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Bicycle-Specific Traffic Signals: Results from State-of-the-Practice Review

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Introduction

Increased choices in bicycle-specific facilities and the connectivity of the bicycle network are important in encouraging cycling which has many personal and environmental benefits. Difficult connections or crossing opportunities create discontinuities in the bicycle network and decrease perceived cyclist safety and comfort. Perceived safety has been cited as a significant factor in people's decision to cycle and, therefore, difficult connections obstruct direct routes and/or decrease their attractiveness to less-confident riders by increasing the overall stress level of an route. Some barriers could be alleviated by selected application of bicycle-specific signals.

Motivations

- Currently, there is no existing state-of-the-practice related to bicycle-specific traffic signals in the United States.

Objectives

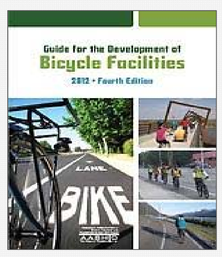
- To present the existing state of the practice that relates to bicycle-specific traffic signals. This includes:
  - A review of relevant guidance documents to discern the availability of guidance applicable to bicycle-specific signals including definitions in vehicle code
  - The results of a survey of jurisdictions with known installations of bicycle-specific signals.

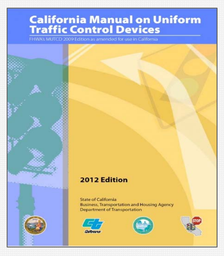
Review of Guidance Documents

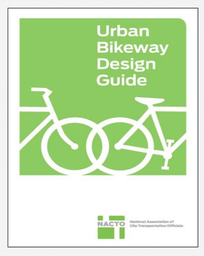
Methodology

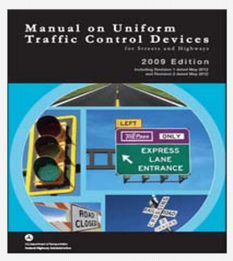
Documents were reviewed with respect to engineering guidance in the following areas:

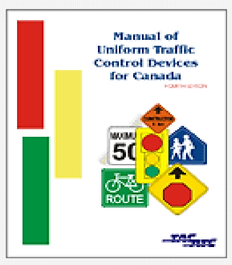
- Physical elements
  - Aesthetic properties of the signal head
  - Placement and mounting
- Operational Elements
  - Detection, Phasing, Restricted movements, Signage
  - Timing











Reviewed Documents

- Guide for the Development of Bicycle Facilities (AASHTO, 2012)
- California Manual on Uniform Traffic Control Devices (MUTCD) (Caltrans, 2012)
- Urban Bikeway Design Guide (NACTO, 2011)
- Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2009)
- Traffic Signal Guidelines for Bicycles (Transportation Association of Canada (TAC), 2004)
- Manual of Uniform Traffic Control Devices for Canada, 2008 update (TAC, 2008)
- Design Manual for Bicycle Traffic (CROW, 2007)

Review of the Literature

The reviewed of the literature was conducted prior to this state of the practice review. Due to space limitations, it was not included in the paper. The existing literature relates mostly to cyclist performance characteristics (acceleration, cruising speed, startup-lost time). The literature showed inconsistencies in the reporting of these characteristics and exploration of variables that affect them. It should be noted that there is very little in terms of published literature that relates to bicycle-specific traffic signals. For a full review of relevant literature, please refer to the related ODOT report:

http://goo.gl/2YoYF OR

Variation in Study Scope

	Influencing factors compared or discussed						
Study	**Grade**	**Trip purpose**	**Visibility**	**Season**	**Cyclist age & ability**	**Gender**	**Facility type**
Opiela et al. (1980)							x
Pein (1997)		x					x
Rubins & Handy (2005)					x		
Shladover et al. (2011)	x	x	x		x		
Wachtel et al. (1995)							
Wheeler et al. (2010)	x			x		x	

