How'd We Get Here? Understanding the MUTCD and Green Book Histories

History of Design Manuals

John M. Mason, PhD PE
Immediate Past Chancellor & Dean
Penn State Harrisburg/ The Capital College

Hermanus Steyn, Pr.Eng., PE
Senior Principal Engineer
Kittelson & Associates, Inc.

December 7, 2023

Outline

- **…. a brief history geometric design (and operations) of highways**
- **Near term trends**
  - **what has laid the groundwork**
  - **what various state agencies are doing**
- **Future transportation / geometric design**
- **Q&A**

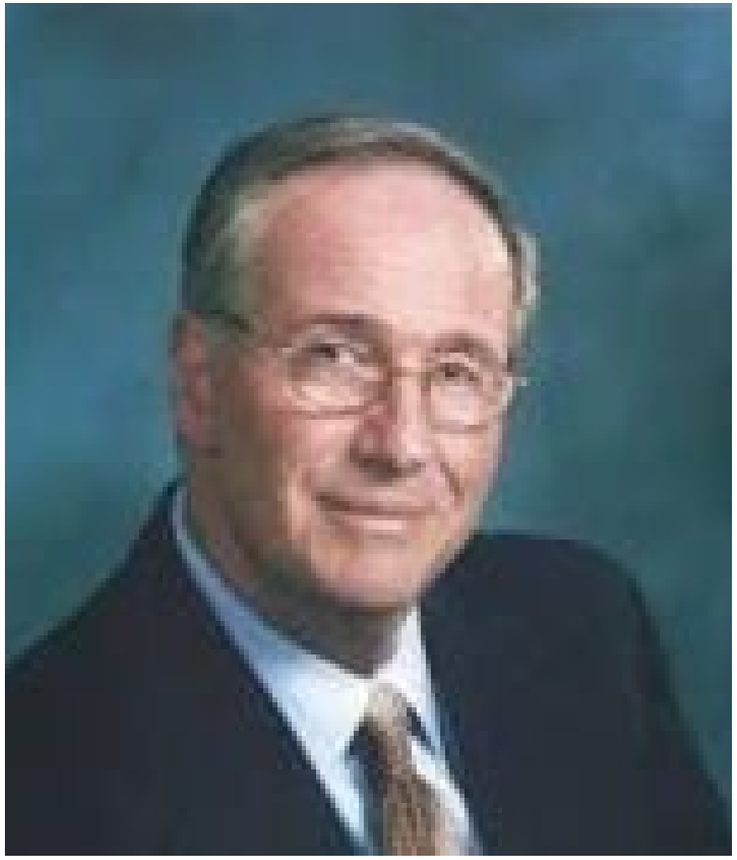
…. a brief history of geometric design (and operations) of highways

- **John M. Mason, PhD PE**
- **Immediate Past Chancellor & Dean**
- **Penn State Harrisburg/ The Capital College**

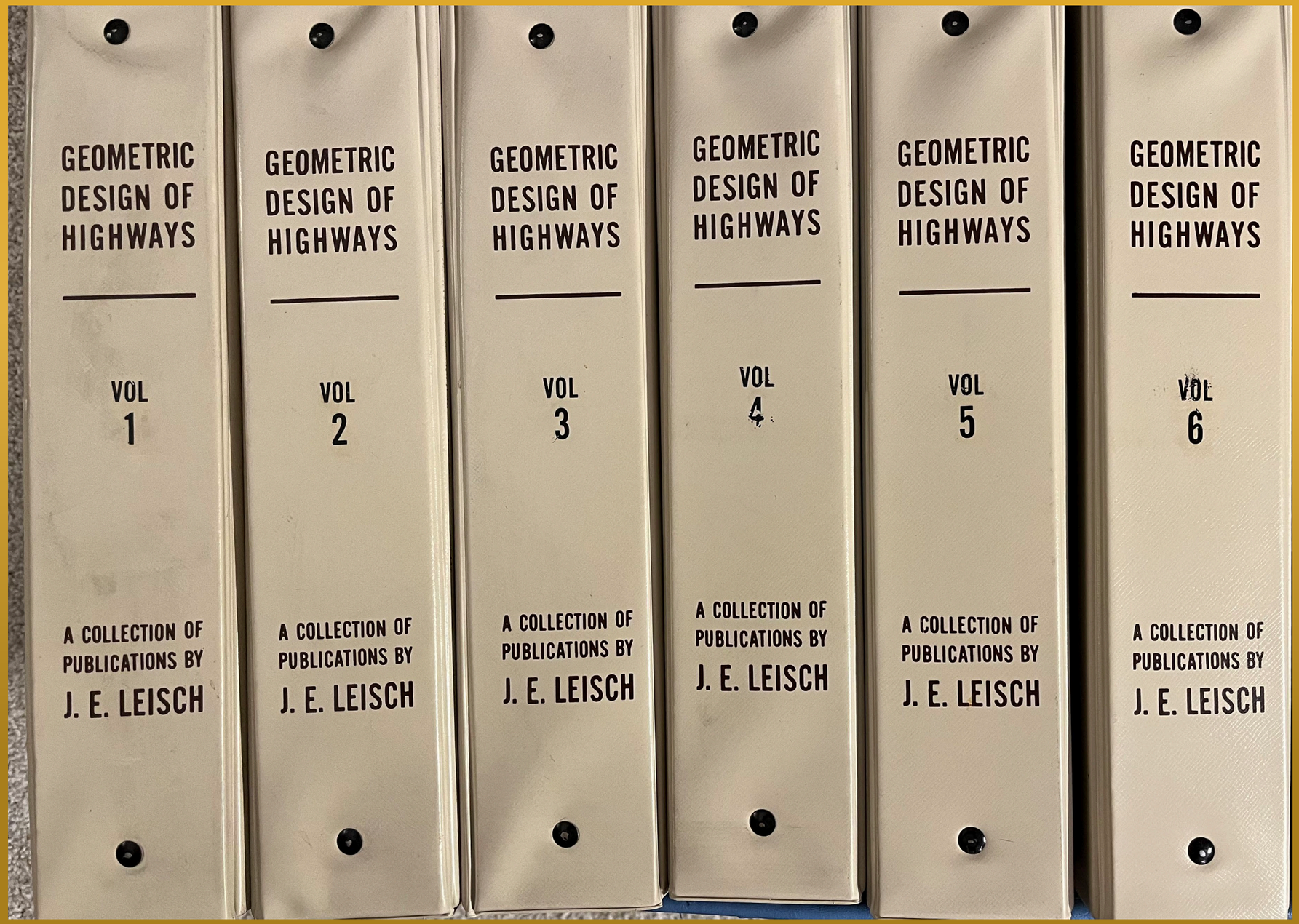
Jack E. Leisch

- **1913-1991**
- **50+yrs in government, education and private sector**
- **Bureau of Public Roads-Chief of Design Division**
- **DeLew, Cather-consultants**
- **JEL/CH2M HILL**
- **Highway planning, design, operations & safety**
- **TRB, ASCE & ITE**

Joel P. Leisch



- **1941-2022**
- **50+ yrs. in private sector consulting (JEL & Associates)**
- **Highway planning, design, operations & safety, freeways and interchanges**
- **Focus on geometric design and capacity analysis**
- **TRB, ASCE and ITE**


GEOMETRIC DESIGN OF HIGHWAYS
VOL 1
A COLLECTION OF PUBLICATIONS BY J. E. LEISCH
GEOMETRIC DESIGN OF HIGHWAYS
VOL 2
A COLLECTION OF PUBLICATIONS BY J. E. LEISCH
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GEOMETRIC DESIGN OF HIGHWAYS
VOL 6
A COLLECTION OF PUBLICATIONS BY J. E. LEISCH

AASHO Policy

Arterial Highways in Urban Areas

Chapter H – Early Predrafts - 1948

Hand-written Manuscript

Typical cross sections of major streets are shown in figures E-1 and -2, for which right-of-way widths are as follows:

Ref. table E-2

Section	Type of urban area	Through traffic lanes		Width of median in feet		Width of border in feet		Right-of-way width in feet	
		No.	Width in feet*						
			A	B	A	B	A	B	A	B
Fig. E-1a Shoulders--no curbs	Residential	2	11	12	0	0	12	20	66	84
	Residential	4	11	12	0	14	8	12	80	106
Fig. E-1b Curbed--no parking	Com. Business	4	11	12	0	4	8	12	62	80
	Residential	4	11	12	0	4	12	16	70	88
	Business	6	11	12	0	4	8	12	84	104
	Residential	6	11	12	0	4	12	16	92	112

Highway Capacity Manual

Practical Applications of Research

BY THE COMMITTEE ON HIGHWAY CAPACITY
DEPARTMENT OF TRAFFIC AND OPERATIONS
HIGHWAY RESEARCH BOARD

JEL PARTICIPATION IN OVERALL PREPARATION
AUTHORED AS PRINTED P.P. 87-104.

