NCHRP

Project 17-47

Human Factors Guidelines for Road Systems—Phase IV Task 9 Conduct Pilot Testing of the HFG

Final Report

By

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The Business *of* Innovation

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO ....American Association of State Highway and Transportation Officials
DOT ....Department of Transportation
FHWA.. Federal Highway Administration
FYA .... Flashing Yellow Arrow
HFG .... Human Factors Guidelines
HSCA..Highway Safety Corridor Analysis
HSIP.. Highway Safety Improvement Program
HSM.. Highway Safety Manual
ITD..Idaho Transportation Department
ITE .... Institute of Transportation Engineers
ITS ....Intelligent Transportation System
MUTCD.. Manual on Uniform Traffic Control Devices
NCHRP ....National Cooperative Highway Research Program
NDOT .... Nevada Department of Transportation
POC.. Point-of-Contact
RSA.. Road Safety Audit

SECTION 1: INTRODUCTION

A number of existing guides, standards, and references are available to facilitate safe roadway design and operational decisions, including the *American Association of State Highway and Transportation Officials (AASHTO) Green Book*, the *Manual on Uniform Traffic Control Devices (MUTCD)*, and the *Highway Safety Manual*. These materials, however, often lack a substantive presentation and discussion of human factors principles and concepts that could be used by highway designers and traffic engineers to improve roadway design and traffic safety. While it is widely acknowledged that traffic safety reflects the consideration and integration of three components—the roadway, the vehicle, and the roadway user—existing references applicable to road system design have limitations in providing highway designers and traffic engineers with adequate guidance for incorporating road user needs, limitations, and capabilities when dealing with design and operational issues.

In response to this need, the National Cooperative Highway Research Program (NCHRP) carried out a series of projects (Projects 17-18(8), HR 17-31, HR 17-41, and HR 17-47) resulting in the development of a new resource document for highway designers, traffic engineers, and other practitioners. The purpose of the Human Factors Guidelines (HFG) document, as stated in the original Statement of Work for the project, was "to provide the best factual information and insight on road users' characteristics in a useful CD-ROM format to facilitate safe roadway design and operational decisions." The HFG is intended to be a resource document for highway designers, traffic engineers, and other practitioners. In Phase I of the HFG effort (summarized in Lerner, Llaneras, Smiley, & Hanscom, 2004), the objective was to "lay the groundwork for a first edition of the HFG." Phase II of the HFG effort resulted in an interim guidelines document (Campbell, Richard, & Graham, 2008). Phase III of the HFG development resulted in the addition of five new chapters to the existing guidelines document, and Phase IV of the project resulted in a complete guidelines document, *Human Factors Guidelines for Road Systems, Report 600, Second Edition* (Campbell et al., 2012).

This report describes the activities and results associated with an additional Task 9: Conduct Pilot Testing of the HFG Document, which was added to the Phase IV project following completion of the Second Edition. The objective of Task 9 was to conduct pilot testing of the HFG in a few select states to assess the HFG's value and efficacy. Task 9 activities took place during the period of approximately June 2012 to April 2014. Our general approach consisted of five key steps:

1. Identify states willing to participate in a 3-16 month pilot test of the HFG.

2. Work with key participants/points-of-contact (POCs) in those states and develop a general plan for how the HFG will be used and a schedule for the pilot test, distribute the HFG to end users, to communicate the purpose and use of the HFG to end-users, and schedule/conduct a training session with state-level end-users.

3. After the training and during the pilot testing, support the individual participants/pilot states by answering questions as they came up during the testing and maintaining communications with the key points-of-contact.

4. Collect evaluation data from participants during and at the end of the pilot testing period.

5. Prepare a report documenting the objectives, methods, and results of the pilot testing.

This report constitutes Step 5 of Task 9 and contains the following sections:

- Section 2 describes the training and evaluation methods used at the pilot test sites.
- Section 3 describes the evaluation results provided by the state-level POCs following their training sessions and subsequent use of the HFG document.
- Section 4 provides conclusions of the pilot test and evaluation process and results.
- Appendices A through C provide copies of the training and evaluation materials used at the pilot test site training sessions.

SECTION 2: METHODS

The objective of Task 9 was to conduct pilot testing of the HFG and assess the usefulness of the HFG to roadway designers and traffic engineers, and other end-users. Task 9 activities took place between approximately June 2012 (when outreach and recruitment activities directed to the states began) to April 2014 (when the evaluations ended).

IDENTIFY PARTICIPANT STATES

Outreach activities to recruit states interested in participating in the pilot testing included attendance and an HFG presentation at four meetings:

- AASHTO Standing Committee on Highway Traffic Safety on May 3, 2012.
- Northeast Association of State Transportation Officials on June 10, 2012.
- AASHTO Subcommittee on Safety Management on August 30, 2012.
- AASHTO Traffic Engineering and Highway Traffic Safety Meeting on June 24, 2013.

