4-10-2015

Geometric Design, Speed, and Safety

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Geometric Design, Speed, and Safety

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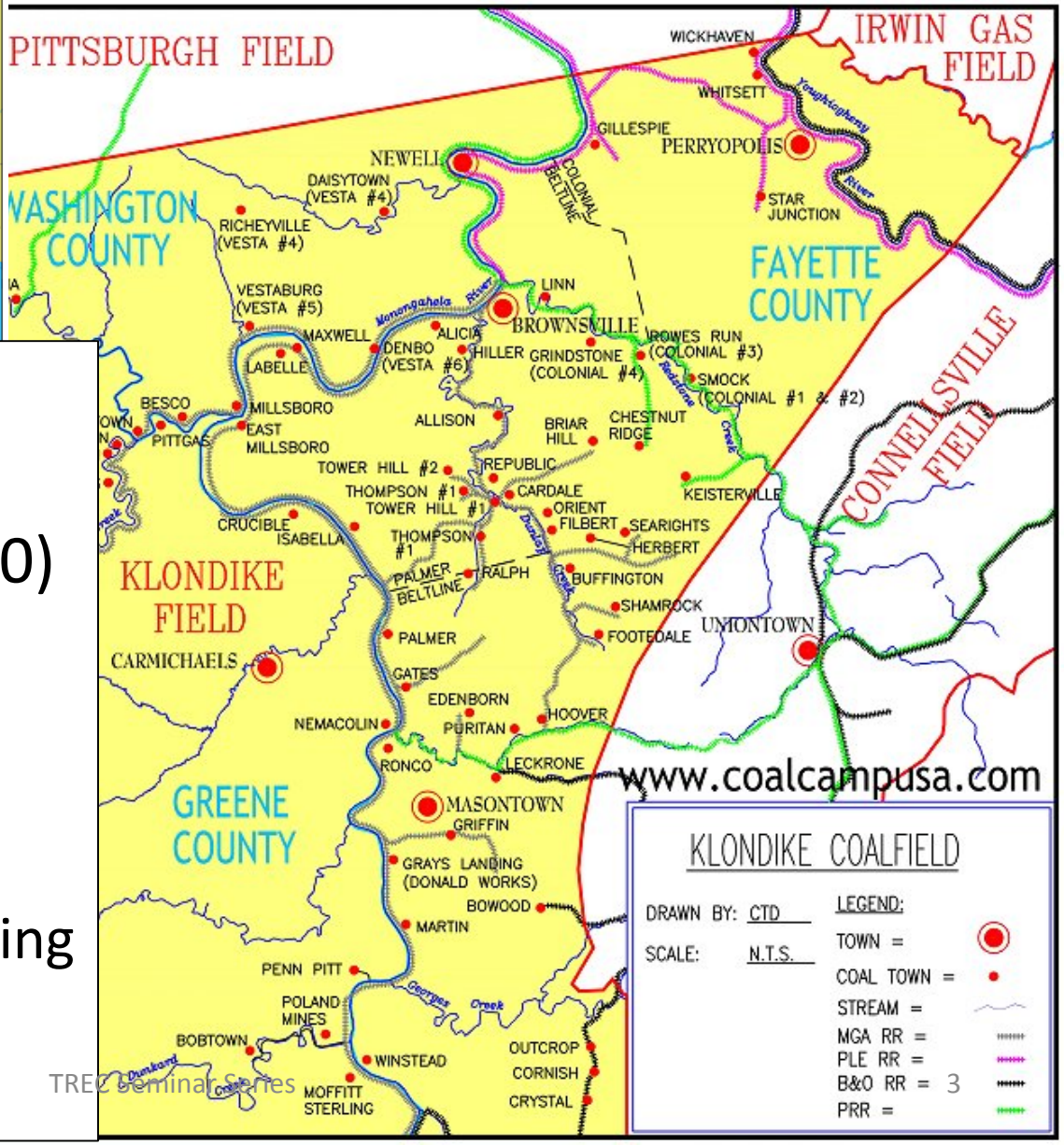
From the TREC “instructions for Friday seminar speakers…”

Students in the seminar appreciate knowing how you advanced to your current position, so a brief background statement is usually of interest…

THE UNIVERSITY OF UTAH

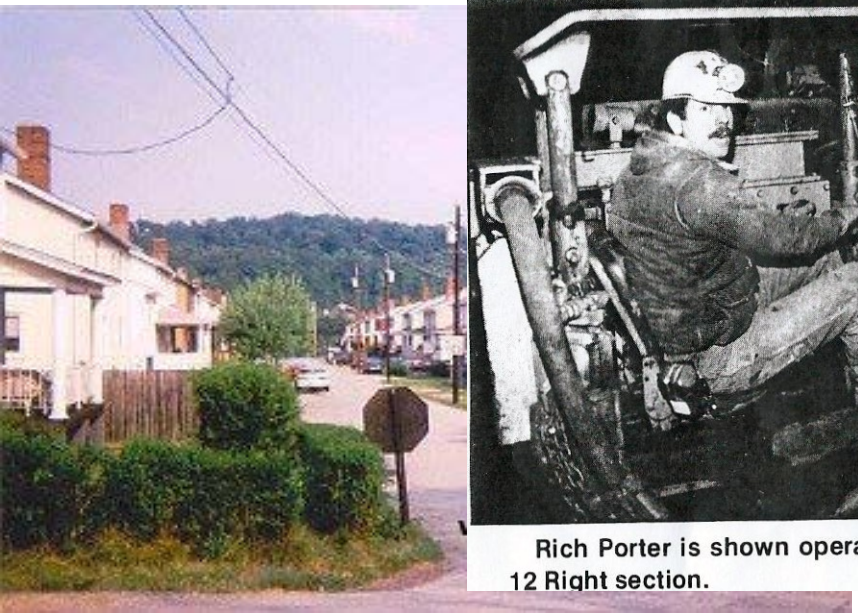
SW PA Coal Patches

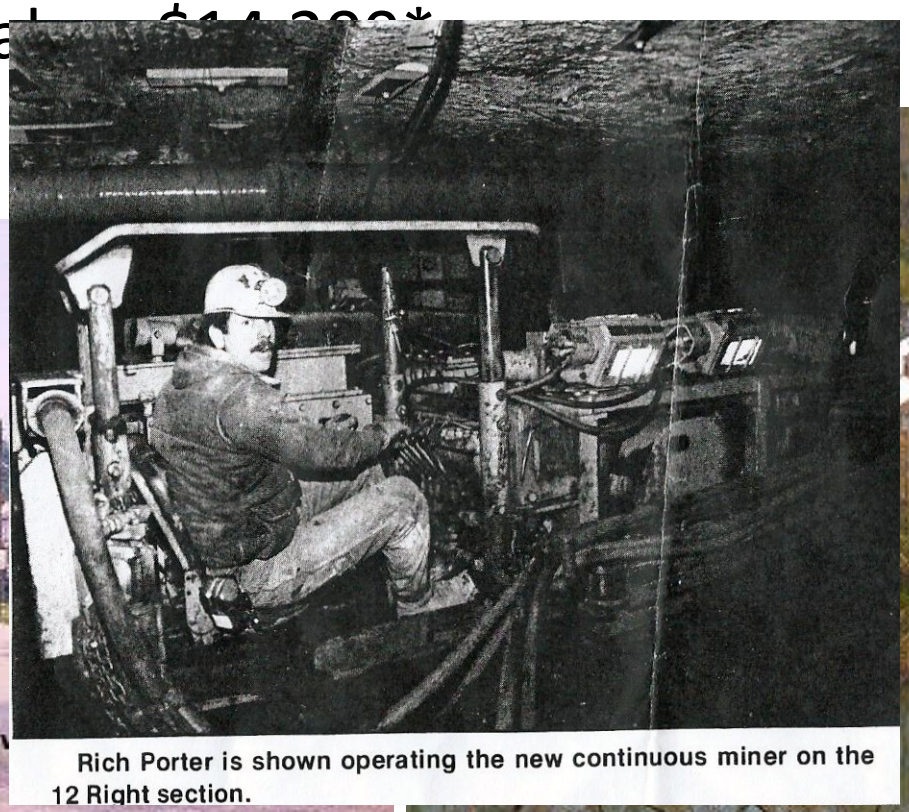


- Pittsburgh coal seam
- Monongahela River
- Coal patches (1880-1920)
  - -- Highly stratified
  - -- 75% + eastern and southern European
  - -- Company stores
  - -- Rented company housing
  - -- Iron and Coal Police
  - -- Union formation

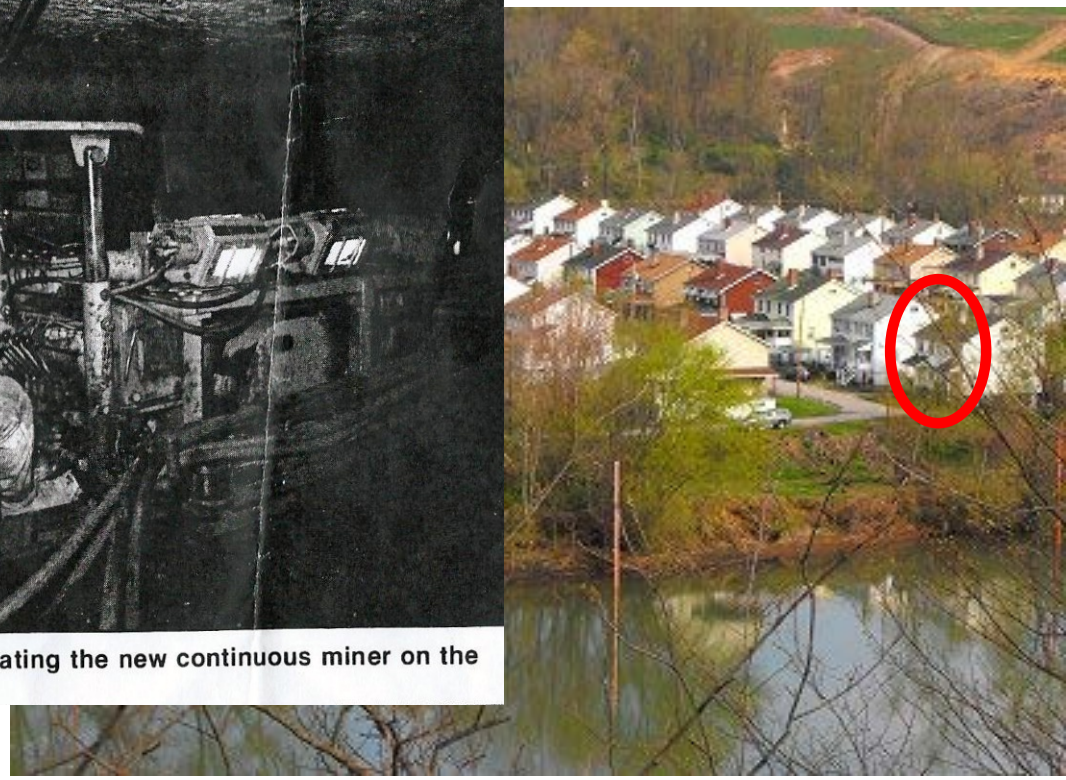
Vesta #6
Denbo, PA (pop. 713*)

- avg house va
- avg income:





Rich Porter is shown operating the new continuous miner on the 12 Right section.



* data from 2000 census

Pictures from www.coalcampusa.com

Education and Academic Experience

- Penn State, '95-'97…?
- Penn State, '97-'99
- Penn State, '00
- Virginia Tech (research)
- Penn State, '07
- Texas A&M
- The U (July 2009 -)

Teaching and Research:

- highway and street design
- road safety
- project development
- traffic operations
- statistics/econometrics
- risk and reliability analysis

Geometric Design, Speed, and Safety

- Why do we get what we get?
- Can we get what we want? How?