U. S. Department of Commerce
Bureau of Public Roads

United States Government Printing Office, Washington : 1950

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 65 cents

A Policy
on
Grade Separations
for
Intersecting Highways

J. MASON

A POLICY ON CRITERIA FOR
MARKING AND SIGNING
NO-PASSING ZONES ON TWO
AND THREE LANE ROADS

J. MASON

A POLICY
on
HIGHWAY CLASSIFICATION

J. MASON

A POLICY
on
INTERSECTIONS at GRADE

Reprinted 1985 by
Criterion Press
P.O. Box 6852
Leawood, Kansas 66206

AMERICAN ASSOCIATION OF
STATE HIGHWAY OFFICIALS

J. MASON

A POLICY
on
ROTARY INTERSECTIONS

AMERICAN ASSOCIATION OF
STATE HIGHWAY OFFICIALS

A Policy on Sight Distance
For Highways

J. MASON

A Policy on Highway
Types

(GEOMETRIC)

American Association of State
Highway Officials

J. MASON

Preface

The Committee on Planning and Design Policies was organized in 1937 upon authority of the Executive Committee of the Association. The purpose of the committee is the formulation of administrative policies looking toward the incorporation in practice of highway design features which will result in maximum safety and utility. The committee outlines the program of work, after which personnel assigned by the Bureau of Public Roads under supervision of the Secretary investigates each subject and prepares tentative discussions with indicated design controls and guide values. These are criticized, revised, and supplemented by members of the committee until a policy on each subject acceptable to the committee is completed, after which it is submitted through the Committee on Standards to the Executive Committee for letter ballot by the States.

In the period 1938 to 1944 the Committee on Planning and Design Policies developed seven policies which were adopted by the Association and printed as separate brochures. In 1950 the group was reprinted without change and bound as a single volume entitled Policies on Geometric Highway Design. Now, this revised policy, adopted May 3, 1954, completely supersedes the group of seven former policies. Previous material still applicable has been expanded and brought up to date, duplications have been eliminated, and several phases of geometric design formerly not covered have been included.

Other committee products are the Design Standards for the National System of Interstate Highways and the Design Standards for Construction and Reconstruction of Secondary and Feeder Roads, both adopted by the Association August 1, 1945. Geometric Design Standards for Highways (Primary) were prepared by the Committee on Design and adopted in May, 1941. These standards are based on the former policies on Geometric

A POLICY
on
GEOMETRIC DESIGN
of
RURAL HIGHWAYS

AMERICAN ASSOCIATION OF
STATE HIGHWAY OFFICIALS

Published by the Association
GENERAL OFFICES
917 National Press Building
Washington, D. C.

1954

Fifth Printing—1961

A POLICY ON ARTERIAL HIGHWAYS IN URBAN AREAS

AMERICAN ASSOCIATION OF
STATE HIGHWAY OFFICIALS

JEL Principal Author in Development of Text. The Preface, Contents, & Several Chapters Included Herewith - Those That Show Original Work. (Some Pencil Manuscripts which Follow in this Vol.)

1957/
JHM

service to be provided, the design speed should reflect the desired running speeds. An approximate relation over the whole range of conditions is shown in figure C-8. General working ranges of running and design speeds for the three types of arterial highways are as follows:

Ref., table C-1

Speed element	Major streets	Expressways at grade	Freeways
unning speed, mph:			
low volumes	25-40	35-45	40-50
peak hours	20-30	25-35	30-35
sign speed, mph:			
downtown areas	30 min.	40 min.	50 min.
suburban areas	30-50	40-60	50-60

A POLICY ON
ARTERIAL HIGHWAYS IN URBAN AREAS

Committee on Planning and Design Policies
American Association of State Highway Officials

CHAPTER J--INTERCHANGES

APPENDIX--ENGINEERING METHODS

JULY 1956

JEL Principal Author

Chapter Titles

A--Introduction and Summary
B--Arterial Highways and Their Location
C--Design Controls and Criteria
D--General Design Elements
E--Major Streets
F--At-Grade Expressways
G--Depressed Freeways
H--Elevated Freeways
I--Combination-Type Arterial Highways

J--INTERCHANGES

APPENDIX--ENGINEERING METHODS

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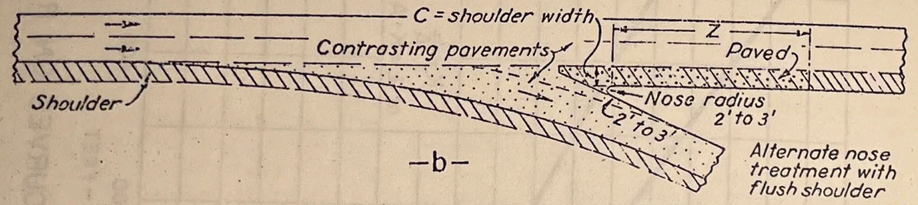

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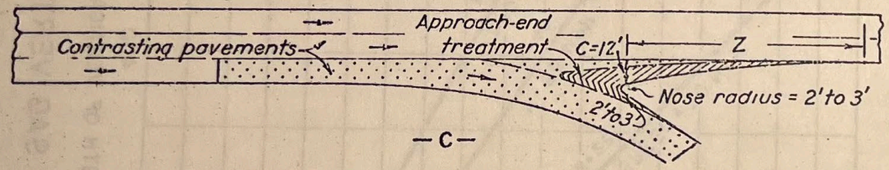
SINGLE-LANE EXIT WITH DECELERATION LANE



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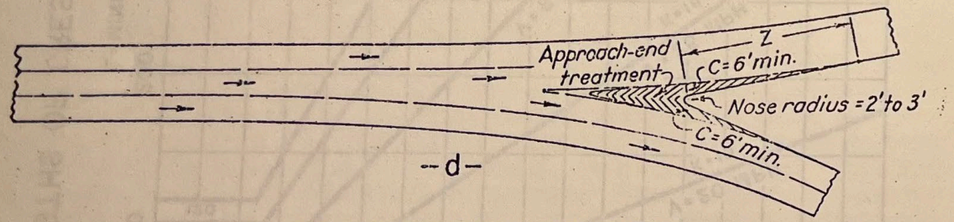
SINGLE-LANE EXIT WITH RIGHT LANE ON HIGHWAY APPROACH CONTINUED ONTO RAMP



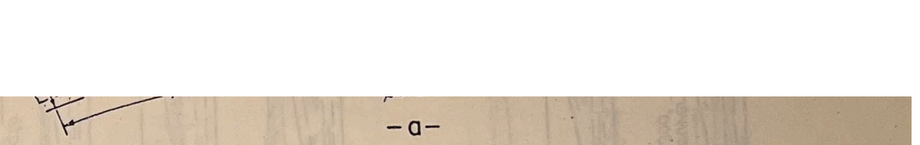
—d—

2-LANE EXIT OR MAJOR HIGHWAY FORK

MINIMUM LENGTH OF TAPER BEYOND AN OFFSET NOSE

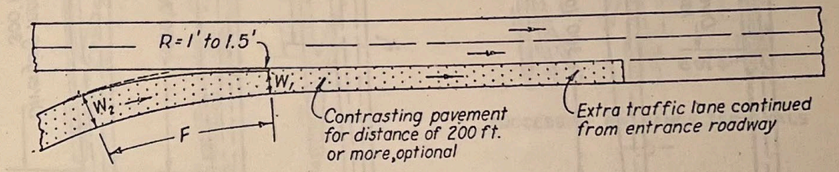
Design speed of highway, mph	40	50	60-70
Z in feet per foot of offset (C)			
Minimum	8	10	12
Desirable	12	15	18