Our strategy was to persuade lead states that participated in early implementation of the *Highway Safety Manual* (HSM) to do the same with the HFG. As a result of these outreach activities and subsequent discussions with interested POCs from the states, the following five states participated in the pilot testing: Arizona, Delaware, Idaho, Nevada, and Wisconsin.

PILOT TESTING ACTIVITIES

Pilot testing activities included distributing electronic and/or hard copies of the HFG to states who agreed to participate in the evaluations, and providing training sessions on how to use the HFG directly to state Department of Transportation (DOT) staff and others identified by the POCs as likely end users. Training sessions consisted of the 2-hour training presentation developed in Phase IV, supported with additional handouts (see Appendix A: HFG for Road Systems – Topic Summaries and Appendix B: Using the HFG during an RSA [Road Safety Audit]). The three key goals of the presentation were to provide end users with the information and ability to:

1. Recognize the value in bringing road user capabilities and limitations into roadway design and traffic engineering.

2. Find guidelines and interpret the presentation of guidelines in the HFG.

3. Use the HFG as a resource for implementing human factors into highway design and traffic engineering projects.

In addition to providing basic training on the HFG, these sessions were used to communicate key objectives of the pilot testing, including critical evaluation questions for the content, format, organization, and efficacy of the HFG. All end users were provided with a set of evaluation questions to help guide their assessment activities (see Appendix C: HFG Evaluation Questions).

Table 1 provides a summary of the five pilot test site characteristics.

Table 1. Overview of the HFG pilot test sites.

State	POC	How the Site Used the HFG	Date of Training / Number of Attendees
Arizona	Kohinoor Kar, PhD, PE, PTOE Transportation Safety Engineer 1615 W. Jackson Street, MD 065R Phoenix, AZ 85007 602.712.6857 KKar@azdot.gov Also, Maysa Hanna (MHanna@azdot.gov) & Mark Poppe (MPoppe@azdot.gov)	• Used the HFG in an "ad-hoc" fashion, with staff most likely to get value from the HFG being provided with the training and then asked to use it day-to-day as they see fit. • Battelle was "on-call" to assist Arizona DOT in identifying solutions in the HFG for specific trouble spots. • Used the HFG as part of 7 rural and urban RSAs: 2 rural freeways, an urban freeway, and 2-lane rural arterial, an urban arterial signalized intersection, a suburban arterial, and an urban arterial.	October 11, 2013 / 39
Delaware	Mark Luszcz, P.E., PTOE Chief Traffic Engineer Delaware Department of Transportation 169 Brick Store Landing Road Smyrna, DE 19977 P: (302) 659-4062 F: (302) 653-2859 mark.luszcz@state.de.us Adam S. Weiser, P.E., PTOE Safety Programs Manager P: (302) 659-4073 F: (302) 653-2859 C: (302) 222-5905 E: Adam.Weiser@state.de.us	• Used the HFG in an "ad-hoc" fashion, with staff most likely to get value from the HFG being provided with the training and then asked to use it day-to-day as they see fit. • Battelle assisted Delaware DOT in identifying solutions in the HFG for specific trouble spots (specifically, a high-crash location: US 113 at Kruger Road/Wood Branch Road & US 113 at Alms House Road/Speedway Road).	July 22, 2013 / 43 January 31, 2014 / 5
Idaho	Brent Jennings, P.E. Highway Safety Manager Idaho Transportation Dept. 3311 W State Street Boise ID (208) 334-8557 brent.jennings@itd.idaho.gov	• Incorporating use of the HFG as part of a new "Highway Corridor Safety Analysis Project" to help prioritize safety improvement needs and project across the state. • Implementation details include the requirement in ITD project charters (project planning documents) that human factors be examined and considered as part of the safety analysis / design process. • Used both the HSM and the HFG to identify and assess "priority segments."	December 5, 2012 / 20 January 30, 2014 / 18

State	POC	How the Site Used the HFG	Date of Training / Number of Attendees
Nevada	Jaime B. Tuddao, P.E. NDOT Senior Safety Engineer Safety Engineering Division 1263 S. Stewart Street Carson City, Nevada 89712 775 888 7467 jtuddao@dot.state.nv.us Chuck Reider, P.E. NDOT Chief Safety Engineer Safety Engineering Division 1263 S. Stewart Street Carson City NV 89712 775-888-7335 creider@dot.state.nv.us	• Used the HFG to assist road safety audits and annual reviews of high-crash sites involving intersections. • Incorporating the HFG into NDOTs RSA program • The “Tropicana” RSA examined a 7-mile corridor, and was intended to look at safety issues from a different perspective and develop recommendations for potential safety enhancements. • Used the HFG to conduct 3 RSAs: (1) Swenson Twain Road, (3) Blue Diamond Road, and (4) Elkhorn Road & Cimarron Road.	December 18, 2012 (Carson City) / 30 February 28, 2013 (Las Vegas) / 15
Wisconsin	Rebecca Y. Szymkowski, P.E., PTOE State Traffic Engineer of Operations/Traffic Supervisor Wisconsin Department of Transportation Bureau of Traffic Operations 4802 Sheboygan Avenue, Room 501 Madison, WI 53707 Office: 608.266.9381 Cell: 608.219.6917 Fax: 608.261.6295 rebecca.szymkowski@dot.wi.gov	• The initial focus was on the I-94 East/West project, which is a planning-level engineering analysis. The project includes one system interchange and five service interchanges. Using the HFG to support the RSA element of the project. • Additional application of the HFG was conducted to support a RSA of STH-29 and STH-49 / Willow Drive in Central Wisconsin.	February 21, 2013 / 14 October 29, 2013 / 6