Pictures from FHWA-HRT-05-098 (2006)

Background

Self-enforcing, self-explaining design

HSM Highway Safety Manual AASHTO

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Speed discord

Speed prediction feedback loop

Design c

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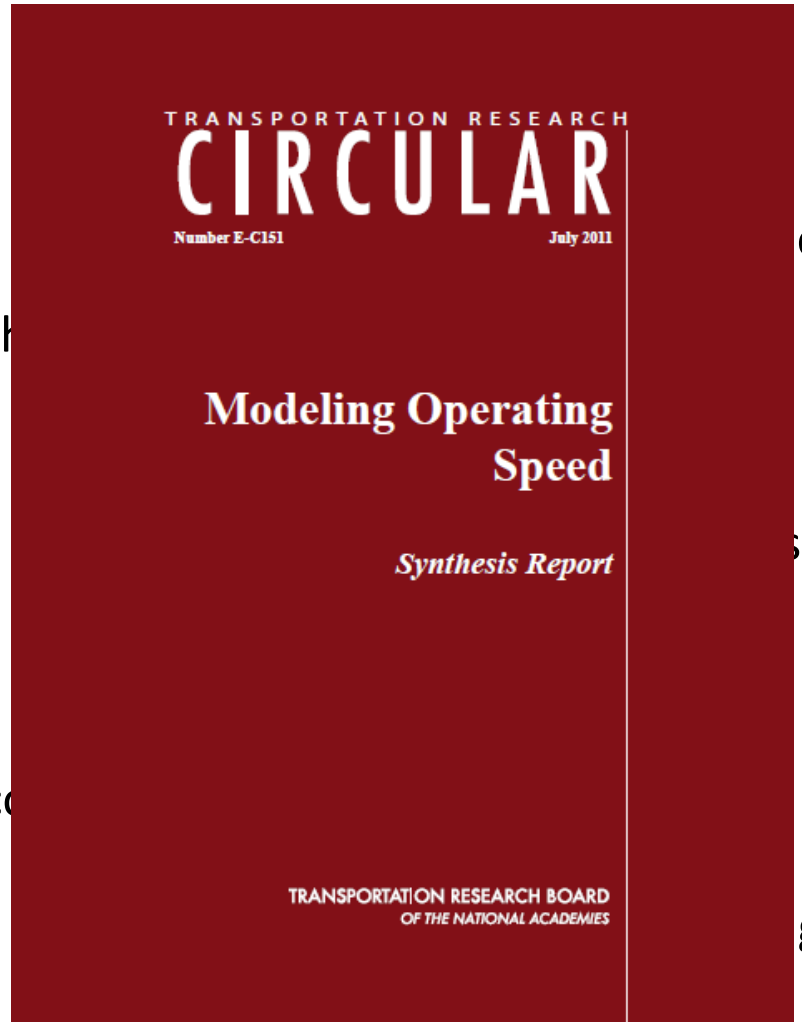
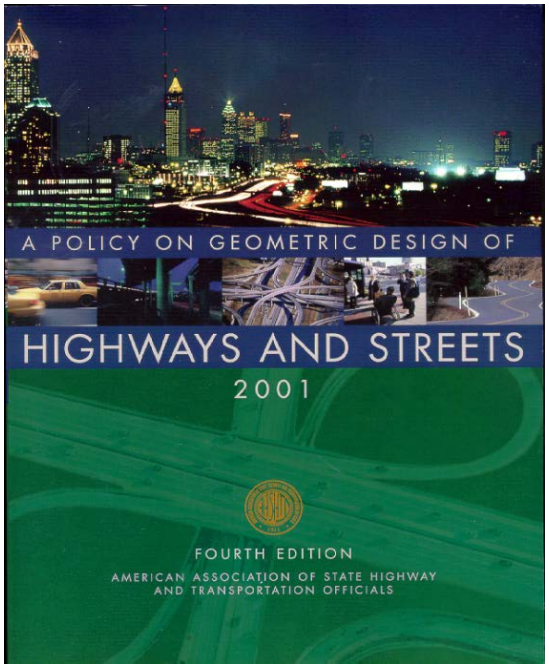


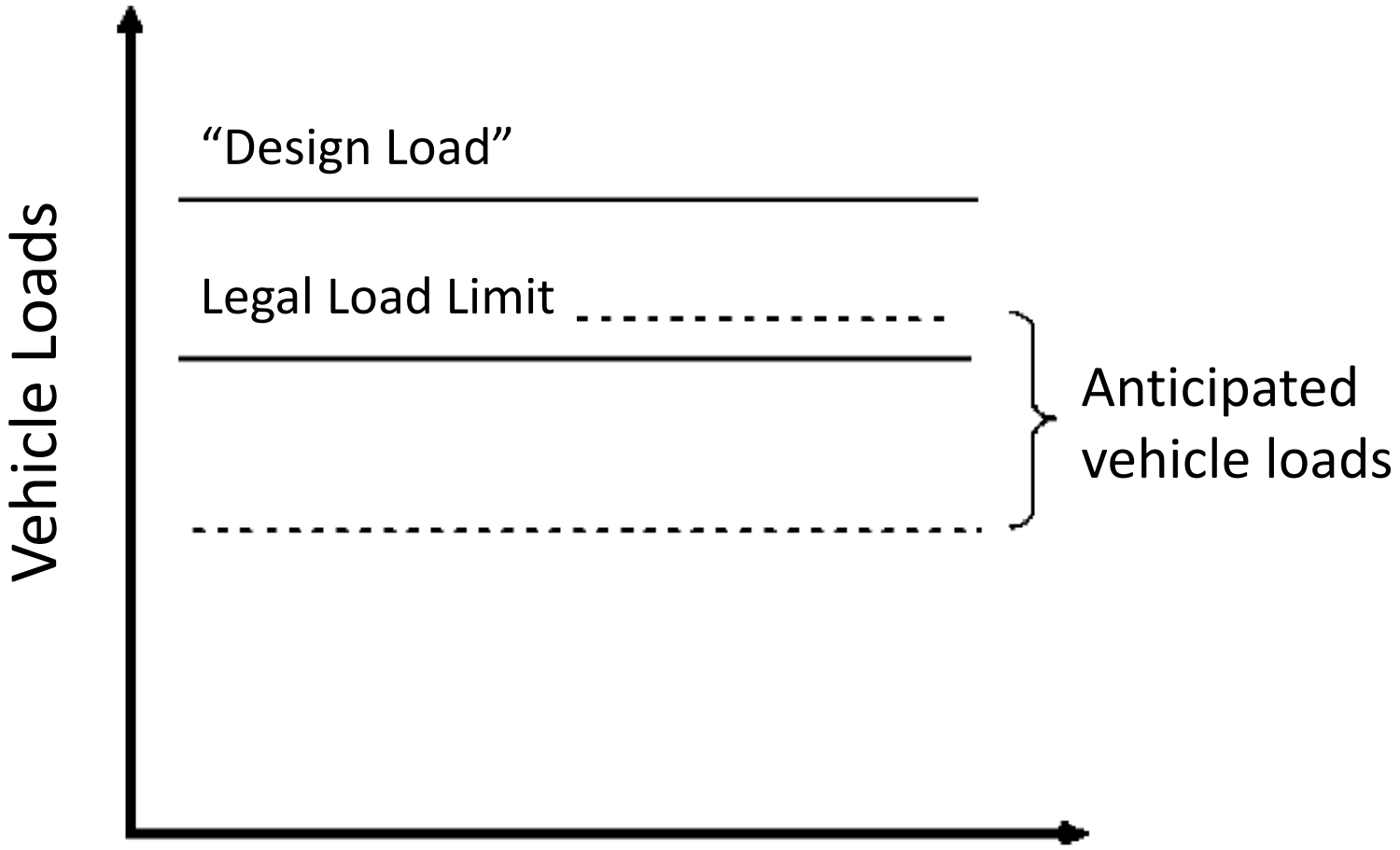
Design Speed



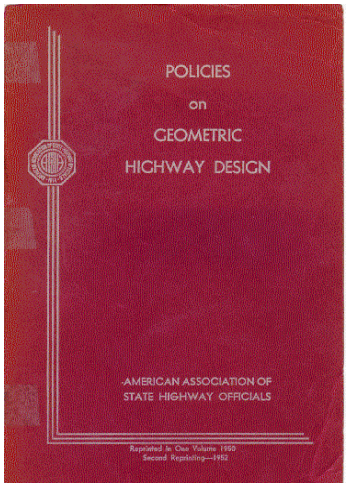
"…a selected speed used to determine the various geometric design features of the roadway…" (2001-current)

"…should be a logical one with respect to topography, anticipated operating speed, the adjacent land use, and the functional classification…"

Structural Design

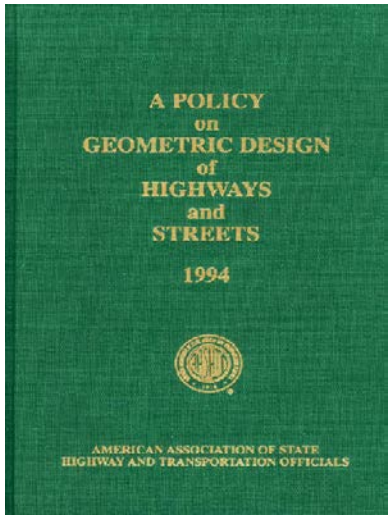


Design Speed (a look back)

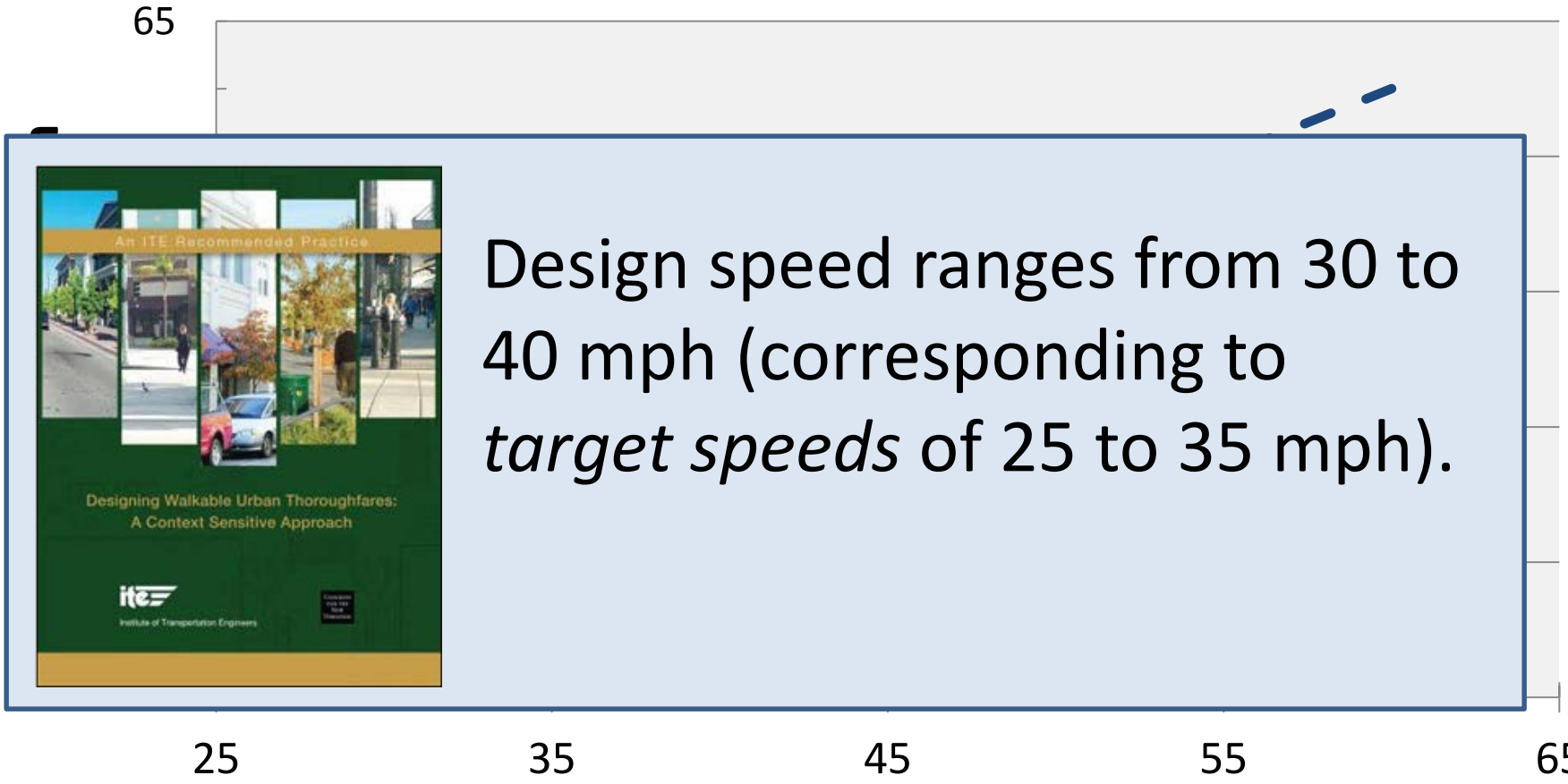


"...the maximum approximately uniform speed which probably will be adopted by the faster group of drivers but not, necessarily, by a small percentage of reckless ones" (pre-1954)

"... the maximum safe speed that can be maintained over a section of highway when conditions are so favorable that the design features of the highway govern." (1954-2001)



Approximate Relation Between Design and Running Speeds for Urban Conditions



Design speed ranges from 30 to 40 mph (corresponding to *target speeds* of 25 to 35 mph).