DESIGNS FOR EXIT TERMINALS



—a—

SINGLE-LANE ENTRANCE WITH ACCELERATION LANE



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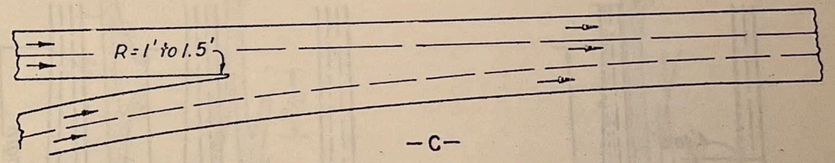
SINGLE-LANE ENTRANCE WITH RAMP PAVEMENT CONTINUED ONTO HIGHWAY AS AN ADDED LANE



—c—

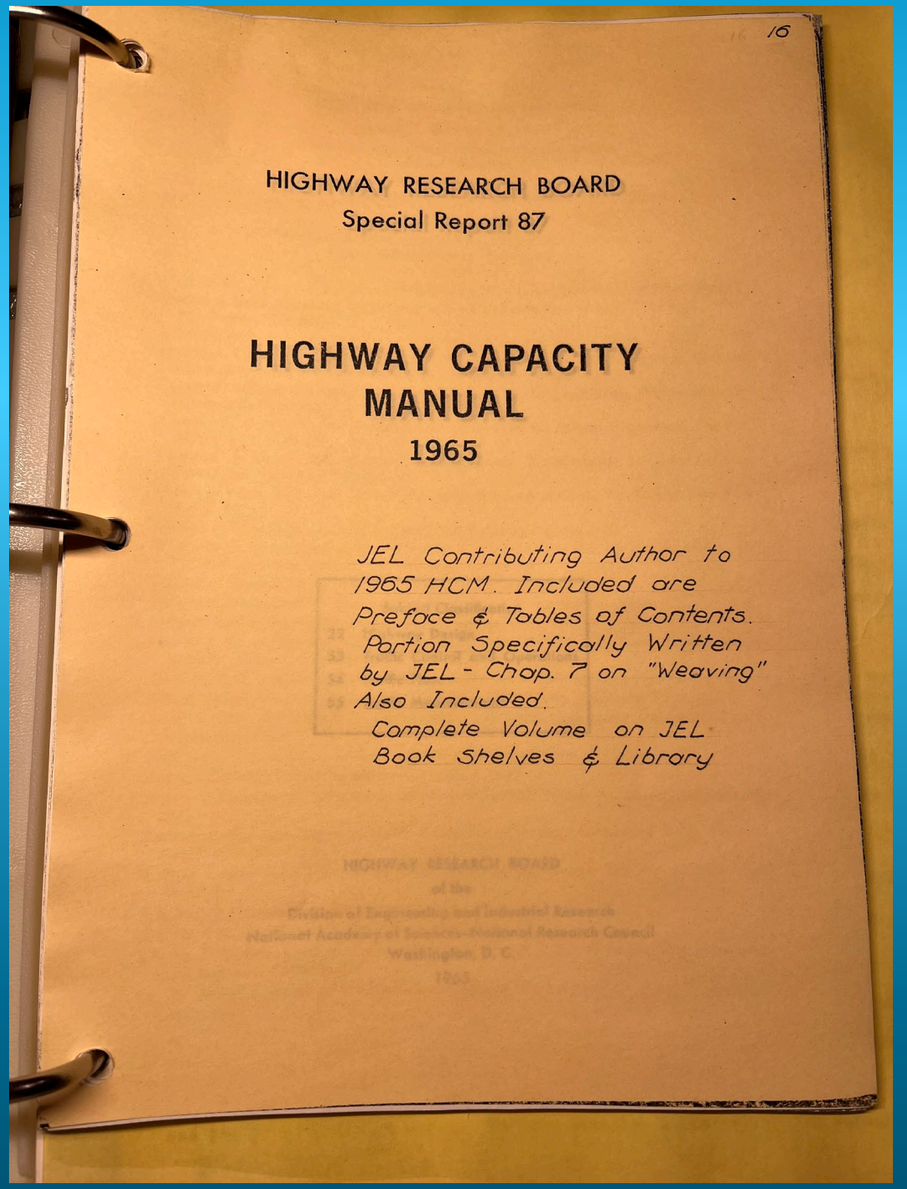
2-LANE ENTRANCE OR MAJOR HIGHWAY FORK

LENGTH FOR NARROWING RAMP PAVEMENT AT ENTRANCE TERMINALS

$(W_2 - W_1)$ — Ramp width reduction — feet	4	6	8	10	12
F — Length for pavement narrowing — feet:					
Minimum	40	60	80	100	120
Desirable	60	90	120	150	180

DESIGNS FOR ENTRANCE TERMINALS

Figure J-3


16
HIGHWAY RESEARCH BOARD
Special Report 87
HIGHWAY CAPACITY
MANUAL
1965
JEL Contributing Author to
1965 HCM. Included are
Preface & Tables of Contents.
Portion Specifically Written
by JEL - Chap. 7 on "Weaving"
Also Included.
Complete Volume on JEL
Book Shelves & Library

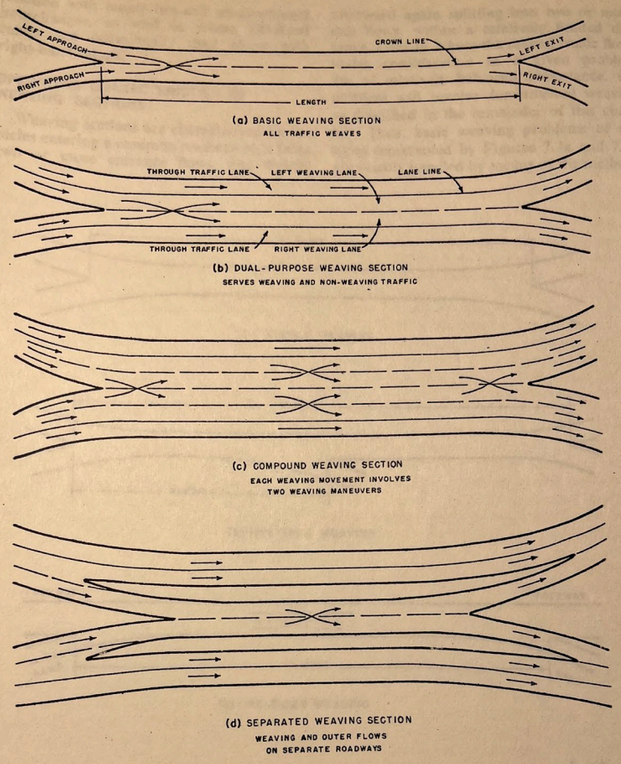


Figure 7.2. Simple weaving arrangements.

sided weaving section is typical on most freeways where the entrances and exits of interchange ramps are on the right. The two-sided weaving sections occur where the roadways of two major routes, crossing each other, are combined through a weaving section, as illustrated in Figures 7.1a, 7.1e, and 7.1h, and as shown for the rotary intersection in Figure 7.1i. Two-sided weaving sections are also likely to be found in con-