Training for the Pilot States

As noted above, the 2-hour training materials developed as part of this project formed the basis for the training of the participants in the pilot study. Presentation topics included:

- Overview of the HFG project and the complementary role the HFG plays as the human factors part of a suite of design resources which include the *Roadside Design Guide*, AASHTO’s *Geometric Design of Highways and Streets* (Green Book), and the recently-released *Highway Safety Manual*, among others. This overview included a description of human factors issues in roadway design and a summary of the guideline development process.
- Discussion and examples of common traffic design problems as they relate to road user abilities and challenges.
- Description of the HFG document (content, and organization) and two-page guideline format.

- Examples of design issues involving human factors elements and how the HFG can provide information to enhance the roadway solution.

Also, the use of the HFG as a resource for RSAs was not originally included in the training sessions. As it became clear that pilot test states were looking to use the HFG in this way, however, the RSA worksheet and slides were developed in early 2013 and added as an example to use in subsequent training sessions (see also Appendix B).

HFG Evaluations

All attendees of the trainings were provided with an HFG Evaluation format the end of the session and requested to provide comments following their actual use of the HFG document, whether it provided information of value, how it could be improved, and any other beneficial insights. The complete HFG Evaluation form is provided in Appendix C.

SECTION 3: RESULTS

Results from the HFG pilot testing and evaluations are provided below in two parts: the first part provides the responses to the HFG evaluation form and the second part provides additional feedback on the use, efficacy, and overall value of the HFG. Much of the information presented here was provided by state DOT POCs, including verbatim comments and descriptions of how the *Human Factors Guidelines for Road Systems* was used by POCs and their colleagues, as well as supplemental images and graphics.

RESPONSES TO THE HFG EVALUATION QUESTIONS

Some of the feedback we obtained on the value and use of the HFG was provided using the HFG Evaluation Questions distributed to all end users across the 5 pilot states (see also Appendix C). We received 13 completed forms; some had been completed by a single individual, while others provided a group response. The collated responses (minus names) are provided below. It should be noted that not all of the questions were addressed by all of the responses we received; also, aside from a few very light edits, the responses are presented “as-is”, relative to the original responses. Each bullet represents a response from one person. A bulleted list response from one individual is shown in-line within the bullet paragraph.

General Information

Your Professional Title:

- Transportation Engineer I
- Transportation Engineer
- Transportation Safety Engineer
- Traffic Safety Engineer
- Chief Traffic Engineer
- Traffic Engineer
- Safety Programs Manager
- Traffic Safety Officer
- Civil Engineer IV
- Civil Engineer II
- Traffic Studies Manager
- Senior Vice President
- Project Engineer
- Project Manager

Please describe your job responsibilities in 1-2 sentences:

- Roadway design.
- PM for design of construction projects

- Road Safety Analysis & Evaluation; Justifying funding for safety improvements; Research & Training
- Reviewing/designing temporary traffic control plans for capital projects throughout our state.
- Conducting traffic safety studies within high crash locations and recommending/designing solutions.
- Assisting the Safety Programs Manager with the implementation of our states' Annual HSIP.
- Responsible for our state's Traffic Section, including the planning, design, construction, maintenance, and operations of traffic control and Intelligent Transportation System (ITS) devices on state maintained roadways, and the administration of our Highway Safety Improvement Program and Integrated Transportation Management Program.
- Effectively and efficiently administer traffic safety procedures and guidelines statewide.
- Responsible for the day-to-day management of the Highway Safety Improvement Program, Work Zone Safety and Mobility Program and Planned Special Events Program.
- Traffic Studies Engineer who is responsible for performing traffic engineering studies throughout the county. Requests includes inquiries mostly from the public ranging from sign requests (i.e. Watch Children sign, WATCH FOR TURNING TRAFFIC sign, NO LITTERING), pavement markings (i.e. stop lines, no passing zones), traffic signals requests, to traffic operation investigations (i.e. left turn phasing at a signal, safety of a commercial entrance location).
- Perform several varies of traffic studies including safety and operation studies requested by publics such traffic signal warrant studies, regulatory and advisory signs warrant, and striping studies. Review a subdivision plan and traffic impact studies.
- Supervise and review traffic engineering studies related to traffic control signs, markings, and signals.
- Senior Project Manager on safety projects for a private consulting firm. Primarily work for the Department of Transportation on various types of safety projects including Road Safety Audits, Highway Safety Manual Implementation and the Strategic Highway Safety Plan.
- I conduct Traffic Impact Analyses, Signal Timing Projects, and roadway/intersection design projects. I also perform Safety Engineering Studies including Road Safety Audits for the Department of Transportation.
- RSA Facilitator and author of more than a dozen RSA reports. Major background in traffic engineering and design of rural and urban roadway facilities, traffic analysis and traffic studies.