Adapted from AASHTO (1957)

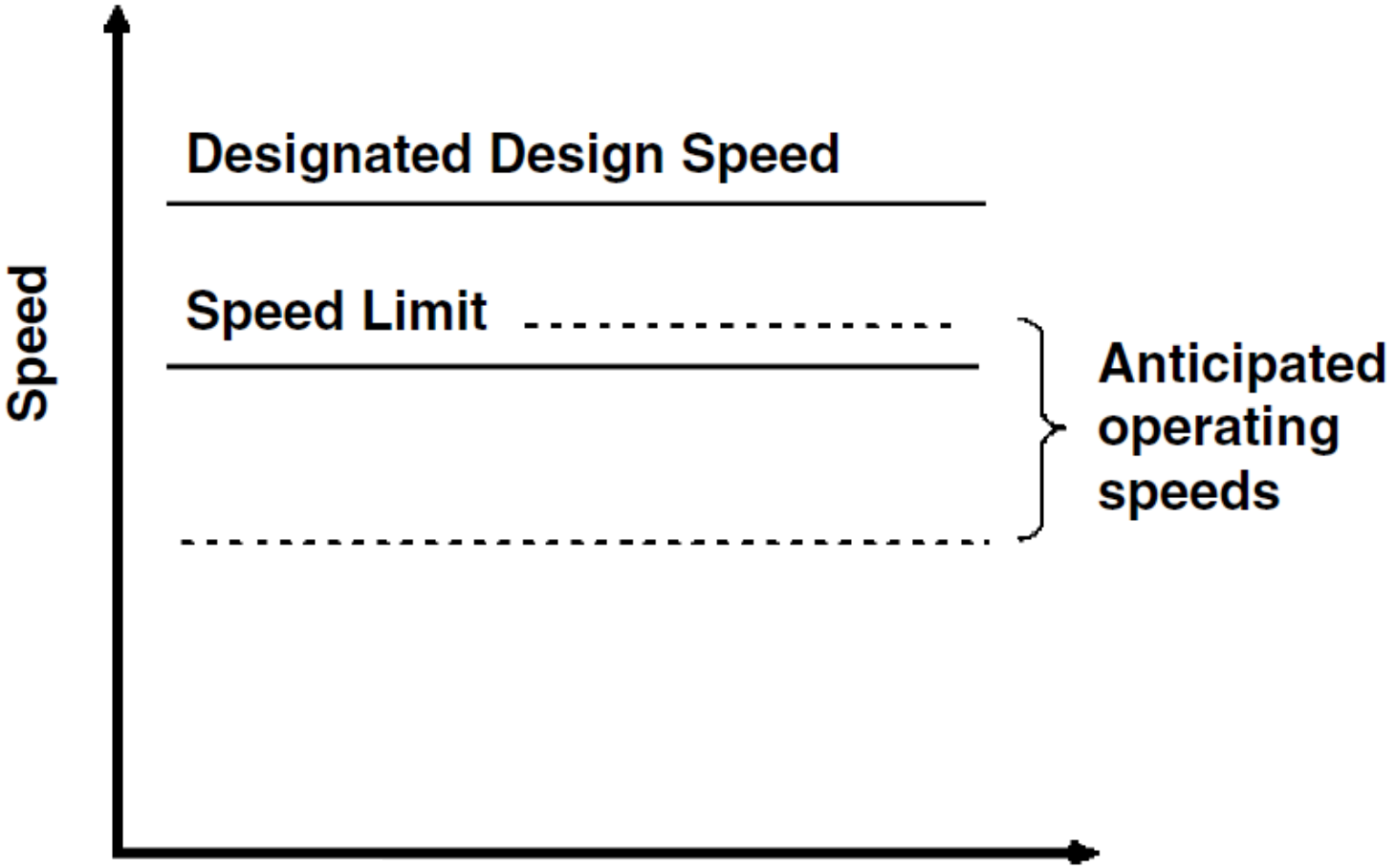
Design Speed Selection

Insights from NCHRP Report 504

- In **urban areas**, designers generally select design speeds that are within the range of anticipated operating speeds, regardless of terrain or functional class. The **selected design speed was often equal to or 5 mph higher than the anticipated posted speed limit** across terrain types and functional classifications.

- In **rural areas**, designers generally select design speeds that are within the range of anticipated operating speeds, regardless of terrain or functional class. The **selected design speed was nearly always 5 mph higher than the anticipated posted speed limit** across terrain types and functional classifications.

Speed Relationships in Design Process
As Intended/Desired…



from Donnell et al. (2009)

Criteria Related to Design Speed

$$\frac{V^2}{15(e+f)} = R$$

$$SSD = 1.47Vt + \frac{V^2}{30\left(\frac{a}{32.2} \pm G\right)}$$

$$M_s = R_v\left(1 - \cos\frac{28.65S}{R_v}\right)$$

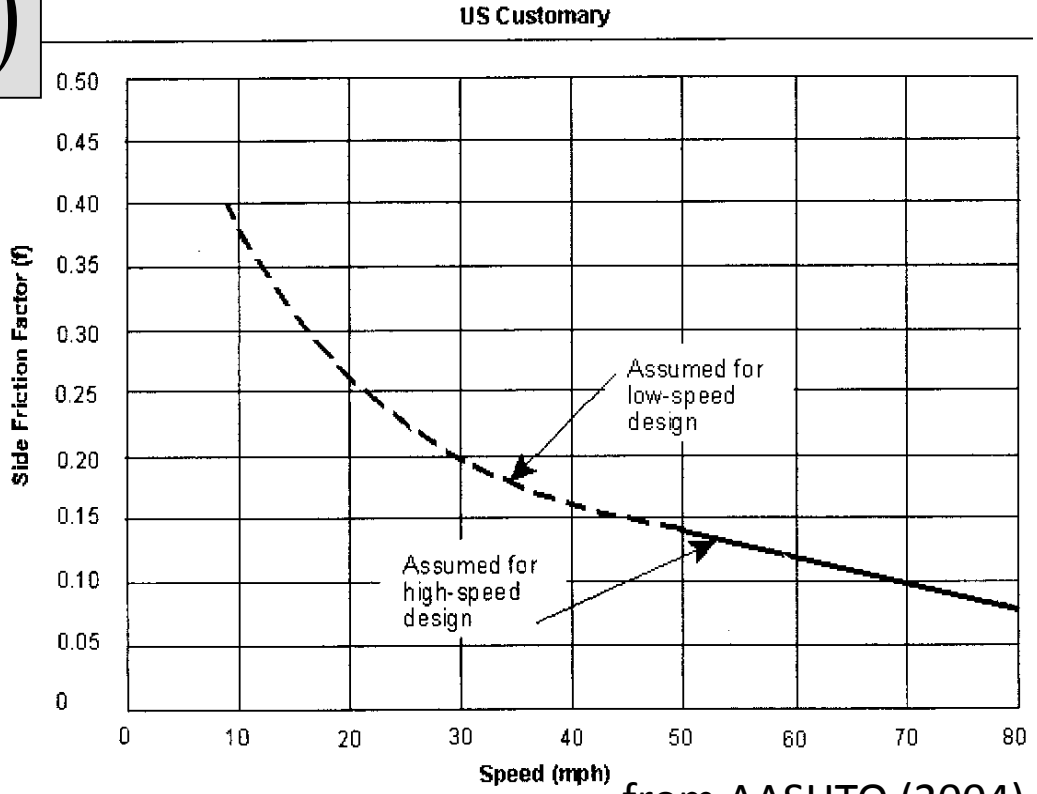
$$L = \frac{AS^2}{200\left(\sqrt{H_1} + \sqrt{H_2}\right)^2}$$

Example of Limiting Values

$$R_{\min} = \frac{V^2}{15\left(e_{\max} + f_{\max}\right)}$$

e_{max}: Influenced by climate conditions, constructability, adjacent land use and the frequency of slow moving vehicles

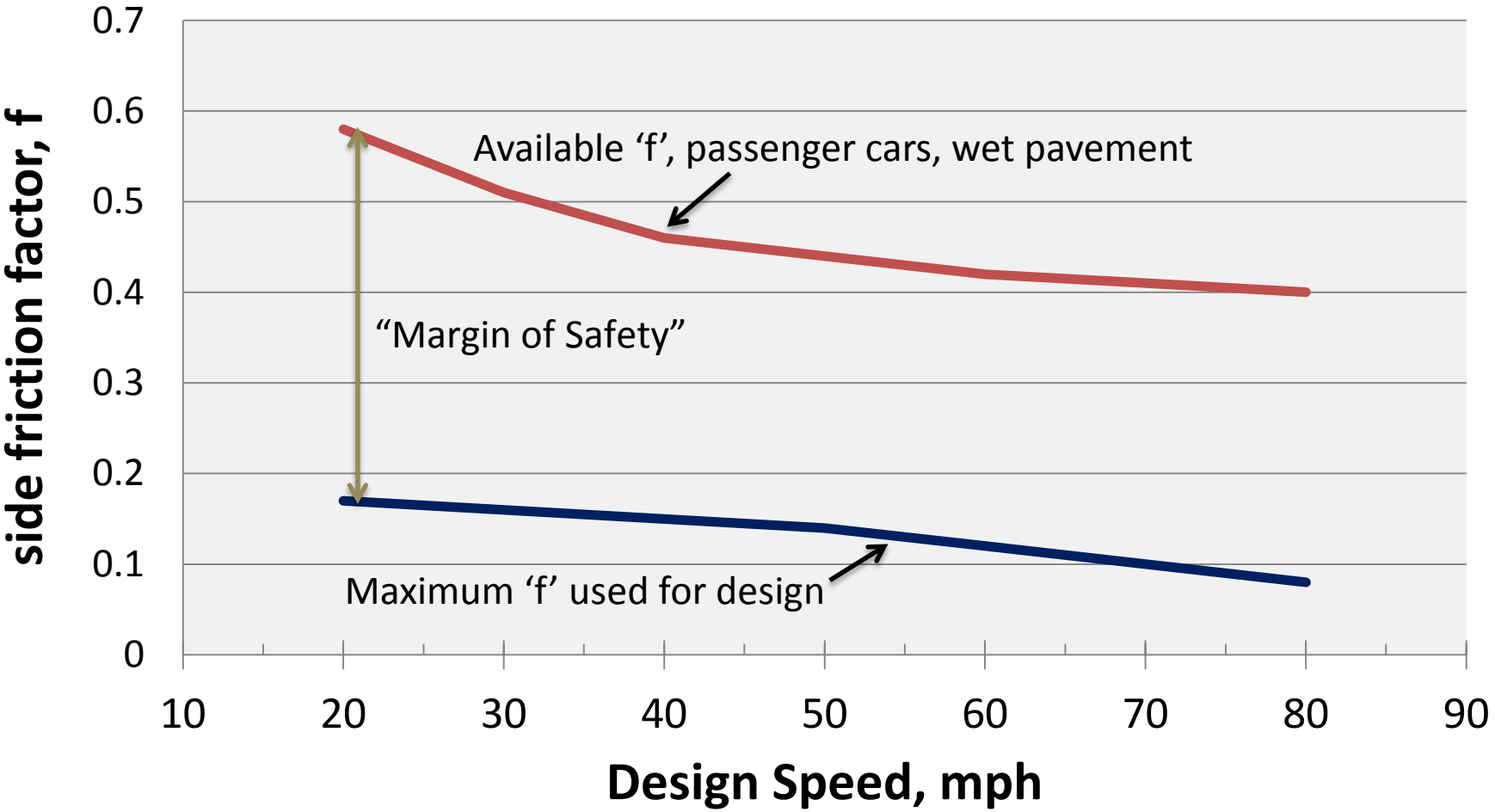
f_{max}: The point "at which discomfort due to the lateral acceleration is evident to drivers has been accepted as a design control for the maximum side friction factor on high-speed streets and highways."



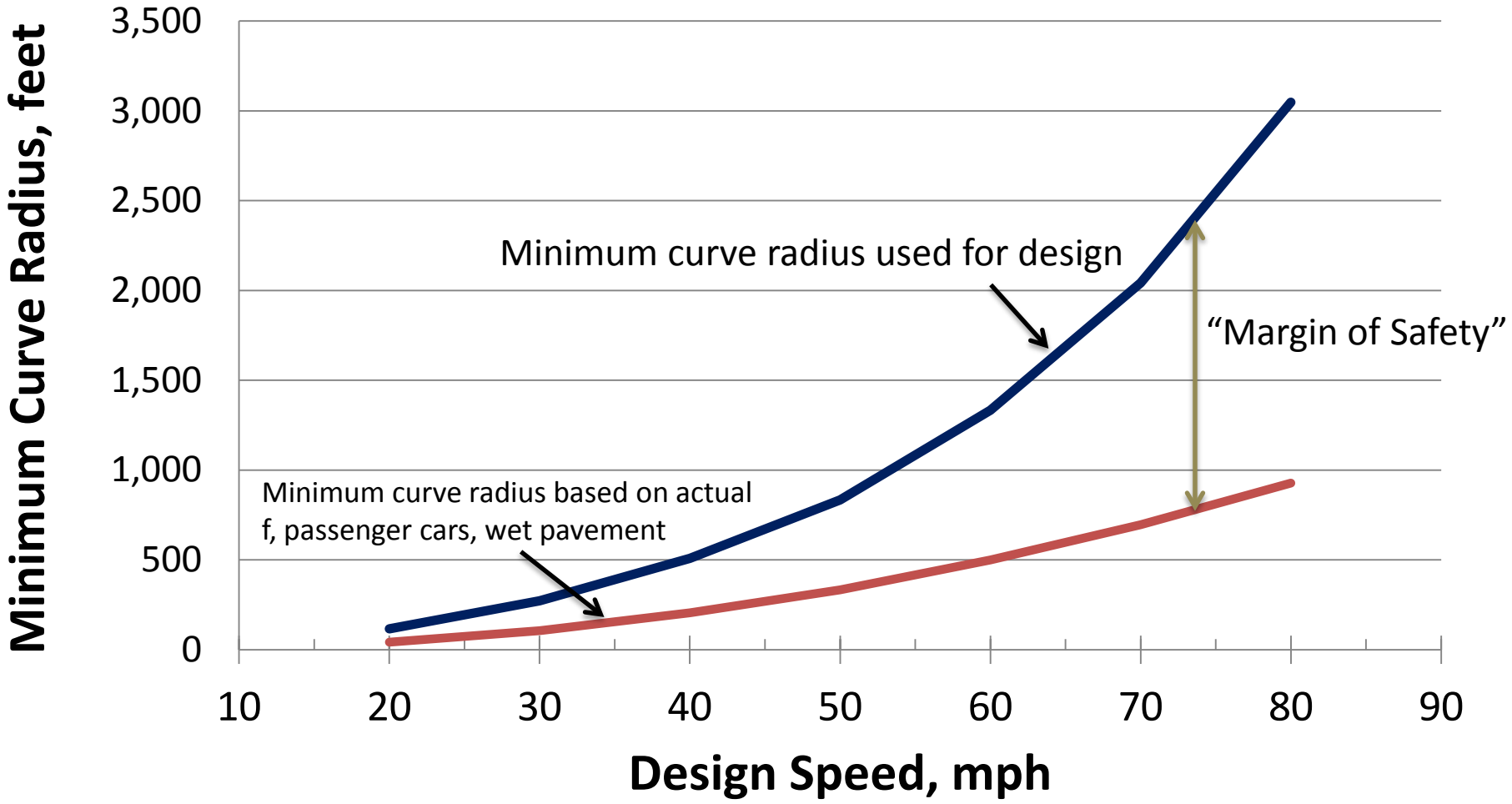
from AASHTO (2004)

Exhibit 3-12. Side Friction Factors Assumed for Design

“Limiting” Values?