Available Guidance for Characteristics of a Bicycle-Specific Traffic Signal

	Operational Characteristics				Timing	
Document	**Detection Type**	**Phasing Type**	**Restricted Movements**	**Accompanying Signage**	**Minimum Interval Times**	**Performance Characteristics**
Guide for the Development of Bicycle Facilities (AASHTO, 2012)	☑				☑	☑
California Manual on Uniform Traffic Control Devices (MUTCD) (Caltrans, 2012)	☑				☑	☑
Urban Bikeway Design Guide (NACTO, 2011)	☑		☑	●	☑	☑
Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2009)	☑				X	
Traffic Signal Guidelines for Bicycles (Transportation Association of Canada (TAC), 2004)	☑	☑			●	☑
Manual of Uniform Traffic Control Devices for Canada, 2008 update (TAC, 2008)	☑					
Design Manual for Bicycle Traffic (CROW, 2007)					●	☑

	Physical characteristics					
Document	**Backplate Color**	**Housing Color**	**Lens Size**	**Bicycle Insignia**	**Placement & Mounting**	**Utilization of Louvers**
Guide for the Development of Bicycle Facilities (AASHTO, 2012)						
California Manual on Uniform Traffic Control Devices (MUTCD) (Caltrans, 2012)			☑	☑		X
Urban Bikeway Design Guide (NACTO, 2011)	●	●		X	●	
Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2009)			☑	☑	●	X
Traffic Signal Guidelines for Bicycles (Transportation Association of Canada (TAC), 2004)	●	●		☑	☑	
Manual of Uniform Traffic Control Devices for Canada, 2008 update (TAC, 2008)			☑		☑	
Design Manual for Bicycle Traffic (CROW, 2007)						

☑ contains detailed guidance for some aspect of the characteristic

● *suggests values or numbers for characteristic but has no detailed guidance*

X discusses in general or has pictorial representation of characteristic but gives no detailed guidance

[Blank] *no mention of this characteristic*

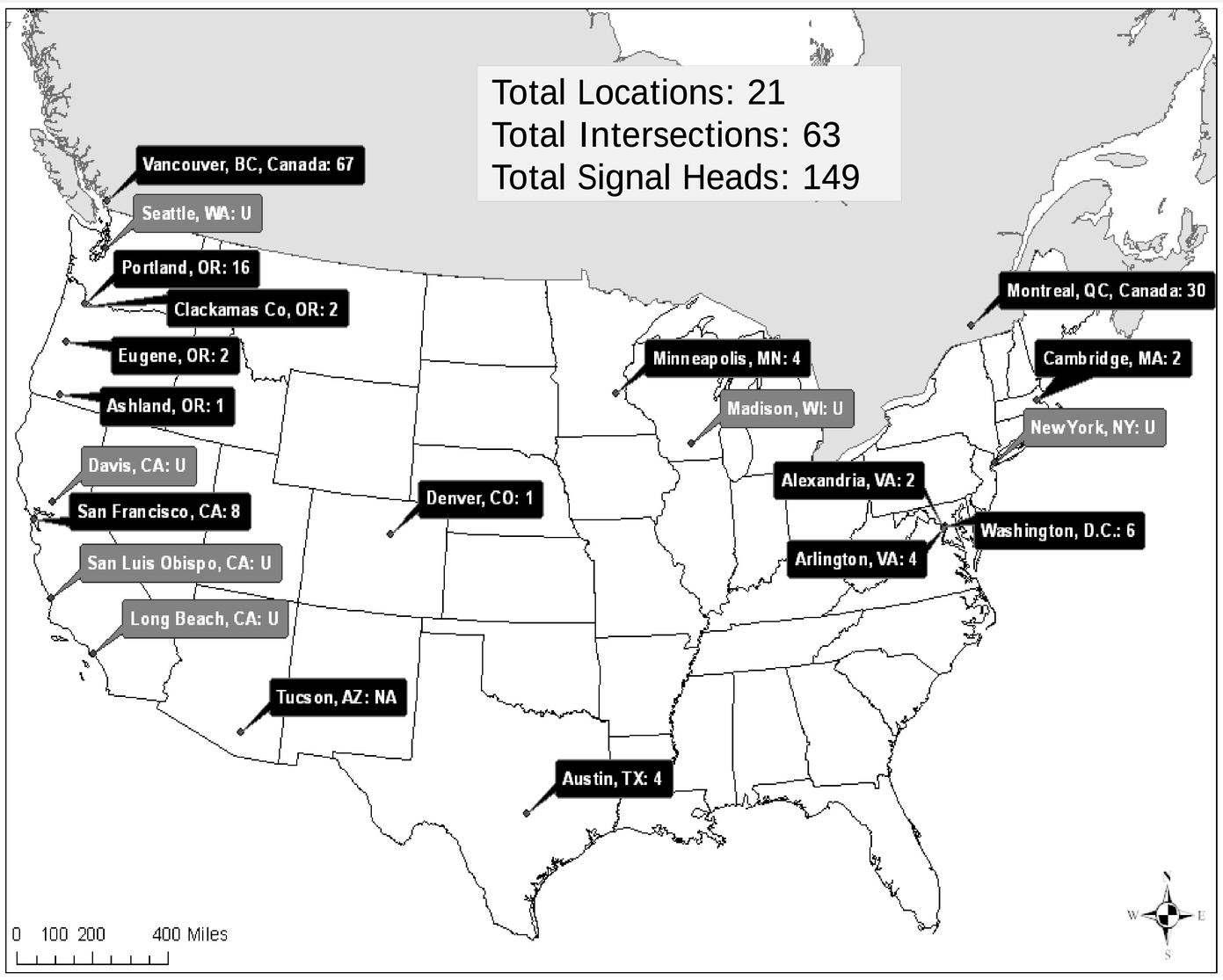
The available documents have fairly consistent, guidance with regard to timing, placement, and detection but have few specifications applicable to the other properties of bicycle-specific signals. This includes the accompanying signage, utilization of louvers, and coloration of signal heads and backplates that may potentially affect the visibility of these signals for all modes.