Training/Degree Areas:

- BSE Civil
- PE/BS Civil
- PhD in Civil Eng (Transportation)
- Transportation Engineering, Traffic Safety
- Civil / Transportation Engineering. Bachelors and Masters in Civil Engineering

- Civil Engineering
- BSCE/Civil Engineering, Transportation concentration.
- Degree is a Civil and Environmental Engineering Degree (B.S.E.). Also have Professional Engineering license (P.E.). Training includes on the job training from work as well as training courses provided from work over the years from both State and national/out of state facilitators.
- Bachelor of Science in Civil and environmental Engineering. Capacity manual and software training, HCS and Synchro. Roundabout training. Mandatory training thru the Department Human Resources.
- BS in Civil Engineering. Several continuing education courses in traffic engineering planning, design and operations.
- MS/BS in Civil Engineering
- BSCE/MSCE (Transportation), Road Safety Audit Certified
- BS Civil; RSA Certification

Years of Experience:

- 12
- 34
- 24
- 4.5
- 19
- 7
- 10.5
- 11
- 4
- 40
- 18
- 17
- 24

General Use of Reference Materials

What are the key standards and reference materials relating to roadway design and safety that you use in your job?

- AASHTO Green Book, Roadside Design Guide, state Roadside Design Guide
- Green Book, MUTCD, Safety Manual, Roadside Design Guide
- AASHTO Roadway Design (Green Book), MUTCD, Roadside Design Guide, HSM most of the time, FHWA Older Driver Handbook, Pedestrian Safety Action Plan (How To Guide – as needed)

- MUTCD, Roadside Design Guide, Highway Capacity Manual, AASHTO Green Book, Highway Safety Manual, Construction Standards and Specifications specific to our state, Microstation, Synchro/HCS
- MUTCD, Roadside Design Guide, Green Book, guidelines and manuals specific to our state, applicable NCHRP research reports, various FHWA references
- Roadside Design Guide, Highway Safety Manual, NCHRP Reports, AASHTO A Policy on Geometric Design of Highways and Streets, MUTCD, and Highway Capacity Manual
- MUTCD, AASHTO Green Book, Roadside Design Guide and Highway Safety Manual
- MUTCD (Manual on Uniform Traffic Control Devices). I also use State resources and publications such as our Traffic Summary Book on a daily basis. When needed, I use other State manuals including a Road Design Manual, Signal Design Manual and nationally recognized publications from NCHRP (i.e. 562- Improving Pedestrian Safety, 572- Roundabout Traffic Analysis etc.) and other transportation publications
- MUTCD, and state-based manuals such as: Signal Design Manual, NCHRP – different parts, Street Lighting Manual, Subdivision Manual, ITE- 9TH Edition
- State-based standards including a MUTCD, AASHTO Green Book and other relevant design manuals and design guidance memos, Highway Safety Manual
- Highway Safety Manual, AASHTO Green Book, NCHRP Reports, Human Factors Guidelines, AASHTO Guide for the Development of Bicycle Facilities, Road Safety Audit Guidelines
- AASHTO Green Book, MUTCD, State and Local Design Standards, Guidelines, and Policies; Roadside Design Guide, Highway Capacity Manual, Highway Safety Manual
- Roadside Design Guide; AASHTO, Highway Safety Manual; MUTCD, NCHRP Report 600 (HFG)

To what extent to you think that the standard sources address human factors topics?

- Somewhat
- Very little
- None of them explicitly address human factors to achieve "better" safety performance – my personal opinion.
- Most of these sources address mainly the engineering aspect of these design elements, however some consideration for human factors has been integrated into the recommendations and requirements provided.
- Human factors topics are the underpinning of most of the reference manuals used, but some of the human factors information is likely out of date, and there is typically not a good linkage between the guidelines/practices/rules and the human factors that were used to develop them.
- I believe these reference materials provide basic guidance on ergonomics (human factors). They help identify the basic human characteristics when initiating the evaluation.