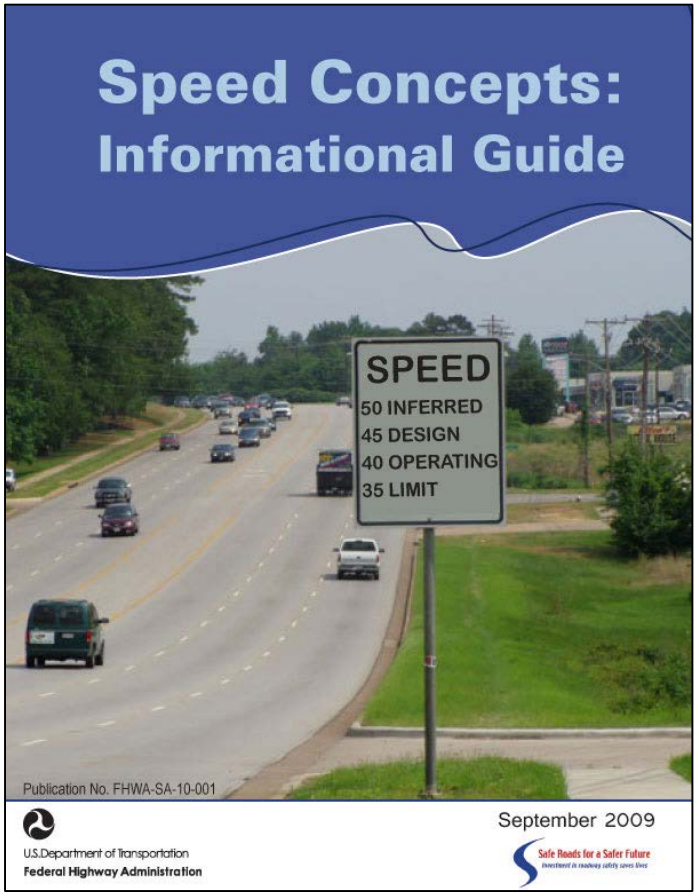
“Limiting” Values?



Roadway Design Guidance

"Above-minimum design values should be used, where practical…"

Inferred Design Speed



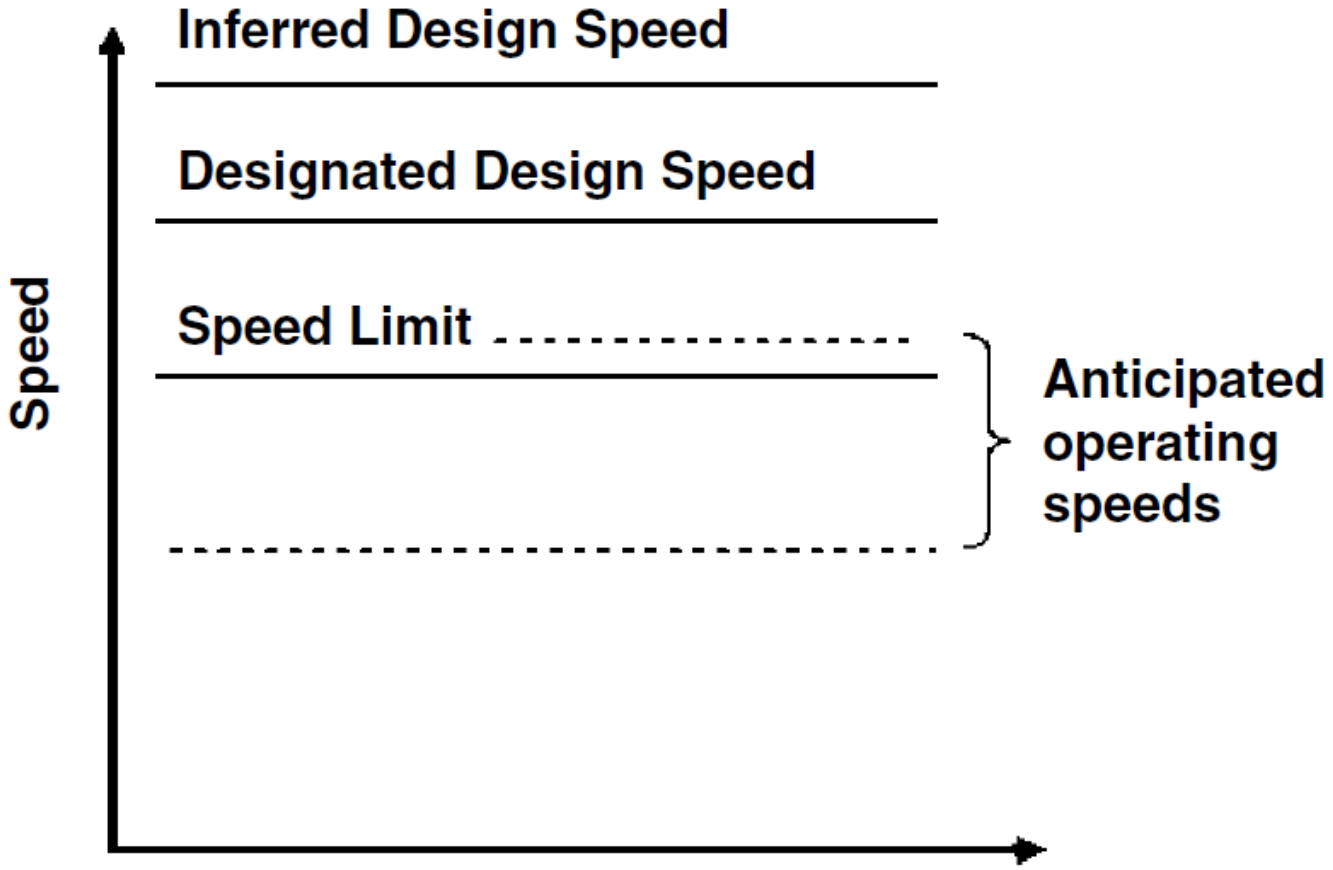
FHWA-SA-10-001

Maximum speed for which all critical design-speed-related criteria are met at a particular location

Inferred design speed of a feature differs from the designated design speed when the actual dimension differs from the criterion-limiting (minimum or maximum) value.

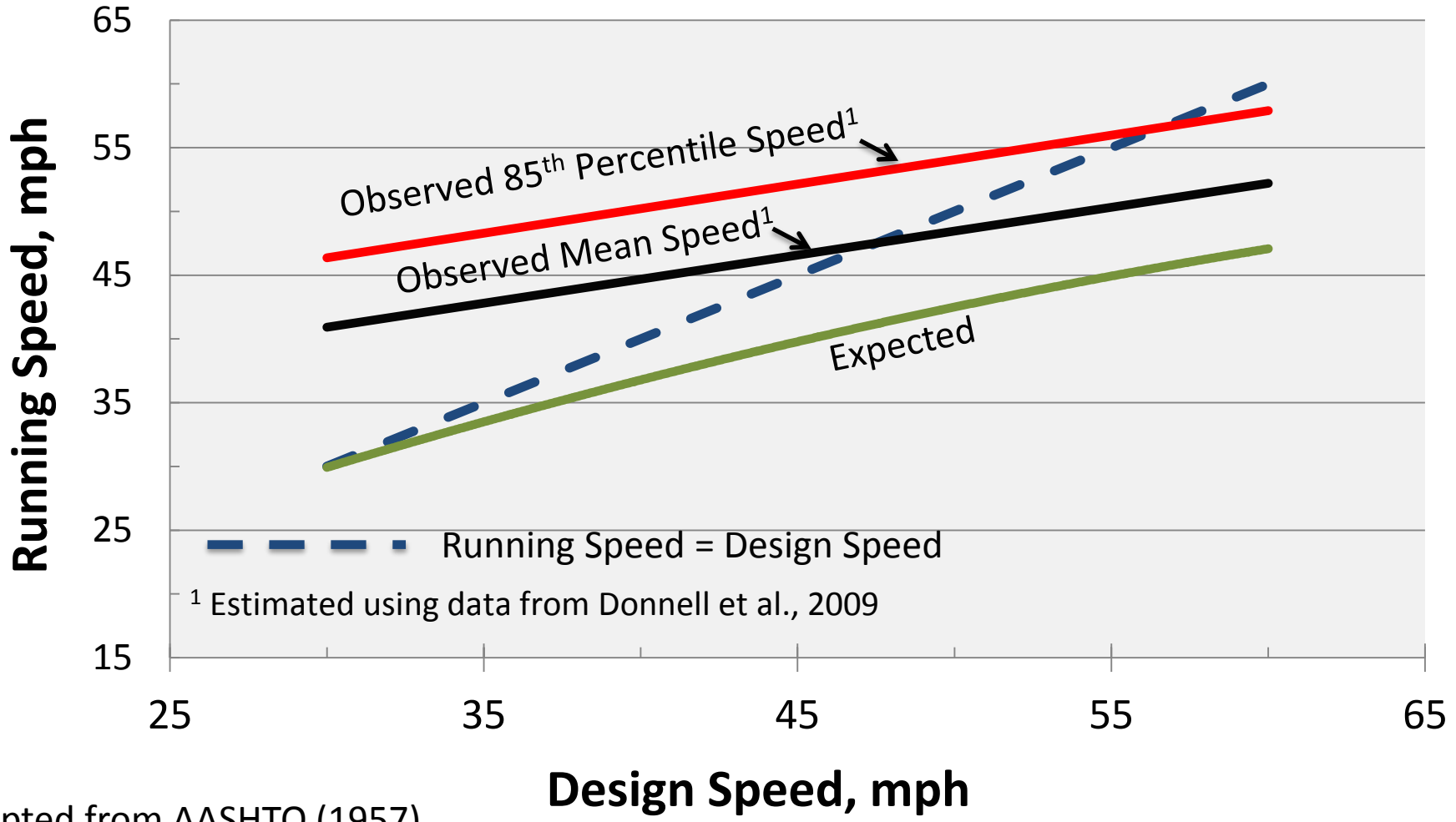
Speed Relationships in Design Process

As Intended…(with inferred design speed)

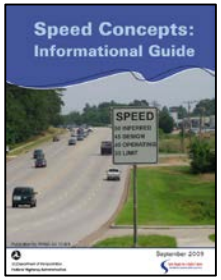


from Donnell et al. (2009)

Expected & Observed Relation Between Design and Running Speeds (Low-Volume)



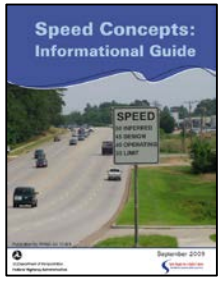
Adapted from AASHTO (1957)