Methodology for Jurisdictional Survey

- Survey created with online software and distributed via e-mail
- The survey requested:
  - Motivations for signal installation
  - Detailed information on the engineering aspects of signal design
  - Design plans and documents
  - Pictures of installed signals
  - Anecdotal accounts of the signal's success or failure
- Information for installations in Portland, OR was gathered via local contacts and site visits.

- Black denotes locations with responses to the survey, gray denotes a non-response
- Numbers after **:** denote the number of signal heads per location

Survey Distribution and Response



Elements of the Signal Head

Characteristic		Number of Signal Heads			Percent of Signal Heads		
		US	CN	Total	US	CN	Total
Backplate Color	Black	18	0	18	35%	-	12%
	Yellow	10	0	10	19%	-	7%
	No backplate	24	97	121	46%	100%	81%
	Unknown	0	0	0	-	-	-
Housing Color	Black	32	37	69	62%	38%	46%
	Yellow	12	60	72	23%	62%	48%
	Other	8	0	8	15%	-	5%
	Unknown	0	0	0	-	-	-
Lens Size	12"	35	7	42	67%	7%	28%
	10"	0	0	0	-	-	-
	8"	9	90	99	17%	93%	66%
	Other	2	0	2	4%	-	1%
	Unknown	6	0	6	12%	-	4%
Bicycle Insignia	Faces Left	19	79	98	37%	81%	66%
	Faces Right	20	0	20	38%	-	13%
	No Insignia	12	18	30	23%	19%	20%
	Unknown	1	0	1	2%	-	1%
Utilization of Louvers	Yes	38	17	55	73%	18%	37%
	No	13	80	93	25%	82%	62%
	Unknown	1	0	1	2%	-	1%

US = United States, CN = Canada
Note: All percentages are rounded to the nearest integer.
Note: Percentages based on total number of surveyed signal heads, 149.

Motivations for Installation

Motivations	Number of Intersections			Percent of Sample		
	US	CN	Total	US	CN	Total
Non-compliance	3	0	3	8%	-	3%
Contra-flow	6	36	42	17%	69%	48%
Unique path	13	3	16	36%	6%	18%
Safety	9	12	21	25%	23%	24%
Other	4	1	5	11%	2%	6%

Placement & Mounting

Characteristic		Number of Intersections			Percent		
		US	CN	Total	US	CN	Total
Intersection Placement*	Near side-only	0	0	0	-	-	-
	Far side-only	22	13	35	81%	36%	56%
	Both	5	23	28	19%	64%	44%
	Unknown	0	0	0	-	5%	-
Mounting Height	< 10 ft	13	0	13	25%	-	9%
	10-14.9 ft	19	93	112	37%	96%	75%
	15+ ft	8	4	12	15%	4%	8%
	Unknown	12	0	12	23%	-	8%

* Percentages based on total number of surveyed intersections, 63.