- These reference materials cover human factors very briefly, but not to the extent that fosters an understanding of how human factors plays a large role in highway safety. These references also don't necessarily define the human factors implications of making various decisions.
- I think the MUTCD and the national publications mentioned incorporate human factors as an overall part of their manuals. The other publications I mentioned are either data driven or focus more on the technical design/decision making.
- The abovementioned manuals somehow considered human factors in their policies.
- Generally imply the topic. The Highway Safety Manual better than the others.
- Main standards address human factors minimally Road Safety Audit Guidelines incorporate Human Factors somewhat and of course the Human Factors Guidelines address it.
- Somewhat
- Only some, they are just guidelines. Using the internet to access NCHRP Report 600 is the best way to gain access to HF topics and stay up to date on the information.

In general, what do you do when you have a human factors question? Where do you go for help?

- Safety Section
- HFG
- Evaluate, investigate, follow "standards".
- Refer to the state-based MUTCD or Roadside Design Guide. Many of the chapters in the HFG relevant to my position are similar to those found in these manuals.
- Now I will go to the HFG.
- Depending upon the type of request, I would use the reference materials lists or complete an internet search to determine if other agencies have similar issues.
- I use the references noted above as well as other documents such as "Human Factors in Traffic Safety" by Dewar and Olson. Also, I have had training on human factors as it relates to traffic safety, so I am familiar with the subject.
- Usually, I look through the available resources that I have to see if human factors are discussed. I usually research national publications from NCHRP, TRB research papers etc. Sometimes, I will search online to see if there other resources.
- More likely NCHRP or online.
- Course notebooks from previous Human Factors workshops, or the Highway Safety Manual
- Human Factors Guidelines
- Use judgment

Questions about the HFG[1]

Was the presentation format used in the HFG easy to understand? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No
10[2]	1			

- The HFG consists of a very useful format that clearly identifies useful information and summarizes that information very well for the practitioner.

Was the information presented in the individual guidelines easy to use? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No
8	3			

- Again, the information was clearly laid out for the practitioner and summarized in a manner that was easy to understand.

How easy is it to find individual topics of interest in the HFG? (circle answer and add any additional thoughts below)

Easy	Somewhat Easy	Average	Somewhat Difficult	Difficult
8	2			

- The information is organized very well into the various chapter contents, so it is easy to find.

Overall, how would you rate the HFG in terms of clarity and ease-of-use relative to other information sources that you use? (circle answer and add any additional thoughts below)

Better	Somewhat Better	About the Same	Somewhat Worse	Worse
3	6	1		

Was the information presented in the individual guidelines useful and valuable to you? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No
6	4	1		

[1] Any additional comments provided by the respondents are also included.

[2] For questions with scale responses, the number provided below the answer option indicates the number of times that response was given.

Did you try and apply the HFG to a real-world roadway design issue or problem? (Yes / No) If so, describe the problem and whether or not / how the HFG helped you

- No
- Not yet used.
- No
- No
- Yes, we are in the process of using the HFG in statewide evaluations (Pedestrian/Bicycle Safety Studies and Horizontal Curve Studies).
- Yes. Approaching a community in the northern part of our state, there is a transition zone that lowers the speed limit from 50 MPH to 35 MPH, however, drivers routinely travel above the lower posted speed limit and are not transitioning their speeds appropriately. I used the Chapter 9 of the HFG to learn more about this transition area to get ideas of how to promote the lower speed approaching the community. This section was helpful in explaining that signing alone is not sufficient and that other treatments may be necessary.
- Yes. There is a sharp curve on a roadway with several residential driveways where several motorists have run off the roadway and into yards at this location. Motorists appear to run off the roadway due to the speed they are taking in the curve. Chapter 6 of the HFG (Curves- Horizontal Alignment) helped me to consider more options to help bring additional awareness to the sharp curve on the roadway.
- No
- No, N/A
- Yes, we applied it to the two road safety audits recently: Swenson/Twain and Blue Diamond Road.
- Road Safety Audits on Elkhorn Road and Cimarron Road - For the most part, every Road Safety Audit is a Human Factors Guidelines exercise. We are checking for safety issues and concerns from the road user's point of view, so we have to take into account how a person reacts to or comprehends a given circumstance. ▪ During the RSAs the team considered safety issues associated with sight distance issues (Chapter 5), the transition between the bridge and the roadway on Elkhorn Road (Chapter 9), non-signalized intersections (Chapter 10), signalized intersections (Chapter 11), marked and unmarked pedestrian crosswalks (Chapter 15), school zones (Chapter 15), vehicle speeds (Chapter 17), signage (Chapter 18), pavement markings and markers (Chapter 20), and intersection and corridor lighting (Chapter 21). ▪ The Human Factors Guidelines were available for reference when considering recommendations to mitigate the observed safety issues.
- Applying signs that make the most sense to the general public

What chapters/guidelines/topics in the HFG were most useful to you?