Case Study: Blue Course Drive

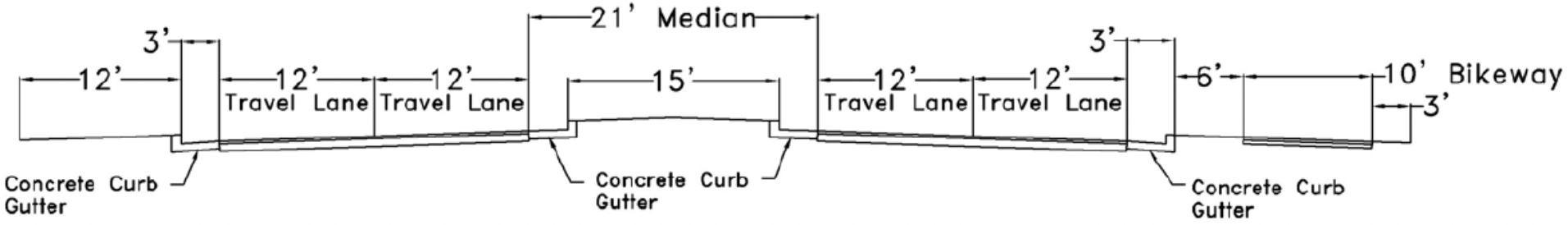
Ferguson Township, PA

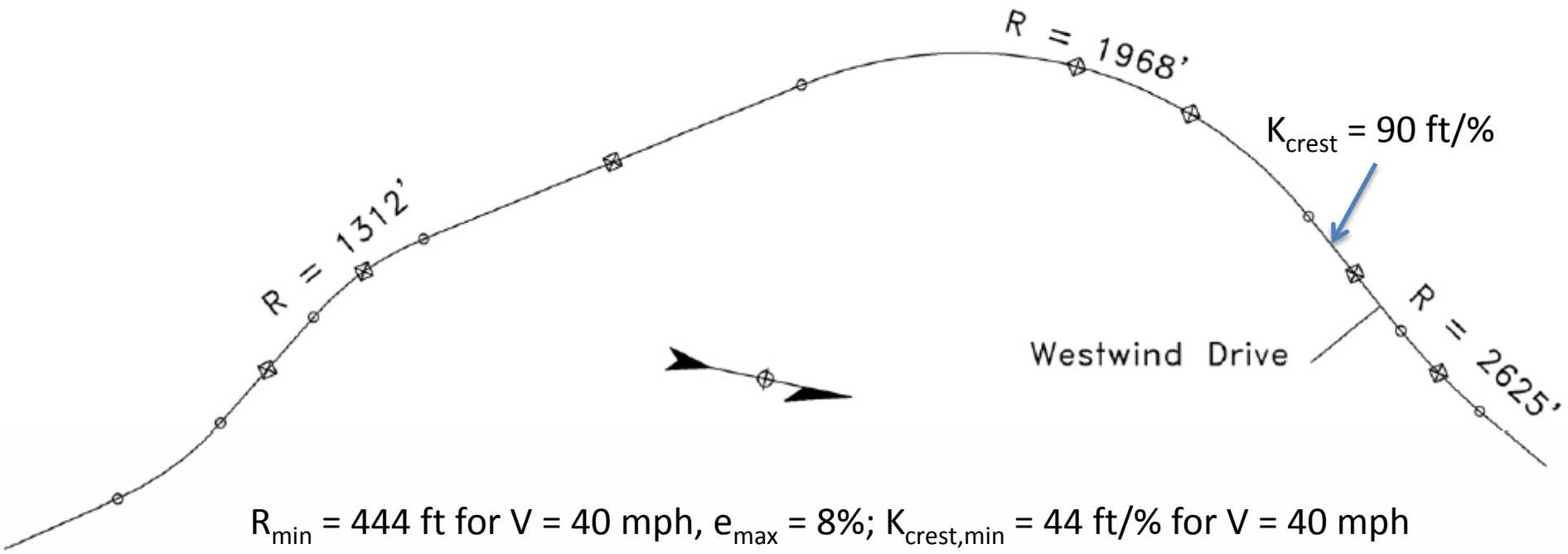
- New alignment ≈ 2002
- ADT ≈ 3,500
- Design speed: 40 mph
- Urban collector
- Segment length: 1.5 miles
- Horizontal curves: 3
- Maximum grade: +3.5%, -6.6%



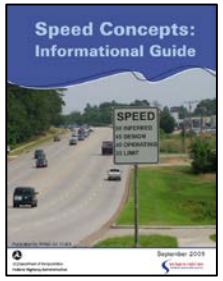
Case Study: Blue Course Drive

Ferguson Township, PA





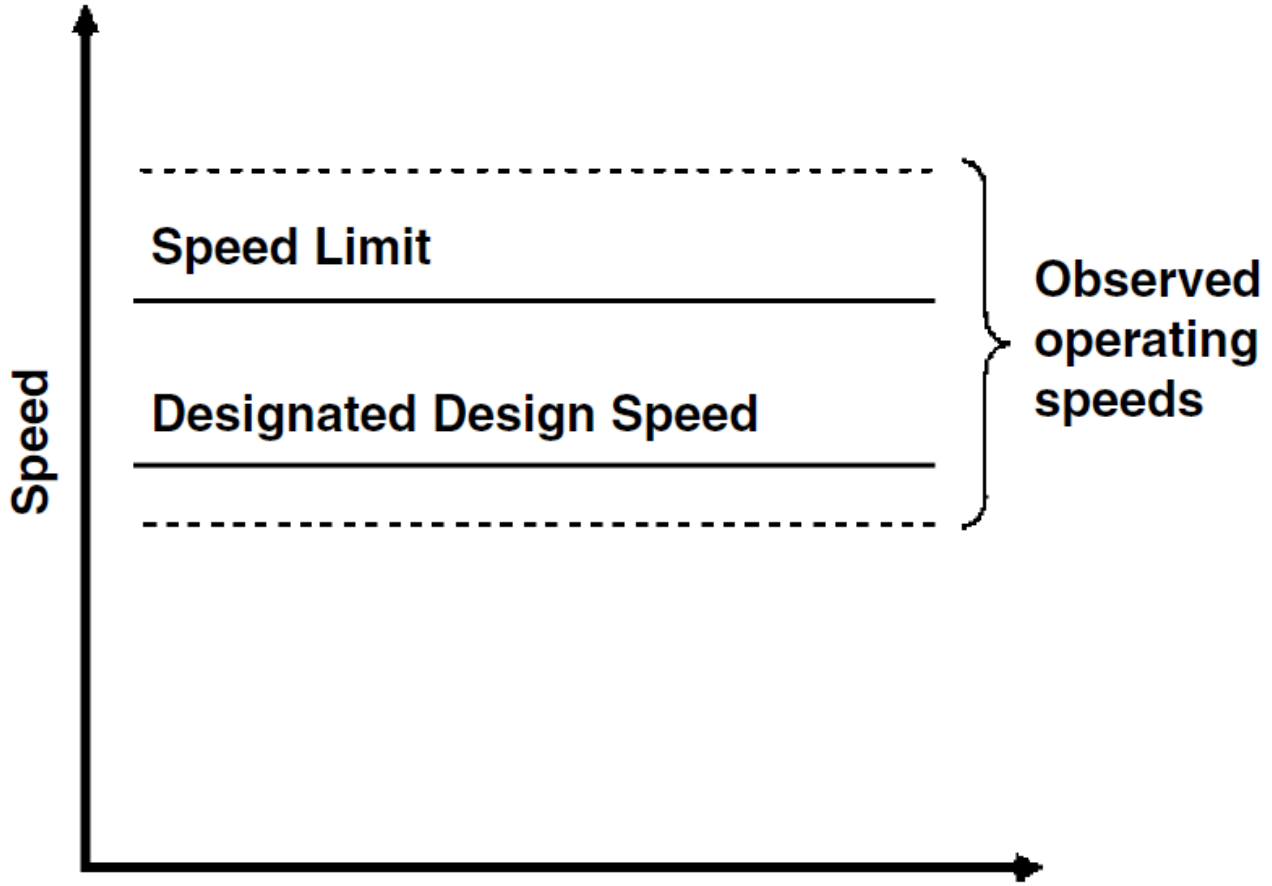
R_{min} = 444 ft for V = 40 mph, e_{max} = 8%; $K_{crest,min}$ = 44 ft/% for V = 40 mph



Case Study: Blue Course Drive

Ferguson Township, PA

Observed Speed Relationships?
Low to Moderate Design Speeds



from Donnell et al. (2009)

Speed Management Through Road Geometrics

"Self-Enforcing, Self-Explaining Roadway Design" from Porter et al. (2012)

1. What is known about relationships between road geometry and operating speeds?

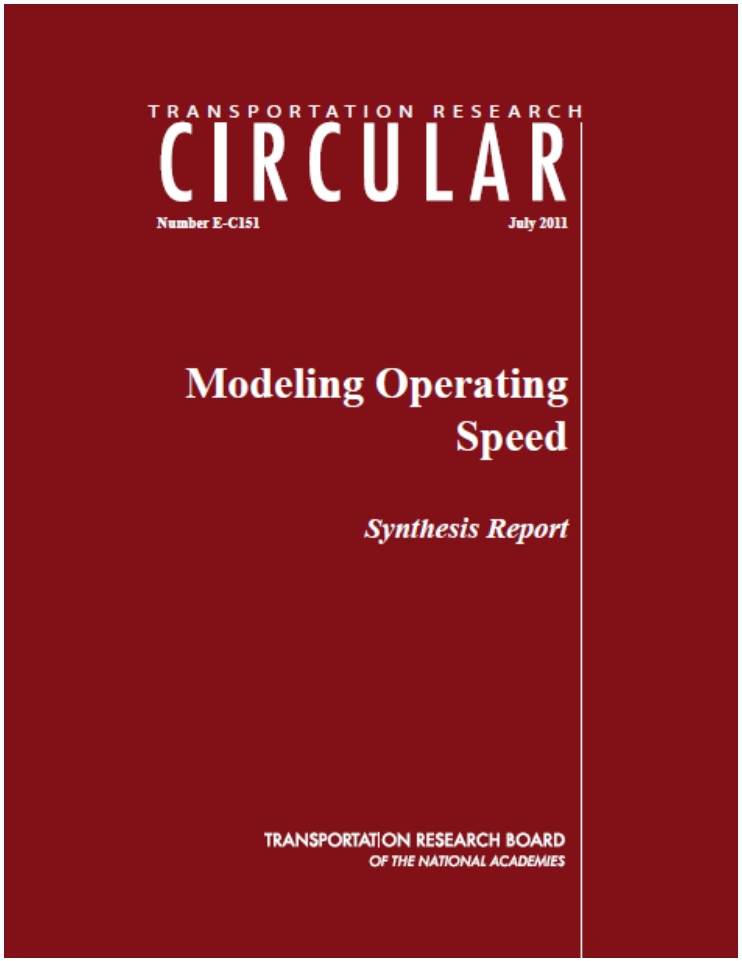
2. To what degree does road geometry influence operating speeds?

3. How are safety and security influenced by road geometry?

4. What are potential impacts to large vehicles?

5. What is the nature of the speed-safety trade-off?

What is known about relationships between road geometry and operating speeds?



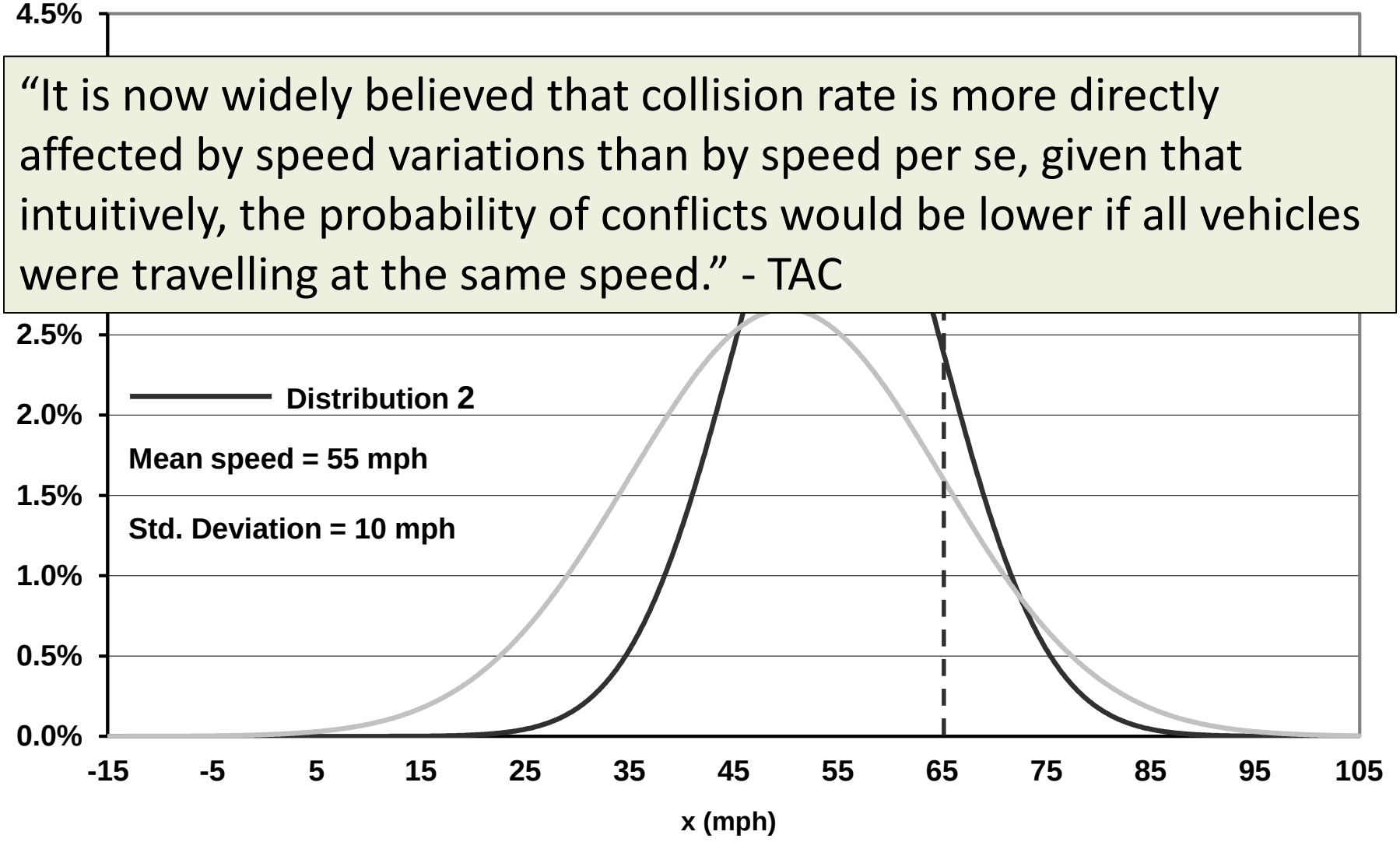
a synthesis of existing operating speed models developed in different regions of the world.