A POLICY
on
GEOMETRIC DESIGN
of
HIGHWAYS
and
STREETS

1984

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AMERICAN ASSOCIATION OF STATE
HIGHWAY AND TRANSPORTATION OFFICIALS

A POLICY
on
GEOMETRIC DESIGN
of
HIGHWAYS
and
STREETS

1990

AMERICAN ASSOCIATION OF STATE
HIGHWAY AND TRANSPORTATION OFFICIALS

A POLICY
on
GEOMETRIC DESIGN
of
HIGHWAYS
and
STREETS

1994

AMERICAN ASSOCIATION OF STATE
HIGHWAY AND TRANSPORTATION OFFICIALS

A Policy on
Geometric
Design of Highways
and Streets

2011
6th Edition

American Association of
State Highway and
Transportation Officials

AASHTO
The Voice of Transportation

A Policy on
Geometric Design of
Highways and Streets

2004

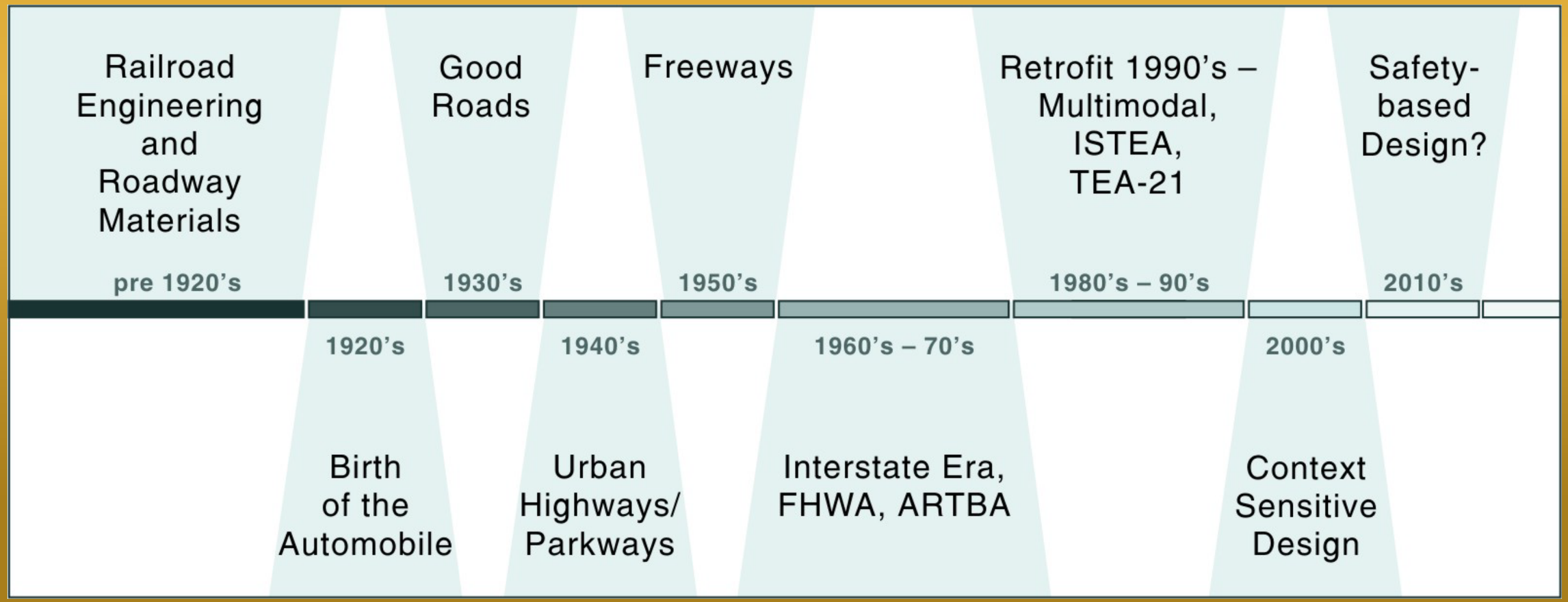
AASHTO

A POLICY ON
GEOMETRIC
DESIGN OF
HIGHWAYS AND
STREETS

Outline

- …. a brief history geometric design (and operations) of highways
- **Near term trends**
  - **what has laid the groundwork**
  - **what various state agencies are doing**
- Future transportation / geometric design
- Q&A

Modern History of Roadway Transportation Timeline

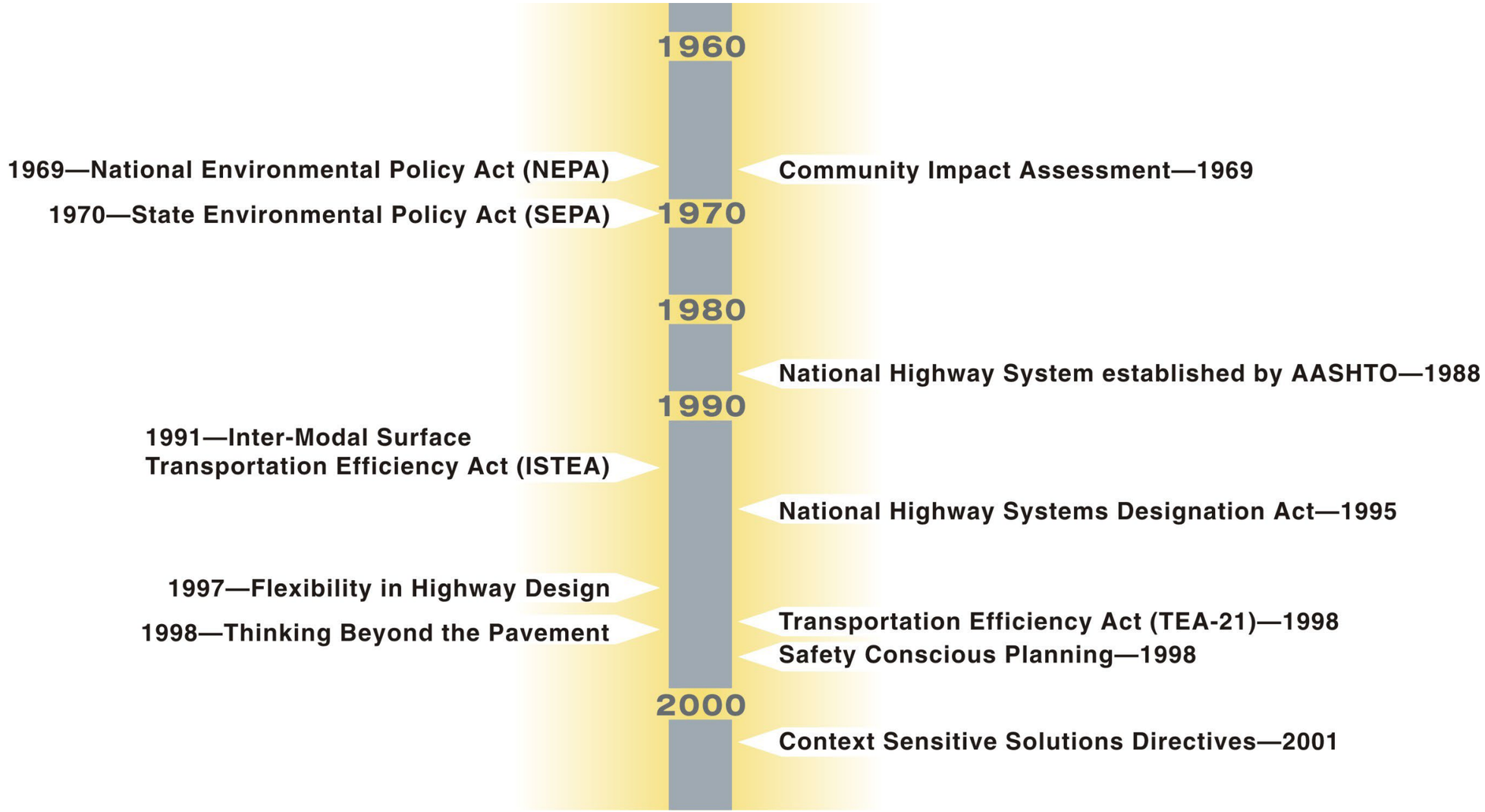


Post-Interstate Trends in Multi-modal Design

- **Federal Aid Highway Act (Interstate Act)**
- **Urban Renewal, Title 1**
- **Civil Rights Act, 1964**
- **NEPA**
- **Community Impact Assessment**
- **Environmental Justice**
- **“Thinking Beyond The Pavement”**
- **Context Sensitive Design/Solutions**
- **Flexibility in Highway Design**
- **Multi-modal Performance**
- **Safety Conscious Planning**