- 5 – 9
- 5 – 21
- Core design chapters
- Chapter 6 – Curves, Chapter 8 – Tangent Sections and Roadside, Chapter 13 – Construction and Work Zones

- Engineering countermeasures to reduce red light running. ▪ Restricting right turns on red to address pedestrian safety. ▪ Determining work zone speed limits. ▪ Methods to increase driver yielding at uncontrolled crosswalks. ▪ Methods to reduce driver speeds in school zones. ▪ Chapter 17 (Speeds)
- All of the chapters have some relevance on current statewide evaluations. Chapter 6 on curves is helpful to understand the difference between actual and apparent curvatures.
- Chapters 3, 4, 5 and 9
- Given that I have only used one chapter of the HFG, I cannot answer this question fully. So far, Chapter 6 has been useful for me
- All the chapters in Part III have been the most useful in the development of successful RSAs.

What chapters/guidelines/topics in the HFG were least useful to you?

- 18 – 21
- 1 – 4
- None – considering the purpose. I've heard from a couple of folks that initial materials were rather long – can be reduced for future trainings.
- Chapter 7 – Grades, Chapter 21 – Lighting
- Chapter 8 (Tangent Sections). Presentation of bilingual information. Post mounted delineators. Markings for roundabouts
- Chapter 9 (Transition Zones between Varying Road Design) and Chapter 19 (Changeable Message Signs) are least used due to minimal requests about these topic areas.
- None
- Given that I have only used one chapter of the HFG, I cannot answer this question.
- Just the chapters that were not related to our project (an RSA) study area: ▪ 12 Interchanges ▪ 13 Construction and Work Zones ▪ 14 Rail-Highway Crossings ▪ 16 Special Considerations for Rural Environments ▪ 19 Changeable Message Signs
- Chapter 19 since our state does not have an abundance of changeable message signs outside the freeway system.

Explain in your words what you like most about the HFG:

- Topic layout & illustrations. References quoted.
- Exposing audience with a better organize guidebook.
- The bar scale system provides a good visual determine what each design guideline is based upon.
- Information is very easy to find within the manual.
- Easy to use and find information.
- Provides human factor underpinning of engineering guidelines.
- Good summary on specific topics, all in one guide, pulling together different subject areas (geometry, signing, striping, signals, etc.).
- References to available research papers for additional information.

- I like how the HFG combines all the reference materials into one useful resource. As I stated above, Chapter 6 on curves helps understand human elements in a completely different manner than the other reference materials.
- I like the layout of the HFG and the presentation of the material. There is not too much material that deters someone from reading and understanding the concepts. There is just enough material presented to get an understanding of the issues around a particular subject and then additional source information in order to perform additional research if necessary. The HFG combines a lot of issues into one easy to use document.
- From my use of Chapter 6, I like how concise the subsections in the chapter are laid out, the cross references and references provided at the end of the chapter, and the ratings of the design guidelines (i.e. based on expert judgment, empirical data).
- The HFG is a good set of guidelines that looks at potential safety issues even if a roadway is designed to standards. It is set up in an easy to use format with good practical information.
- As a facilitator of RSAs, the HFG has helped me guide the team into looking at things in a way other than engineering terms. This helps convey the message that HF plays a role in safety and there are more ways we can improve safety than by just following engineering guide lines.

Explain in your words what you like least about the HFG:

- Handout on page 25, Influence of Perceptual Factors on Curve Driving. Curve Radius combination do not make sense. Vertical curve do not have radiuses, they are defined by curve length, or algebraic differences. Horizontal curves listed have radiuses for very low design speed if used at all (assuming English units are used on graph.)
- Still unclear how easy or difficult it would be to stick to standards and yet address human factors.
- Some of the information is redundant with existing guidelines/manuals
- No information on: 1) interaction between vehicles and bicycles beyond a shared lane scenario, and 2) existing barrier influence on the road user.
- Given that I have only used one chapter of the HFG, I cannot answer this question.
- No issues with the HFG.
- It’s a good source - not much I can say in terms of not liking the HFG.

Do you have any specific recommendations on how the HFG can be improved?

- None
- Depends on agency’s willingness to learn and accept new ideas.
- Expand the number of topic areas.
- Make sure all recommendations are MUTCD compliant (examples: No Turn on Red blank out sign cannot have the colors shown on page 11-4; half signal reference on page 15-4 is not MUTCD compliant)
- I recommend incorporating information on vehicle interaction with other road users, such as bicycles and pedestrians.

- Provide more information related to highway work zones related to driver lane change characteristics.
- Given that I have only used one chapter of the HFG, I cannot answer this question.
- No recommendations at this time.

Additional Thoughts or Recommendations:

- Excellent instructor!
- No additional recommendations.
- None at this time.
- Appreciate and see value in the document but have not directly used it because my role is mostly management and supervision.

KEY RESULTS OF HFG APPLICATION TO ROADWAY DESIGN AND EVALUATION ACTIVITIES[3]

Information from the state-level pilot studies is provided below.

Arizona

Arizona was the last state to sign up for participation in the pilot study, with training conducted in October, 2013. Despite this late start, the state was able to incorporate the use of the HFG into a number of RSAs. The facility type, the crash type that precipitated the RSA, the eventual mitigation, and the specific ways that that the HFG proved to be useful are documented in Table 2 below.