10 authors from 5 different countries

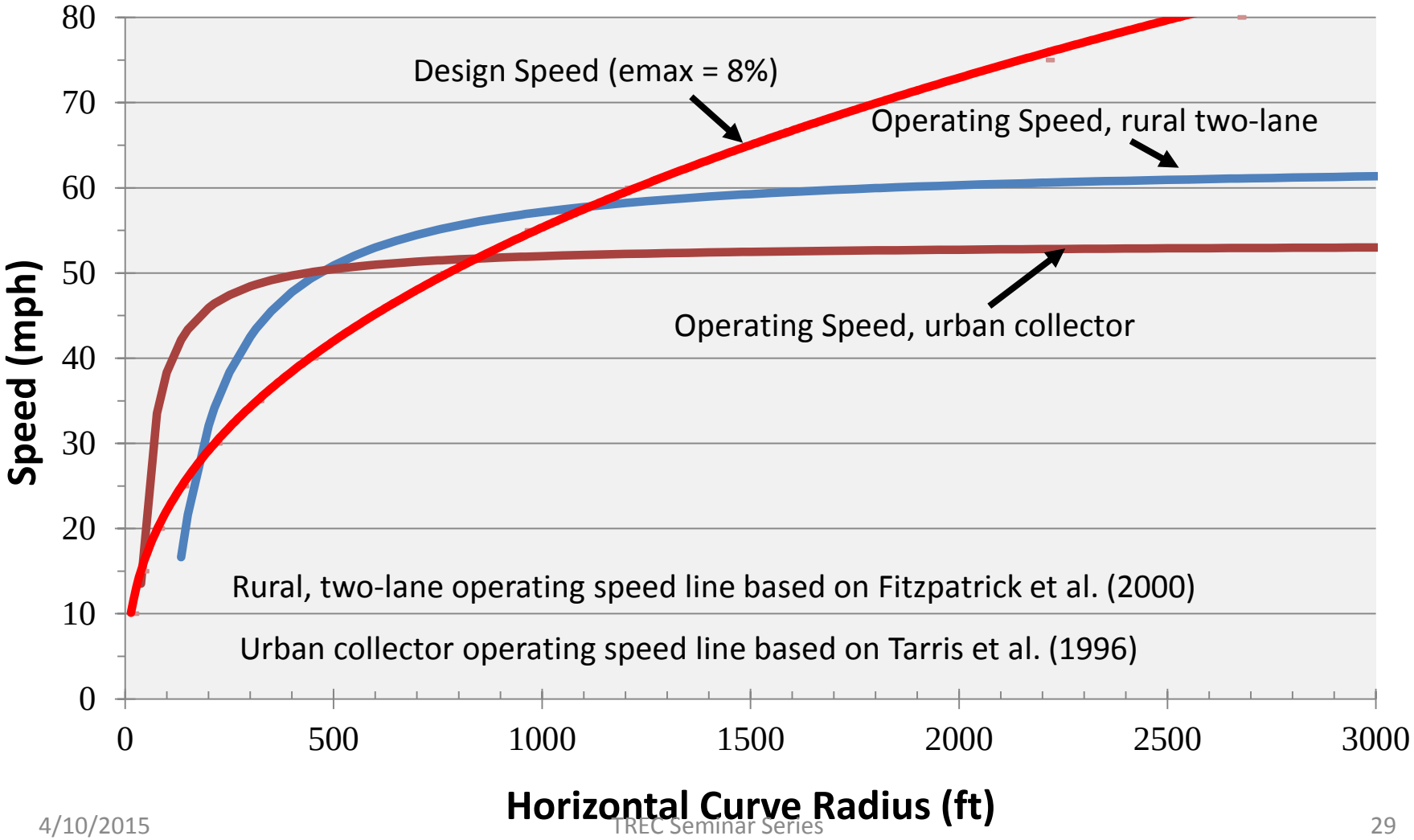
Much of what we know in North America is for rural, two-lane highways

What is known about relationships between road geometry and operating speeds?

"It is now widely believed that collision rate is more directly affected by speed variations than by speed per se, given that intuitively, the probability of conflicts would be lower if all vehicles were travelling at the same speed." - TAC



To what degree does road geometry influence operating speeds?



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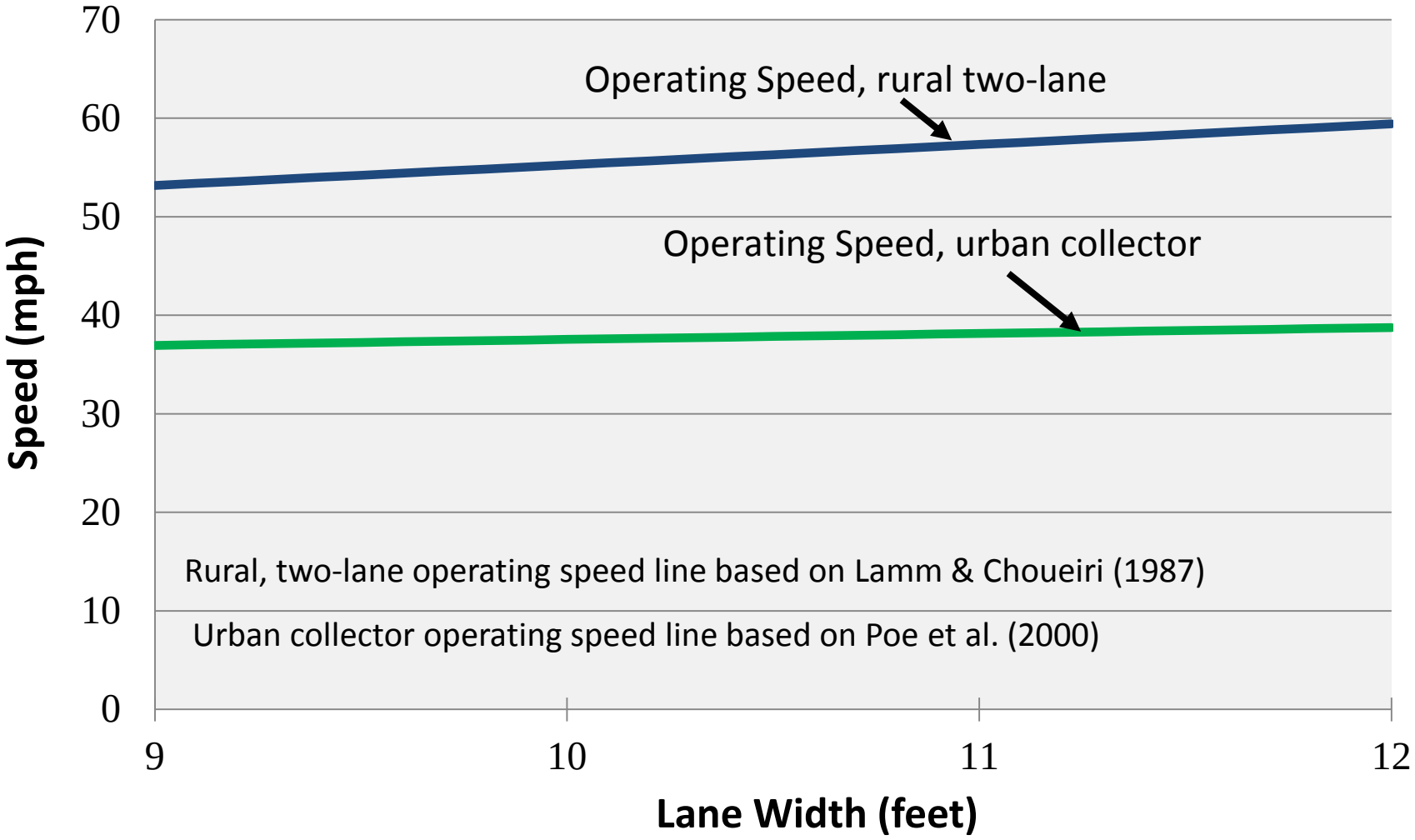
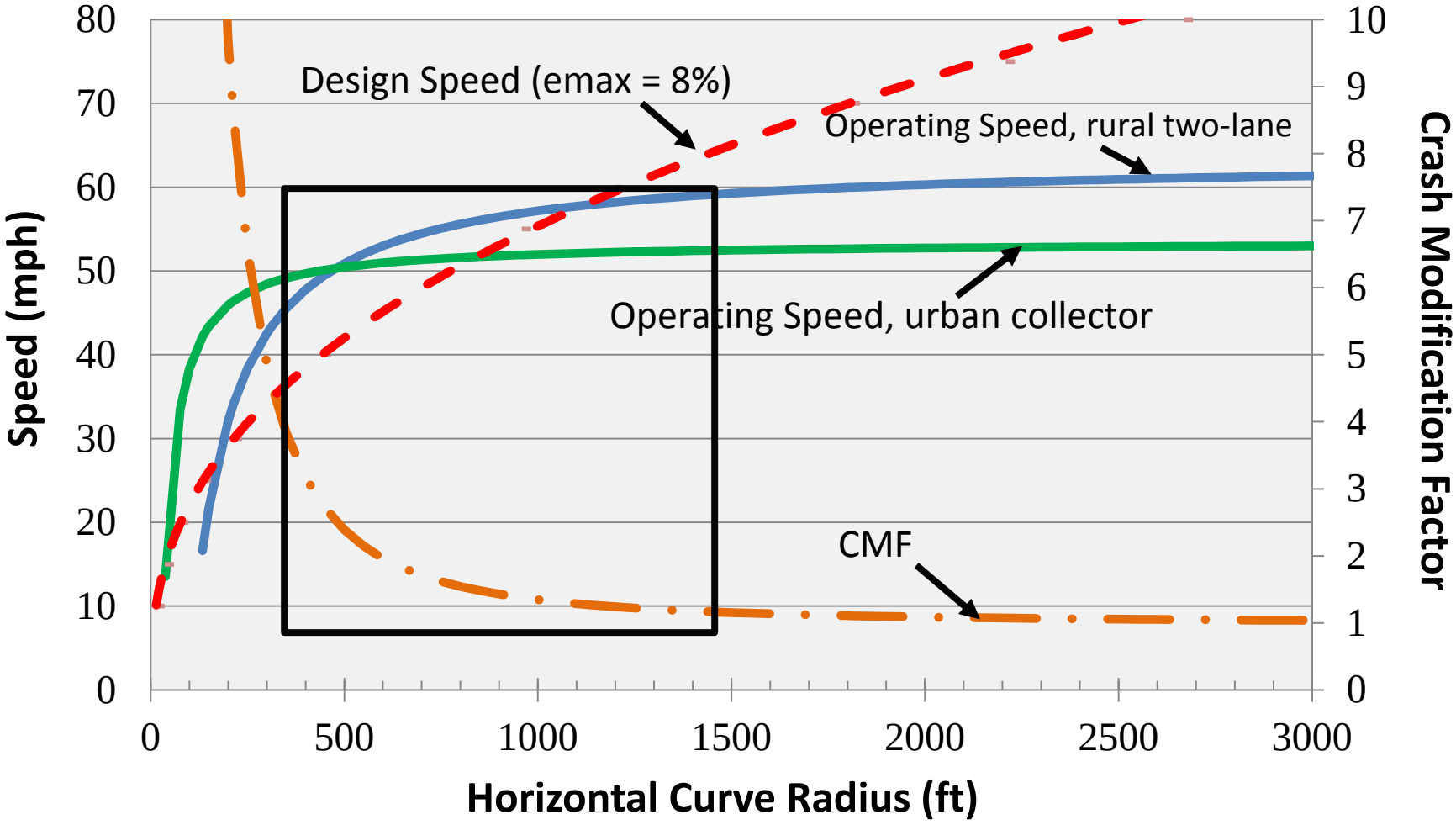
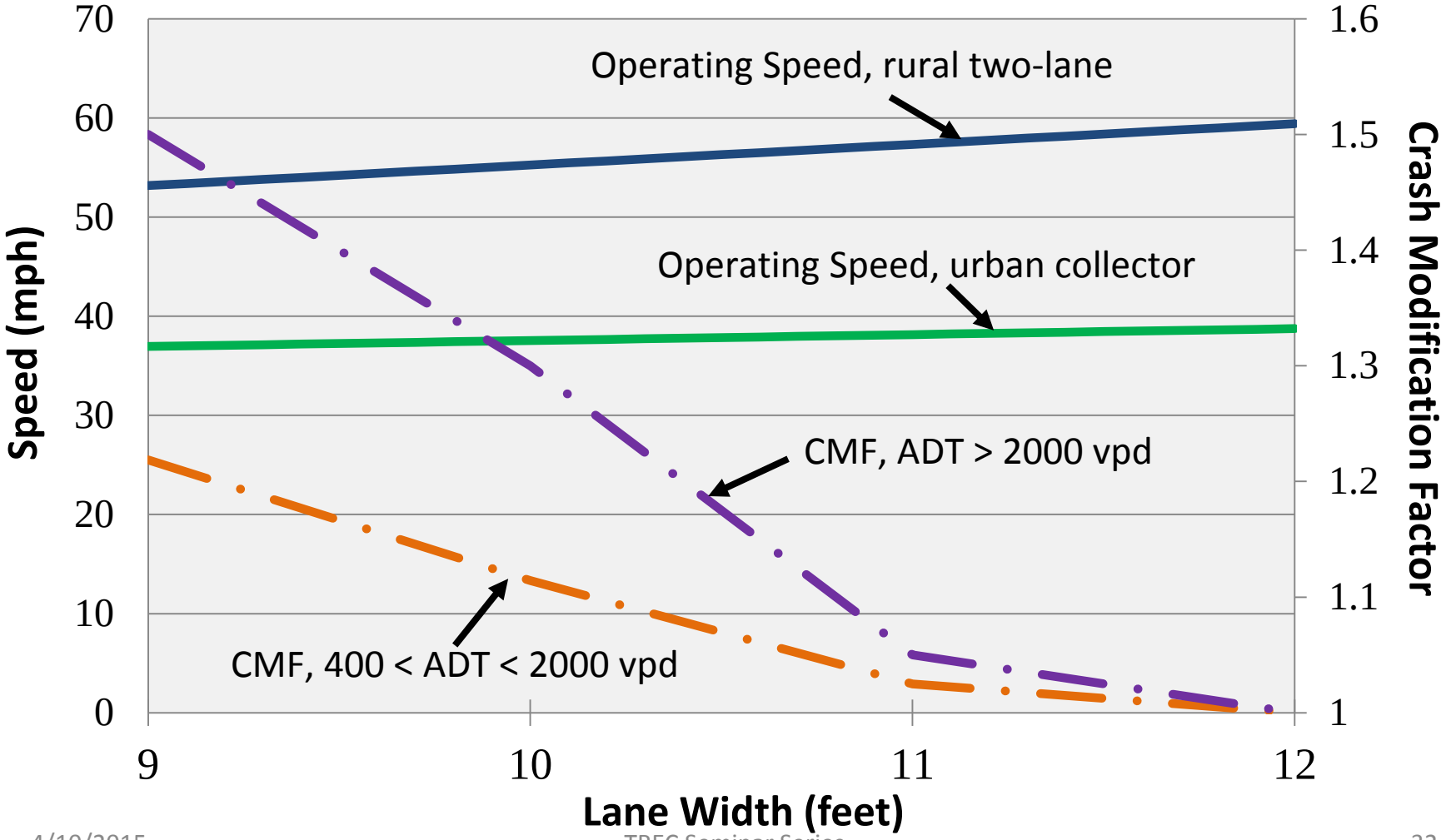