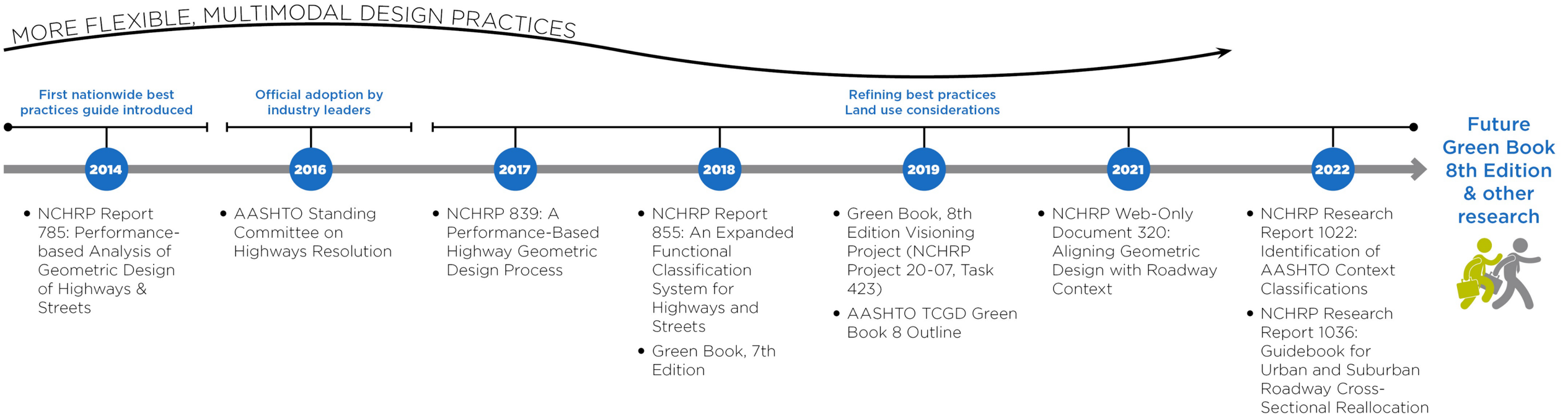
Eisenhower Legacy Website, 2008

Key Policies Timeline

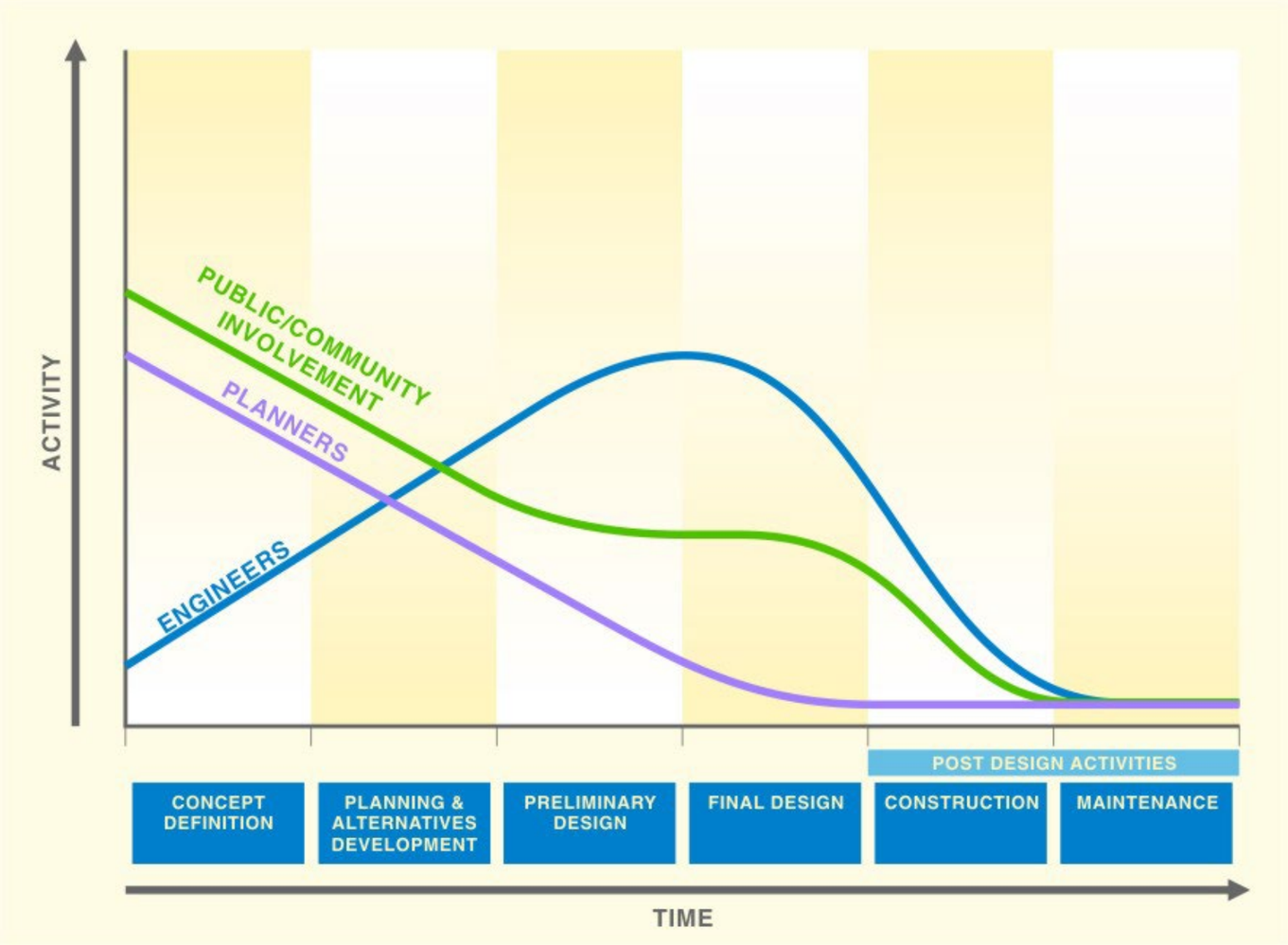


National Initiatives and Publications

- **Emphasizes design flexibility and performance-based design**
- **Increased multimodal emphasis**
- **New context classifications**



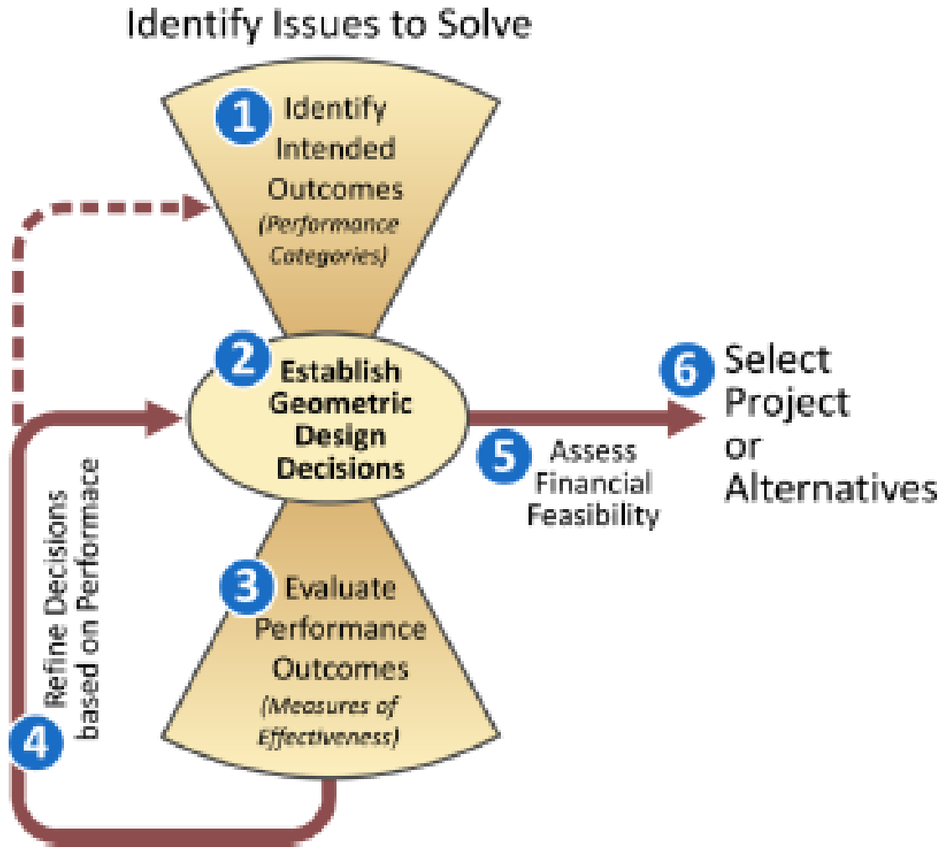
The “Ideal” Project Development Process?



Kittelson & Associates, Inc.