Operational Elements

Design Element		Number of Intersections			Percent of Intersections		
		US	CN	Total	US	CN	Total
Detection Type	Loop	7	0	7	26%	-	11%
	Video	2	0	2	7%	-	3%
	Loop & Push-Button	4	0	4	15%	-	6%
	Push-button Only	2	0	2	7%	-	3%
	No Detection/ Recall	12	36	48	44%	100 %	76%
	Unknown	0	0	0	-	-	-
Phasing Type	Exclusive	16	13	29	59%	36%	46%
	Concurrent	7	23	30	26%	64%	48%
	Leading interval	1	0	1	4%	-	2%
	Unknown	3	0	3	11%	-	5%
Restricted Movements	Yes	19	20	39	70%	56%	62%
	No	6	16	22	22%	44%	35%
	Unknown	2	0	2	7%	-	3%
Accompanying Signage	Yes	20	9	29	74%	25%	46%
	No	6	27	33	22%	75%	52%
	Unknown	1	0	1	4%	-	2%

Conclusions

This review highlighted both the available guidance and the designs for bicycle signals currently being implemented. While there are minor differences, there is generally consistent guidance. To some extent, the guidance documents reflect the lessons learned by the surveyed jurisdictions since installation of the bicycle-specific signals is limited to those places willing to experiment. The survey of practice found a variety in some design elements (e.g. lens size, use of louvers) and consensus on others (e.g. use of lens insignia). Given the accelerated deployments of bicycle-specific signals and current guidance, it is likely that there will be less variety in future designs. Adoption of minimum guidance in the U.S. MUTCD would also likely improve consistency and practice.

Sample Design Differences

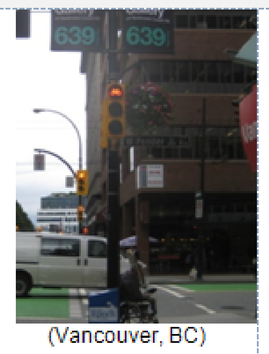
(a) Mounting


(Austin, TX)
Separate pole


(Minneapolis, MN)
Same as vehicle

(b) Placement

(Portland, OR)
Euro-style Near and Far



(Vancouver, BC)
Near and Far


(Long Beach, CA)
Far only


(Portland, OR)
Far only – Diagonal

(c) Insignia

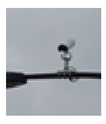

Faces right (Washington, DC)


Faces left (Denver, CO)


Abstract (San Francisco, CA)

(d) Detection

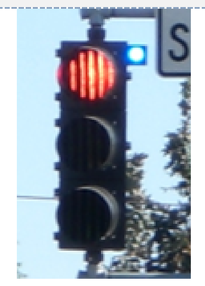
Push button (Portland, OR)


Video (Portland, OR)

(Washington, DC)

(Clackamas Co, OR)

Loop


(Portland, OR)

Detection Light

(Long Beach, CA)

On backplate

(e) Signage

(Vancouver, BC)

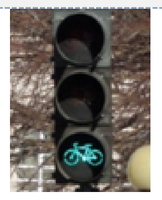
(Minneapolis, MN)

(Eugene, OR)

(Portland, OR)

Black on white

(f) Backplate & Housing


(Denver, CO)


(Vancouver, BC)
No backplate


(Minneapolis, MN)

(Long Beach, CA)
Matching housing and backplate


(Portland, OR)


(Clackamas Co., OR)
Mismatching Housing and backplate

Research Needs / Potential Future Research

- Descriptive data on cyclist performance characteristics like speed, acceleration, start-up lost time, and saturation flow rate that affect intersection clearance time are need for effective timing of intervals to accommodate cyclists
- Quantitative research on the safety effectiveness of bicycle-specific signals
- Empirical information on operational compliance of cyclists with bicycle-specific signals and motorist confusion.