What is the nature of the speed-safety trade-off?



What is the nature of the speed-safety trade-off?



Summary and Conclusions

- Design speed as “safe speed” still reflected in design speed descriptions
- Operating speeds > design speeds when design speeds < 55mph
- No safety support for ‘desirable’ versus ‘undesirable’ speed relationships
- Five questions offered related to speed management through roadway geometrics

Geometric Design, Speed, and Safety

Some possible research recommendations…

From 2009 “Need for Speed” Workshop

We need a process where *speed-related transportation outcomes* of highway and street design alternatives/decisions are *quantified*…

From 2009 “Need for Speed” Workshop

…and the *speed-related decision rationale* are consistent and explainable to a variety of user groups and stakeholders

slide adapted from Mahoney (2006)

Back to the Big Picture

Direct Transportation Support

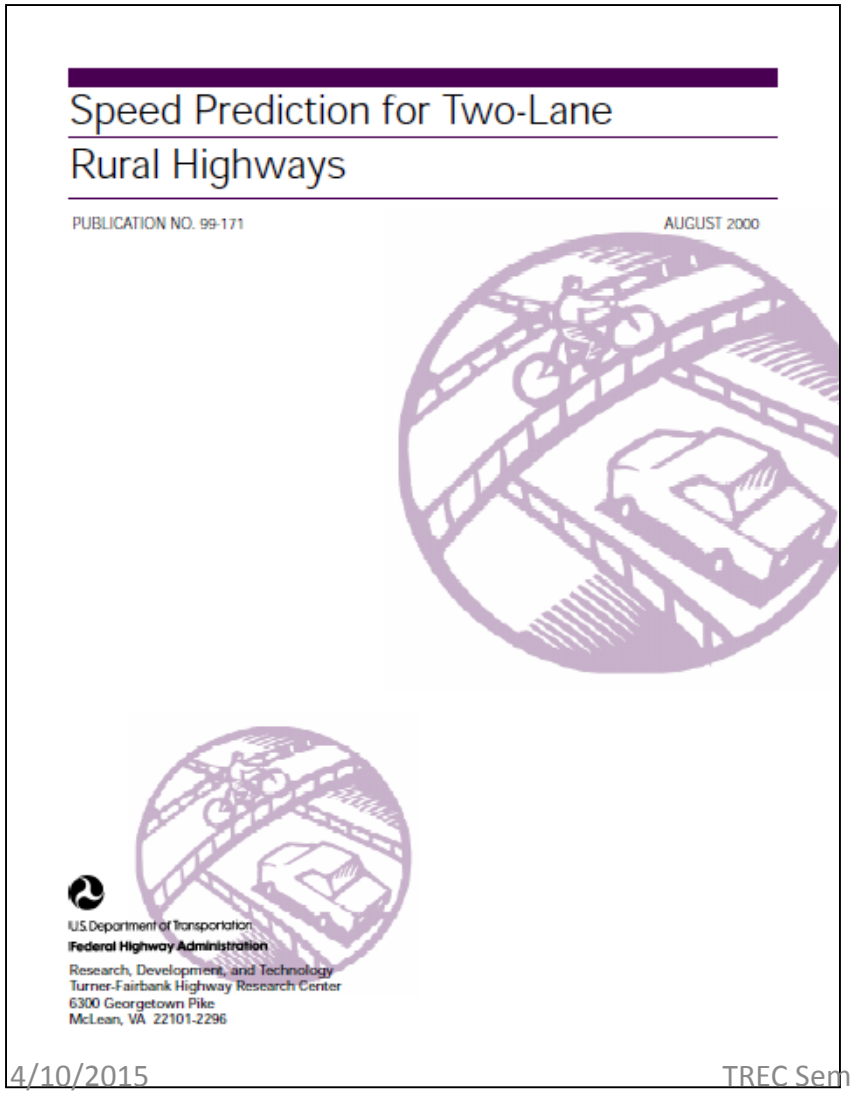
- Accessibility
- Mobility
- Quality of service
- Reliability
- Safety

- Community life
- Cultural enrichment
- Ecological health
- Economic prosperity
- Equity & Justice
- Personal health
- Social interaction

→ Geometric Design and Speed Sensitivity?

Recommendations

Combine Speed and Safety Studies



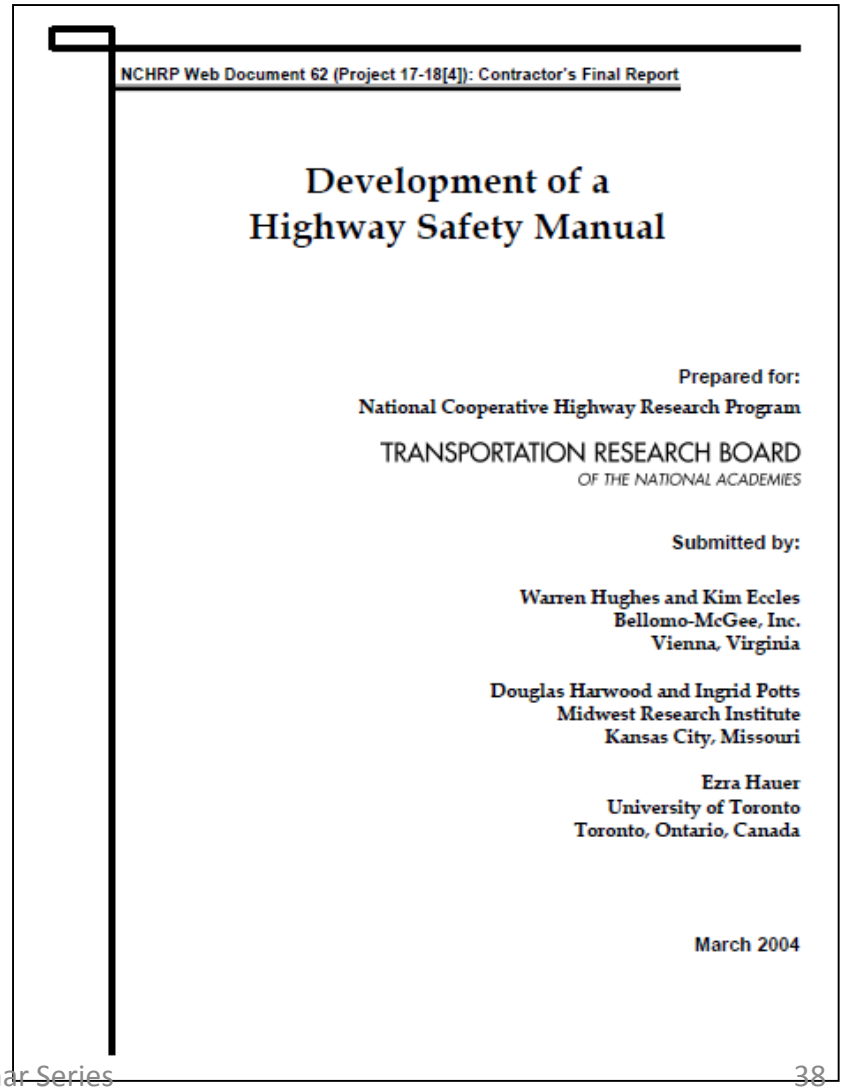
Speed Prediction for Two-Lane Rural Highways

PUBLICATION NO. 99-171

AUGUST 2000

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296



NCHRP Web Document 62 (Project 17-18[4]): Contractor's Final Report

Development of a Highway Safety Manual

Prepared for:
National Cooperative Highway Research Program

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Submitted by:

Warren Hughes and Kim Eccles
Bellomo-McGee, Inc.
Vienna, Virginia

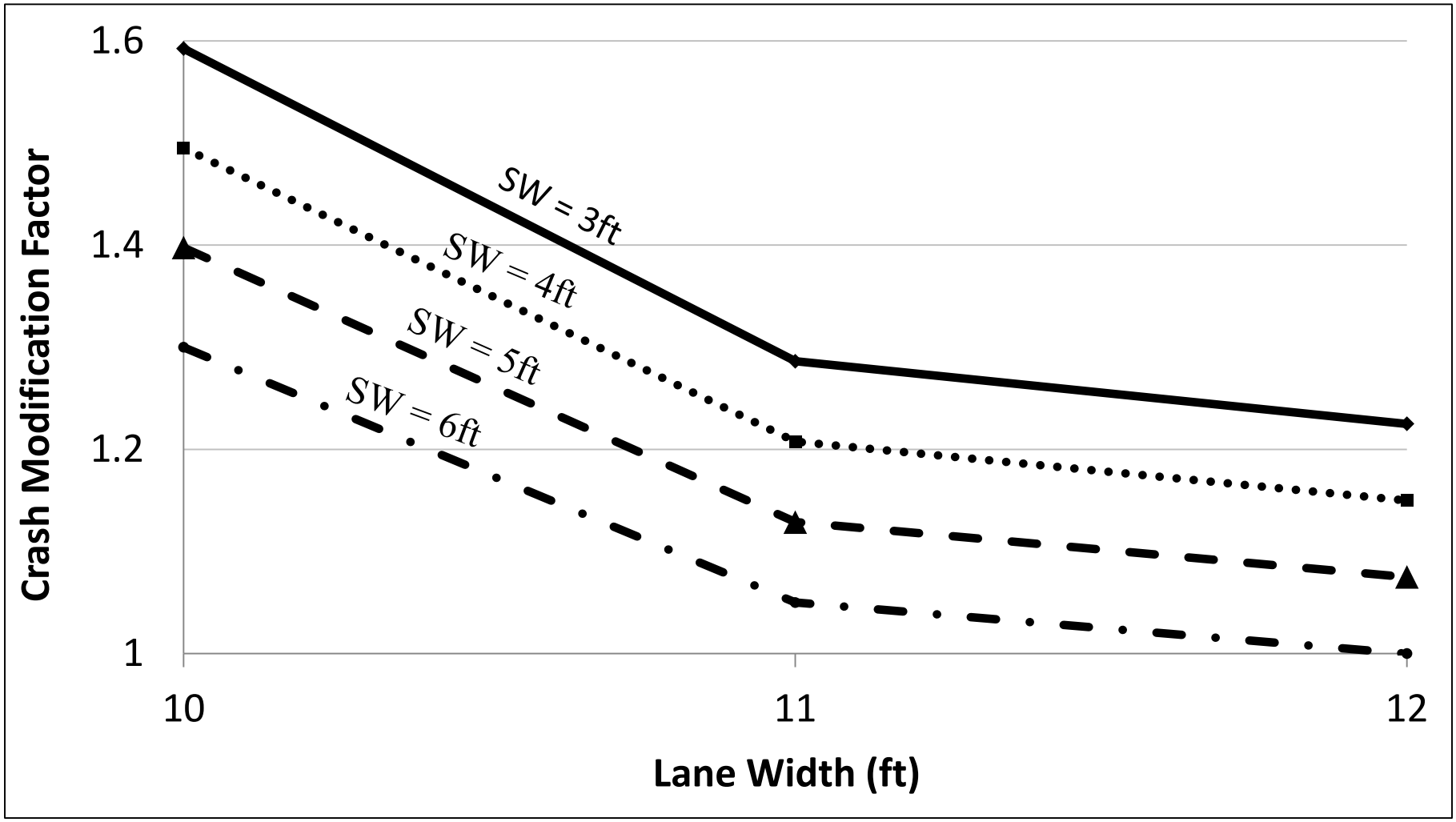
Douglas Harwood and Ingrid Potts
Midwest Research Institute
Kansas City, Missouri

Ezra Hauer
University of Toronto
Toronto, Ontario, Canada

March 2004

Recommendations

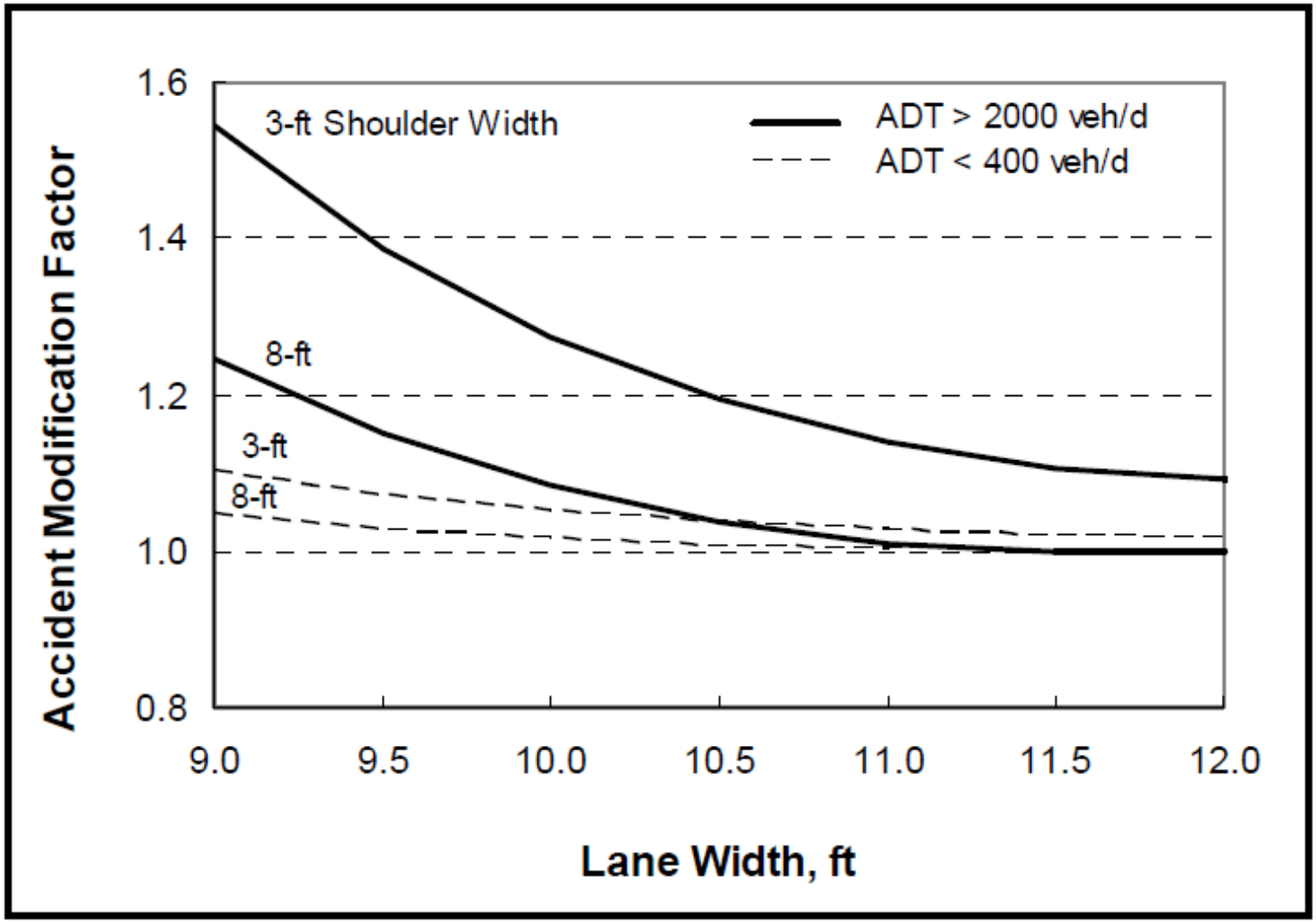
Consider Criteria Combinations



Recommendations

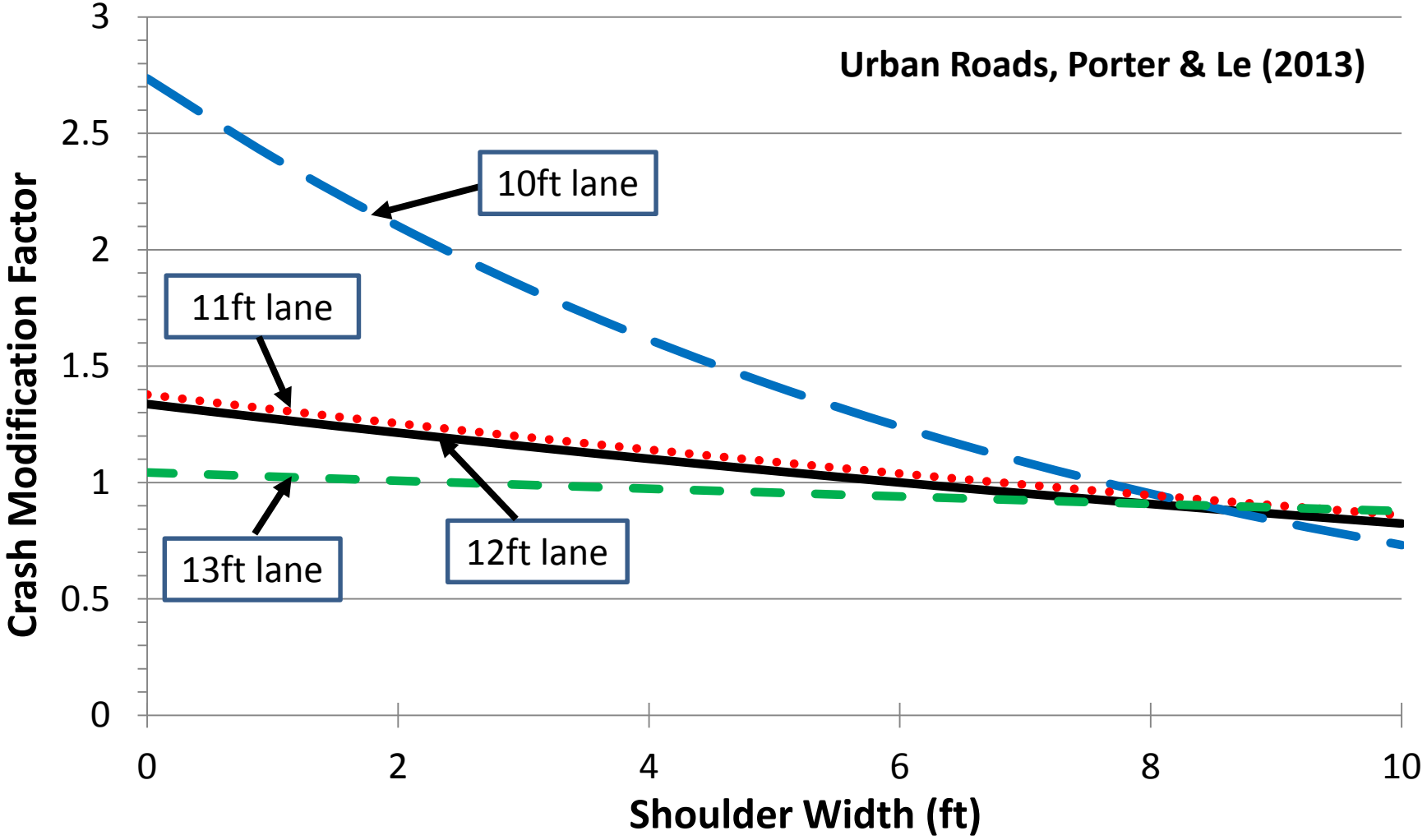
Consider Criteria Combinations

Rural, Two-Lane Highways from Bonneson & Pratt (2009)



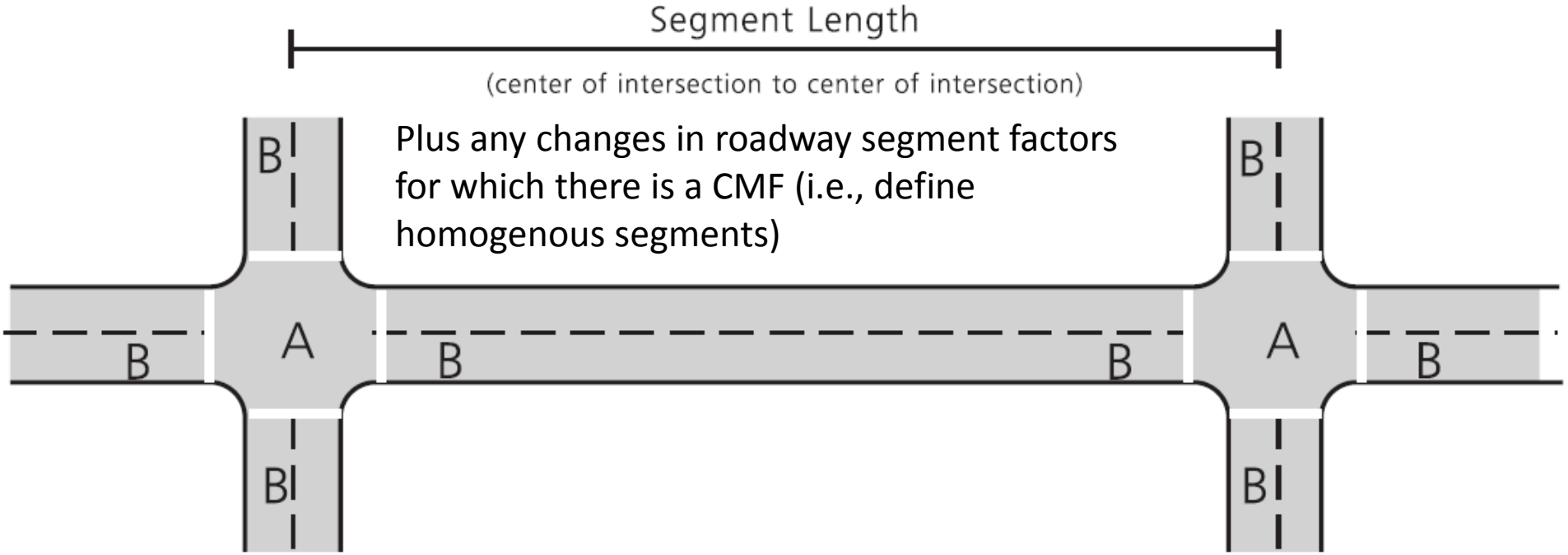
Recommendations

Consider Criteria Combinations



Recommendations

Consider more than "Site Specific Effects"



A All crashes that occur within this region are classified as intersection crashes.

B Crashes in this region may be segment or intersection related, depending on the characteristics of the crash.

From Highway Safety Manual (2010)

Questions

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THE UNIVERSITY OF UTAH