Performance-Based Design

Figure 4-1: Performance-Based Approach



Source: NCHRP Report 785 (1)

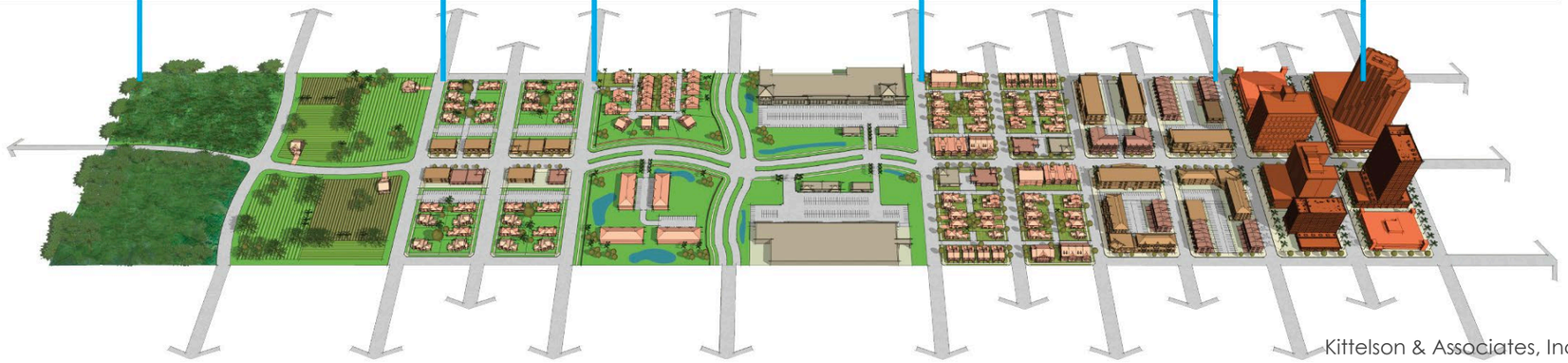
This performance-based approach is based on:

1. Identifying desired project outcomes and performance metrics
2. Establishing design decisions based on the desired outcomes
3. Evaluating the performance of the design
4. Iterating and refining the design to align solutions with the desired outcomes
5. Assessing the financial feasibility of the alternatives
6. Selecting a preferred alternative that aligns with the desired outcomes or re-assessing desired outcomes if no acceptable solution is identified

Context Classifications

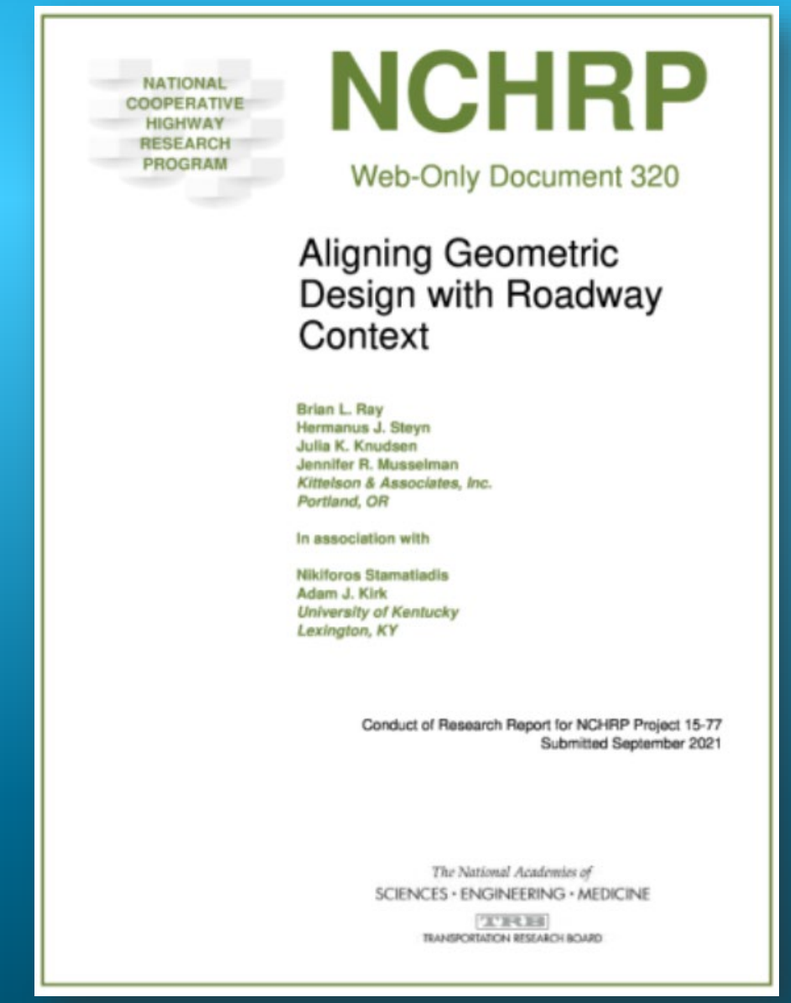
- **Rural**
- **Rural town**
- **Suburban**
- **Urban**
- **Urban core**

Green Book 1–6	**Rural**			**Urban**						
SmartCode (2003)/ **ITE/CNU** (2010)	Natural	Rural		Suburban			General Urban	Urban Center	Urban Core	Special District
Massachusetts (2006)	Rural Natural	Rural Developed	Rural Village	Low Density	Town Center	High Density	Urban Residential	Urban Park	Commercial Business District	
Pennsylvania/New Jersey (2008)	Rural			Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core	
California (2016)	Natural	Developing	Rural Main Street	Suburban Low Density		Suburban High Density	Urban Low Density		Urban High Density	
Florida (2017)	Natural	Rural	Rural Town	Suburban Residential		Suburban Commercial	Urban General	Urban Center	Urban Core	Special District
Minnesota (2018)	Natural	Rural	Rural Crossroad	Suburban Residential		Suburban Commercial	Urban Residential	Urban Commercial	Urban Core	Industrial Warehouse
Green Book 7/ NCHRP 855 (2018)	**Rural**		**Rural Town**	**Suburban**			**Urban**		**Urban Core**	
Oregon (2019)			Rural Community	Suburban Fringe	Suburban Residential Corridor	Suburban Commercial Corridor	Urban Mix		Downtown/ Commercial Business District	
Washington (2019)	Rural			Suburban			Urban		Urban Core	
AASHTO TCGD (2019)	**Rural & Natural Areas**		**Rural Town**	**Suburban**			**Urban**		**Urban Core**	**Industrial, Warehouse, or Port**
Maryland (2019)	Rural		Traditional Town Center	Suburban		Suburban Activity Center		Urban Center	Urban Core	
Pennsylvania (2020)	Rural		Rural Town	Suburban			Urban		Urban Core	
NCHRP 15-72 (2021)	**Rural**		**Rural Town**	**Suburban**			**Urban**		**Urban Core**	**Special Context**



Aligning Design with Roadway Context

- **NCHRP Web-Only Document 320: Aligning Geometric Design with Roadway Context**
  - **Research Objective**
    - ***Draft Part IV: Facility Design in Context of the proposed Green Book, 8th Edition (GB8)***
    - ***Develop material suitable for use in the future project to develop the GB8.***



For each context

- **Design Controls**
- **Horizontal and Vertical Design Considerations**
- **Sight Distance Considerations**

Table 16-6: Suburban Context Design Controls

Design Control	Local	Collector	Arterial	Freeway
Design Speed[1]	20-to-30 mph	30-to-35 mph	30-to-40 mph	50-to-70 mph
Design/Control Vehicle[3]	DV=WB-40 CV=WB-62		DV = WB-40 CV=WB-62. WB-67 for NHS or designated freight routes	DV=WB-62. WB-67 for NHS or designated freight routes
Traffic Volumes	• High traffic volumes may exist during peak periods. • Traffic volumes may increase as the roadway transitions from Rural and Natural Areas to Urban contexts. Traffic is likely to include transit and freight. • A high percentage of heavy vehicles may exist near light industrial areas.			
Non-Motorized User Needs	• Pedestrian and bicycle volumes are expected, especially near commercial development and where transit is present. • Large blocks can limit crossing opportunities. Midblock crossings may be required near clusters of commercial development and transit stops; traffic control devices (RRFB, PHB, Signal) may be needed in high-speed settings. • Separation from vehicle traffic may increase safety and comfort.			
Vehicle Access Points and Density	Frequent residential and commercial driveways.		Relatively low access density in some locations and clusters of high access density in other locations (i.e., supporting commercial development).	Minimum 1 mile between interchanges.
Terrain	Rolling; level.			

mph: miles per hour
DV: Design vehicle, CV: Control Vehicle, WB: wheelbase
RRFB: Rectangular Rapid Flash Beacon, PHB: Pedestrian Hybrid Beacon

Establishing target speed (design speed) ranges for each context will drive many design elements.
Project created a starting point for future refinement (GB8 team). . .

