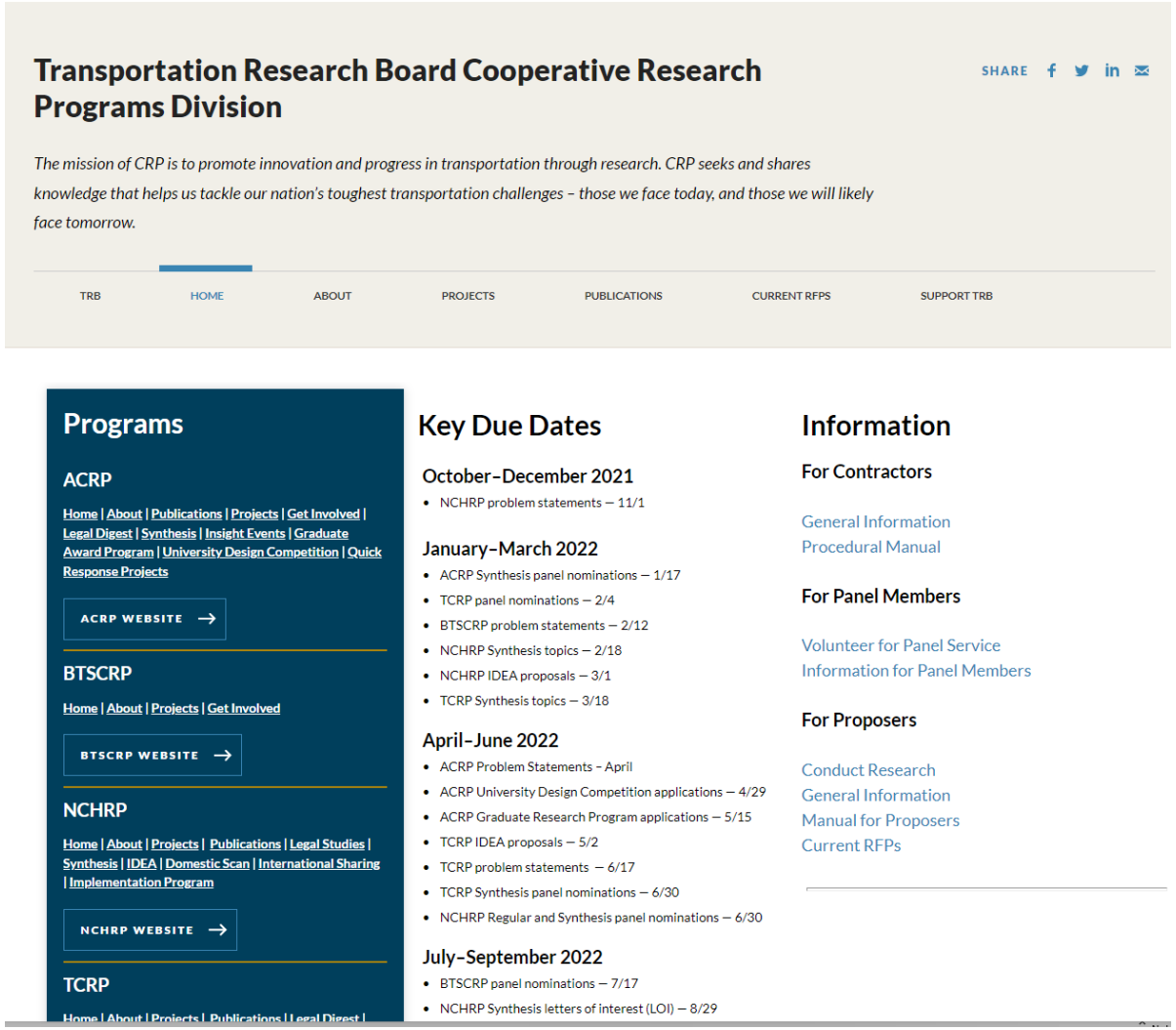
A18 https://rns.trb.org/

	A	B	C	D
1	**TRID Searches to find new Research in Progress**			
2				
3	**Research Projects entered into TRID from March 2021 to December 2021**	**Notes**		
4	https://trid.trb.org/Results?txtKeywords=&txtTitle=&txtSerial=&ddlSubject=1776&txtReportNum=&ddlTrisfile=RiP&txtIndex=&specificTerms=&txtAgency=&sourceagency=&txtAuthor=&ddlResultType=PR&chkFulltextOnly=0&recordLanguage=&subjectLogic=or&dateStart=202103&dateEnd=202212&rangeType=recordcreateddate&sortBy=created&sortOrder=DESC&rpp=25	The "from" date for this search can be changed to a later date after clicking on the link and getting the results.		
5				
6	**Same search as above, but just for State DOT projects**			
7	https://trid.trb.org/Results?txtKeywords=&txtTitle=&txtSerial=&ddlSubject=1776&txtReportNum=&ddlTrisfile=STATEDOT&txtIndex=&specificTerms=&txtAgency=&sourceagency=&txtAuthor=&ddlResultType=PR&chkFulltextOnly=0&recordLanguage=&subjectLogic=or&dateStart=202103&dateEnd=202212&rangeType=recordcreateddate&sortBy=created&sortOrder=DESC&rpp=25			
8				
9	**Same search as above, but just for TRB projects, including NCHRP**			
10	https://trid.trb.org/Results?txtKeywords=&txtTitle=&txtSerial=&ddlSubject=1776&txtReportNum=&ddlTrisfile=TRB&txtIndex=&specificTerms=&txtAgency=&sourceagency=&txtAuthor=&ddlResultType=PR&chkFulltextOnly=0&recordLanguage=&subjectLogic=or&dateStart=202103&dateEnd=202212&rangeType=recordcreateddate&sortBy=created&sortOrder=DESC&rpp=25			
11				
12	**Same search as above, but just for University Transportation Center projects**			
	https://trid.trb.org/Results?txtKeywords=&txtTitle=&txtSerial=&ddlSubject=1776&txt			

Roadmap Needs | Current Research Projects | Other Research Statements | TRID Searching

How can I influence the research?