[3] For the most part, these comments and pilot study results are presented as we received them from the five state POCs. Therefore, they do not follow a common format or presentation style.

Table 2. Summary of how Arizona DOT used the HFG as part of their RSA process and ways that the HFG was characterized as "Very Helpful."

RSA Focus: Facility	Crashes	Mitigation	Key Issues Where the HFG was Found to be Very Helpful
Rural freeway	Lane departure	Reconstruction	Reverse curves with short tangent
Rural freeway	Lane departure	Curve warning signs, advisory speed, chevrons	Successive curves with differing geometry
Urban freeway	Lane departure, rear end	Sign spreading	Information overload - freeway signing
2 lane rural arterial/concentration of access points	Intersection crashes	Reduce posted speed	Setting appropriate speed limits
Urban arterial signalized intersection	Vehicle/pedestrian, vehicle/bicycle	Prohibit right turn on red	Right turn on red vis-à-vis pedestrian safety
Suburban arterial	Night time pedestrian crashes	Install roadway lighting	Lighting for pedestrian safety
Urban arterial	Vehicle/pedestrian, rear end, same direction side-swipe	Relocate bus stop	Locating bus stops

In addition to the table above, Arizona DOT staff also noted that*: "The work sheet "Using the HFG During a Road Safety Audit" would be more useful if it were a check list format arranged in the same order as the HFG topic summary."*

Delaware

Delaware DOT primarily used the HFG in an "ad-hoc" fashion and provided most of their feedback using the HFG Evaluation Questions summarized above. There was a site in Delaware, however, that was associated with a high number of crashes and Delaware DOT staff were interested in seeing if the HFG could be used to identify possible issues and countermeasures for this site—US 113 at Kruger Road/Wood Branch Road and US 113 at Alms House Road/Speedway Road—located south of Georgetown, as shown below in Figure 1. These two intersections were identified and studied as part of a Hazard Elimination Program in 2008. While some mitigations were put in place at that time, crashes have actually increased and Delaware Dot staff wanted to apply the HFG to this problem site.

Source: Delaware DOT

Figure 1. US 113 at Kruger Road/Wood Branch Road & US 113 at Alms House Road/Speedway Road in Delaware.

Table 3 below summarizes the possible safety issues associated with this intersection, as well as the chapters/guidelines within the HFG that were deemed valuable to the Delaware DOTs assessment activities.

Table 3. Possible safety issues at US 113 at Kruger Road/Wood Branch Road & US 113 at Alms House Road/Speedway Road, as well as relevant HFG chapters and guidelines.

<table>
<tr><th colspan="2">Candidate Safety Issues</th></tr>
<tr><th>Relevant HFG Page and Guideline</th><th>How the HFG Might Help</th></tr>
<tr><td colspan="2">Given the large number of angle crashes, it may be that drivers are improperly judging oncoming vehicle speeds/gaps. This applies to both left and right turners. There are a number of factors that will impact drivers' ability to judge the speed/distance of vehicles on US 113 as they wait to turn, including perceived speed and distance, but also changes in speed, angle of heading (curvature of the roadway, as well as skew in the intersection), changes in lighting/contrast, and differences in elevation between the stopped vehicles and the moving vehicles (the stopped vehicles are lower). US 113 is a straight roadway, but elevation changes might be contributing to misjudgments.
A related issue is that drivers turning left may not be taking advantage of the safety and extra time offered by the median; i.e., they may be thinking of the left as a single stage activity (decide to turn, then drive through the median and enter a driving lane) rather as a two-stage activity (decide to drive through oncoming traffic to the left to get to the median, stop or slow down inside the median to re-assess speed/distance/gaps of oncoming traffic, and then decide to enter a driving lane).</td></tr>
<tr><td>10-2 Acceptable Gap Distance</td><td>Gives values and rationales for the gaps required by different vehicles for left and right turns.</td></tr>
<tr><td>10-4 Factors Affecting Acceptable Gap</td><td>Discusses factors influencing gap acceptance and also includes a task analysis of the steps of performing a turn across traffic onto a four-lane highway. As noted in the DDOT report, observed turning speeds seemed slower than expected as well – the uphill nature of the turn may be accounted for in drivers' gap judgments.</td></tr>
<tr><td>17-4 Speed Perception and Driving Speed</td><td>This guideline discusses how various cues can cause drivers to overestimate or underestimate their own or another vehicle's speed. This applies more to own-vehicle speed that others', but it is still helpful</td></tr>
<tr><td>10-6 Sight Distance at Left-Skewed Intersections</td><td>Drivers at these intersections need to look backwards over their right shoulder and past parts of their own vehicle. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle, set back distance, and properties of typical vehicles.</td></tr>
<tr><td>10-8 Sight Distance at Right-Skewed Intersections</td><td>Vision of drivers at these intersections is limited by their ability to turn their eyes and neck to look backwards over their left shoulder. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle and set back distance, with special considerations for the restricted movement of older drivers.</td></tr>
<tr><td colspan="2">Is the intersection sight distance adequate?</td></tr>
<tr><td>5-6 Determining Intersection Sight Distance</td><td>Provides references to formulas in the AASHTO green book for selecting the proper sight distance. This issue and some possible countermeasures already seem to be addressed in the current report.</td></tr>
<tr><td colspan="2">Is the stopping sight distance adequate?</td></tr>
<tr><td>5-4 Determining Stopping Sight Distance</td><td>Provides standard formulas for calculating stopping sight distance, and discusses how human factors reduce typical performance below what is optimally possible. This issue and some possible countermeasures already seem to be addressed in the current report.</td></tr>
</table>