For each context

- **Cross Section Value Ranges**
- **Intersection Considerations**

Table 16-10: Suburban Context Cross Section Design Elements

Design Element	Local	Collector	Arterial	Freeway
Number of Travel Lanes	2 lanes	2-4 lanes	2-4 lanes[1]	4-6 lanes[1]
Median Provisions	Raised: Not anticipated Flush: 0-to-2 ft.	Raised: 8-to-22 ft.		Flush or depressed: 26 to 64 ft.
Pedestrian Features				
Type of Facility	Pedestrian walking space may include shoulder or sidewalk.	Sidewalk on both sides; potential shared-use path.		N/A
Width	6 ft	6 ft	6 ft, increase to 8 ft in clusters of development and where transit is present	N/A
Buffer	Provide buffer, or sufficient sidewalk width for buffering, if sidewalk or path is adjacent to the curb.			N/A
Pedestrian Refuge Island	Consider refuge island when four or more travel lanes are present. If signalized, provide adequate time for single-stage crossing. 6 ft minimum, 8 ft preferred, measured in the direction of pedestrian travel.			N/A
On-Street Parking	May be present for residential use and is typically undesignated.	Consider on-street parking near residential and commercial development. On-street parking: 8 ft	Not typical; may be present near commercial development when speeds are 35 mph or less.	N/A

For each context

- **Cross Section Value Ranges**
- **Intersection Considerations**

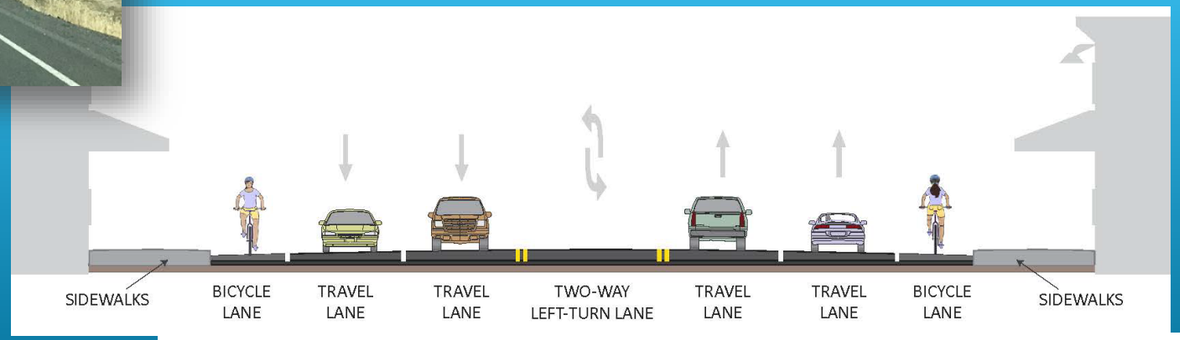
Values based on state agency input, research team experience, AASHTO Green Book, 7th Edition

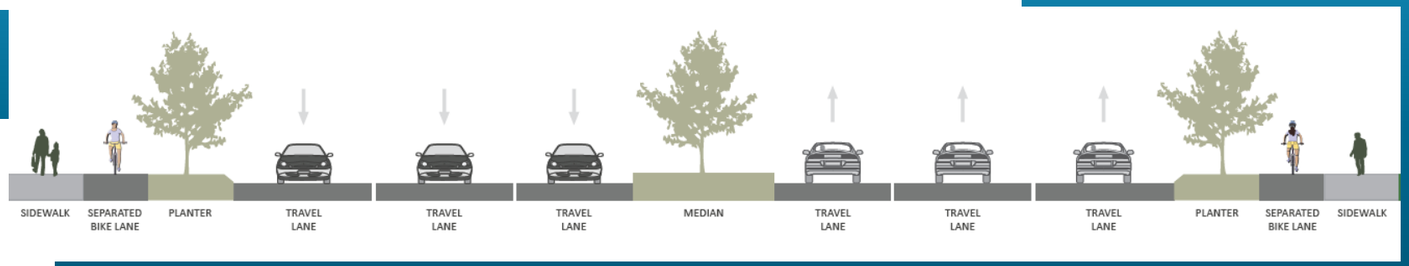
Values are meant to be a starting point for the GB8 team to continue discussions . . .

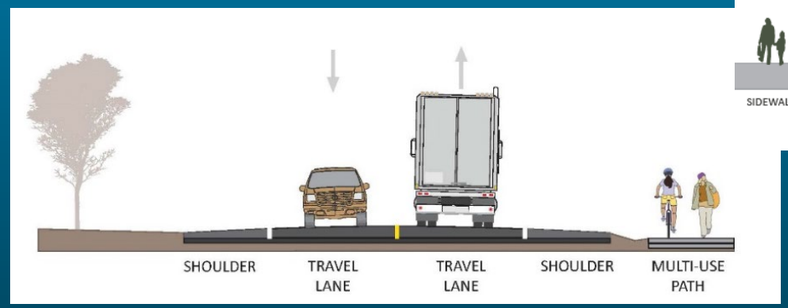
Bicycle Features				
Preferred Facility	Shared lane markings.	Separated bicycle lane or shared-use path preferred. Consider a 6-8-ft buffered bicycle lane depending on roadway characteristics.	Separated bicycle lane or shared-use path preferred.	Shared-use path preferred. Paved shoulder (depending on jurisdiction).
Buffers	Not anticipated.	Bicycle facilities should be separated from travel lanes by a buffer		N/A
Types of separation	Not anticipated.	Raised island, flexible delineator posts, concrete barrier, guardrail, bioswale, ditch.		N/A
Travel Lane Width(s)				
Through Lanes and Turn Lanes	9-11 ft	10-12 ft	11-12 ft	11-12 ft
Auxiliary Lanes	10 ft	10-12 ft	11-12 ft	12 ft
Shoulder[2]				
Width	2-6 ft	4-8 ft	4-8 ft	Outside: 10-12 ft Inside: 4-10 ft
Composition Material	Paved	Paved	Paved	Paved
Function	Pedestrian/bicycle use, mail/garbage pickup.	Pedestrian/bicycle use, emergency use, mail/garbage pickup.		Off-tracking, bus on shoulder, emergency use, occasional travel/detour, bicycle use (depending on jurisdiction).
Lane & Shoulder Cross Slopes	Avoid superelevation, use normal crown.	2% preferred / 4% maximum		2% minimum / 12% maximum

For each context

- **Example Cross Sections**
- **Example Location Photos**







Outline

- …. a brief history geometric design (and operations) of highways
- Near term trends
  - what has laid the groundwork
  - what various state agencies are doing
- **Future transportation / geometric design**
  - **Future Green Book**
  - **Safe System Approach**
  - **Target Speed**
  - **Roadside Design**
- Q&A