National Highway Cooperative Research Program
Transit Cooperative Research Program
Behavioral Traffic Safety Cooperative Research Program



https://www.nationalacademies.org/trb/programs/cooperative-research-programs

Or go to trb.org and click on Programs.

How can I influence the research?

- TRB Committees (ACH10: Pedestrians and ACH20: Bicycle)
- State DOTs
  - Each has a research office and different processes for soliciting and selecting research projects.
  - Many state DOTs participate in "pooled fund" projects
- University Transportation Centers
  - All UTCs require non-federal matching funds
  - Will be new competition for UTCs this year under the IIJA/BI
- Provide input to US DOT on their *Transportation Research and Development Strategic Plan*

The Research Roadmap:

Highest Priority Needs (6)

Research Problem Statements

RPSs for the six highest-priority needs (not ranked):

A1. Applying and integrating active transportation data into planning and operations.

A2. Using minimum accommodations vs. alternative approaches to increase active transportation.

A3. Determining context-driven optimal spacing between marked crosswalks.

A4. Addressing barriers to integrating active transportation throughout planning and engineering practice.

A5. Racial and economic disparities in pedestrian and bicyclist safety.

A6. Speed management solutions and strategies to improve pedestrian and bicyclist safety on arterial roadways.

Follow the 2020 NCHRP problem statement format

Questions & Contact info

Jennifer Dill, Ph.D.
Professor, Urban Studies & Planning
Director, Transportation Research & Education Center (TREC)
Portland State University
trec.pdx.edu
jdill@pdx.edu
@JenniferDillPSU

Shannon Eggleston
AASHTO
https://active.transportation.org/
seggleston@aashto.org