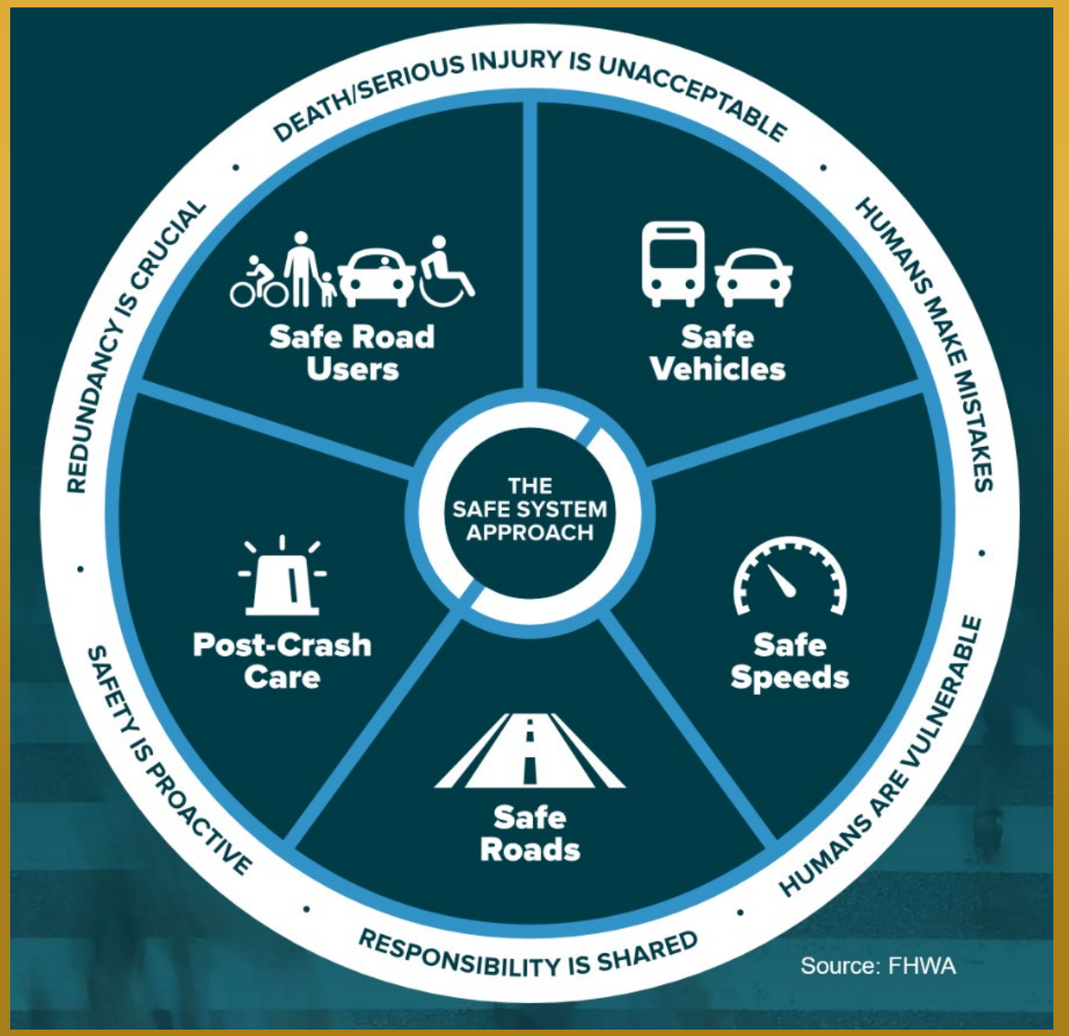
Outline of Future Green Book, 8th Ed.

Part	Chapter	Description
Part I - Introduction	1	Overview
	2	Key Concepts in Geometric Design
	3	Overview of Performance-Based Design
	4	Project Needs and Objectives Statement
Part II - Performance-Based Design Process	5	Performance Analysis Tools
	6	Steps in Performance Based Design
Part III – Design Controls and Criteria	7	Design Controls
	8	Roadway Alignment
	9	Cross-Section Elements
	10	At-Grade Intersections
	11	Freeways
	12	Interchanges
	13	Other Elements Affecting Geometric Design

Part	Chapter	Description
Part IV – Tailoring Geometric Design to Roadway Context	14	Rural and Natural Context
	15	Rural Town Context
	16	Suburban Context
	17	Urban Context
	18	Urban Core Context
	19	Special Contexts

Fresh Look at Transportation Needs: Safe System Approach

- **Emphasis on Multimodal**
  - **SCOH Resolutions**
  - **Addressing pedestrian and bicycle crashes**
- **Slower Speeds in Urban Environments**
  - **Safe System Approach**



Target Speed

- **State DOTs establishing Target speeds based on context**
- **In-Process and Upcoming Research**
  - **NCHRP Project 15-76: Designing for Target Speed**
  - **NCHRP Project 17-111: Speed Management Strategies to Improve Pedestrian and Bicyclist Safety on Arterials and Higher-Speed Roadways**

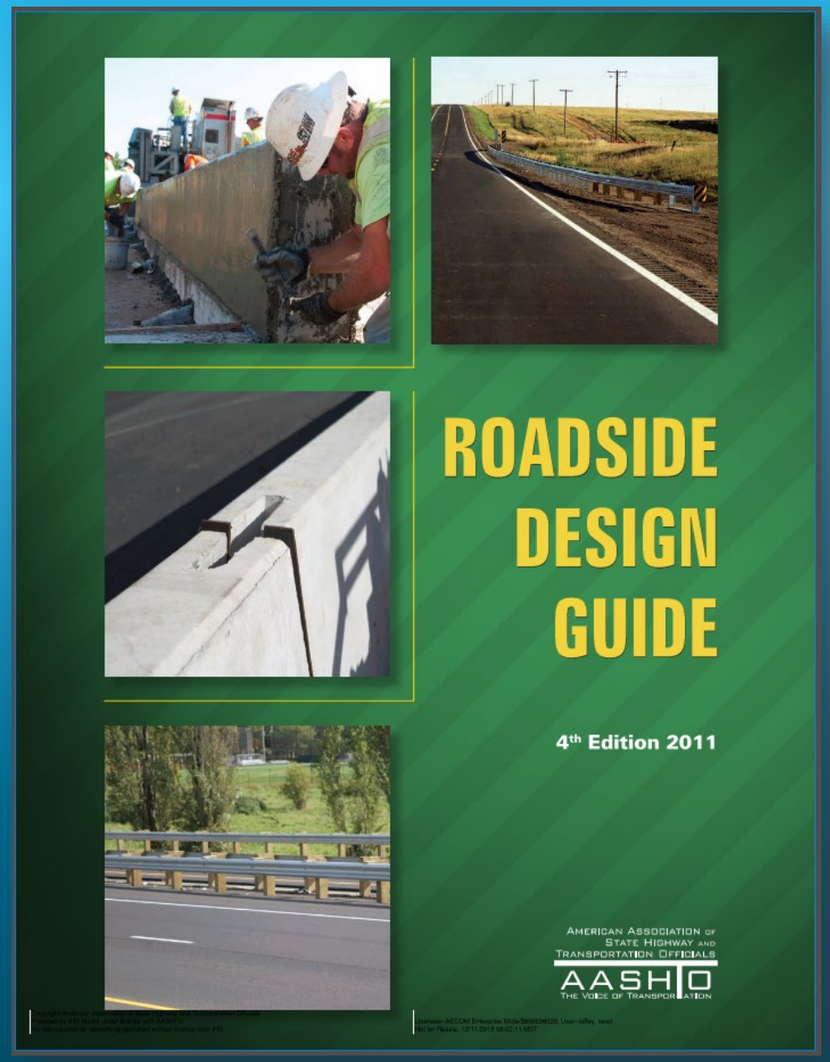
Table 3-10: Recommended ODOT Target Speed and Design Treatments for Urban Contexts

Urban Context	Target Speed (MPH)	Design Treatments
Traditional Downtown/CBD	20-25	Roundabouts, lane narrowing, speed feedback signs, on-street parking[1], street trees[2], median islands, curb extensions, chicanes[3], textured surface, coordinated signal timing, speed tables[3], road diets
Urban Mix	25-30	Roundabouts, lane narrowing, speed feedback signs, on-street parking[1], street trees[2], median islands, curb extensions, chicanes[3], textured surface, coordinated signal timing, road diets
Commercial Corridor	30-35	Roundabout, lane narrowing, speed feedback signs, landscaped median Islands, coordinated signal timing, road diets
Residential Corridor	30-35	Roundabout, lane narrowing, speed feedback signs, landscaped median Islands, coordinated signal timing, road diets
Suburban Fringe*	35-40	Roundabouts, transverse pavement markings, lane narrowing, speed feedback signs, road diets, entry treatments
Rural Community	25-35	Roundabouts, lane narrowing, speed feedback signs, on-street parking[1], street trees[2], median islands, curb extensions, chicanes[3], speed tables[3], road diets, entry treatment

* The suburban fringe context is typically suburban adjacent to rural areas at the edge of urban development, but often is in the process of developing. For projects in the suburban fringe context zone, practitioners should consider likely future development and consider applying designs for residential corridor, commercial corridor, or urban mix contexts if this type of development is likely to occur.

AASHTO Roadside Design Guide

- **Chapter 10 speaks to:**
  - **Roadside Safety in Urban or Restricted Environments**
- **Not much information about lower-speed environment and context classifications**
- **What does roadside design look like?**
  - **In urban-related contexts (urban core, urban, suburban, rural town)?**
  - **In lower-speed environments?**
- **Can we use roadside design to encourage slower speeds?**
  - **“Who was first the chicken or the egg?”**



Questions & Answers

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