Idaho

In an effort to improve highway safety, the Idaho Transportation Department (ITD) undertook an innovative, data-driven program for safety analysis on roadways throughout the State – an effort encompassing 5,000 miles of roadway across six districts. Building on previous work in a pilot program to examine rural road safety, the program applied a new method for evaluating and prioritizing safety improvements and has demonstrated its usefulness for helping to identify highest priority locations for safety improvements.

This project comprised four main parts: 1) assessing 5 years of crash records across the state in order to determine potential priority locations for safety improvements; 2) diagnosing the priority locations in order to determine causal relationships between the physical characteristics of a location and the crash records associated with that site; 3) determining recommended safety improvements that address the diagnosis for each priority location and result in the greatest reduction in fatality and crash rates; and 4) conducting a benefit cost analysis to rank the recommended safety improvements and determine how best to invest a limited amount of funding for the maximum effect. The scope of the project required innovation at every step of the way in order to facilitate the efficient collection and analysis of such a large dataset and the effective production of results that can be directly applied to the distribution of funds over a short-term funding horizon.

To maximize the benefit from a limited pool of funding, each safety improvement project needed to be ranked based on the expected benefit in fatality and crash reductions offset by an annualized cost of the project. Based on historical data, ITD determined the expected benefit based on an average cost applied to each level of crash severity combined with the expected reduction in fatality and crash rates associated with a given safety improvement project. The expected reduction is based on the improvement as well as the existing roadway characteristics and crash history. The resulting list of ranked safety improvement projects provides ITD with a recommendation for how best to distribute funding for projects.

As part of this process the consideration of *Human Factors* was introduced into the culture of highway safety in Idaho. As part of the diagnosis (crash causality) it is recognized that human factors play a significant role in determining crash cause and when understood countermeasures can be implemented to work toward the elimination of crashes that result in death and serious injury. During the development of Idaho's Highway Safety and Prioritization Plan model, the consideration of Human Factors was incorporated into the process. Below is an outline that illustrates the introduction and training for Idaho.

1. **Introduction to the Human Factors Guidelines (HFG) to Idaho.** Background information was provided by Dr. John Campbell (lead author of the HFG) to familiarize the Idaho Team with the objectives and history of the Human Factors Guideline (HFG). An overview of the HFG development was provided, including a description of the development approach and empirical foundations. The standard two-page format used in the HFG to present the individual human factor guidelines was also explained.

2. **Review of Topics Related to Safety.** The contents of the HFG were summarized. This included information on:

a. How to use the HFG document.

b. Bringing road user capabilities into highway and traffic engineering practice.

c. Incorporating human factors in roadway location elements (e.g., speed selection on horizontal curves).

d. Incorporating human factors in traffic engineering elements (e.g., where and how to use post-mounted delineators).

e. Additional information in the HFG, such as tutorials.

3. **Review of Chapter 16 – Special Considerations for Rural Environments.** A chapter summary was presented, together with specific information for the four guidelines contained in this chapter:

   a. Passing lanes

   b. Countermeasures for pavement/shoulder drop-offs

   c. Rumble strips

   d. Design consistency in rural driving

   Other guidelines related to rural highways not included in this chapter were summarized.

4. **Sample Tutorials.** The different ways that the HFG can be used in safety analyses was discussed. Two example applications for complex interchanges were also presented.

5. **Using the HFG to Diagnose High-Crash Frequency Locations and Identify Potential Countermeasures.** The standard process for diagnosing high-crash frequency locations and identifying potential countermeasures without the HFG were described weaknesses in the process related to human factors was identified. Ways in which the HFG can be used to address the weaknesses were then discussed. An example problem was provided to demonstrate the application of the HFG within the standard process and how the results of the process may be improved with the use of the HFG.

6. **Using the HFG and the HSM Together.** Use of the HFG with the Highway Safety Manual (HSM) was outlined in an example safety analysis. The focus was on how the HFG can be specifically used to augment the HSM procedures for crash diagnosis and the selection of countermeasures. A brief description of the human factors chapter in the HSM was provided.

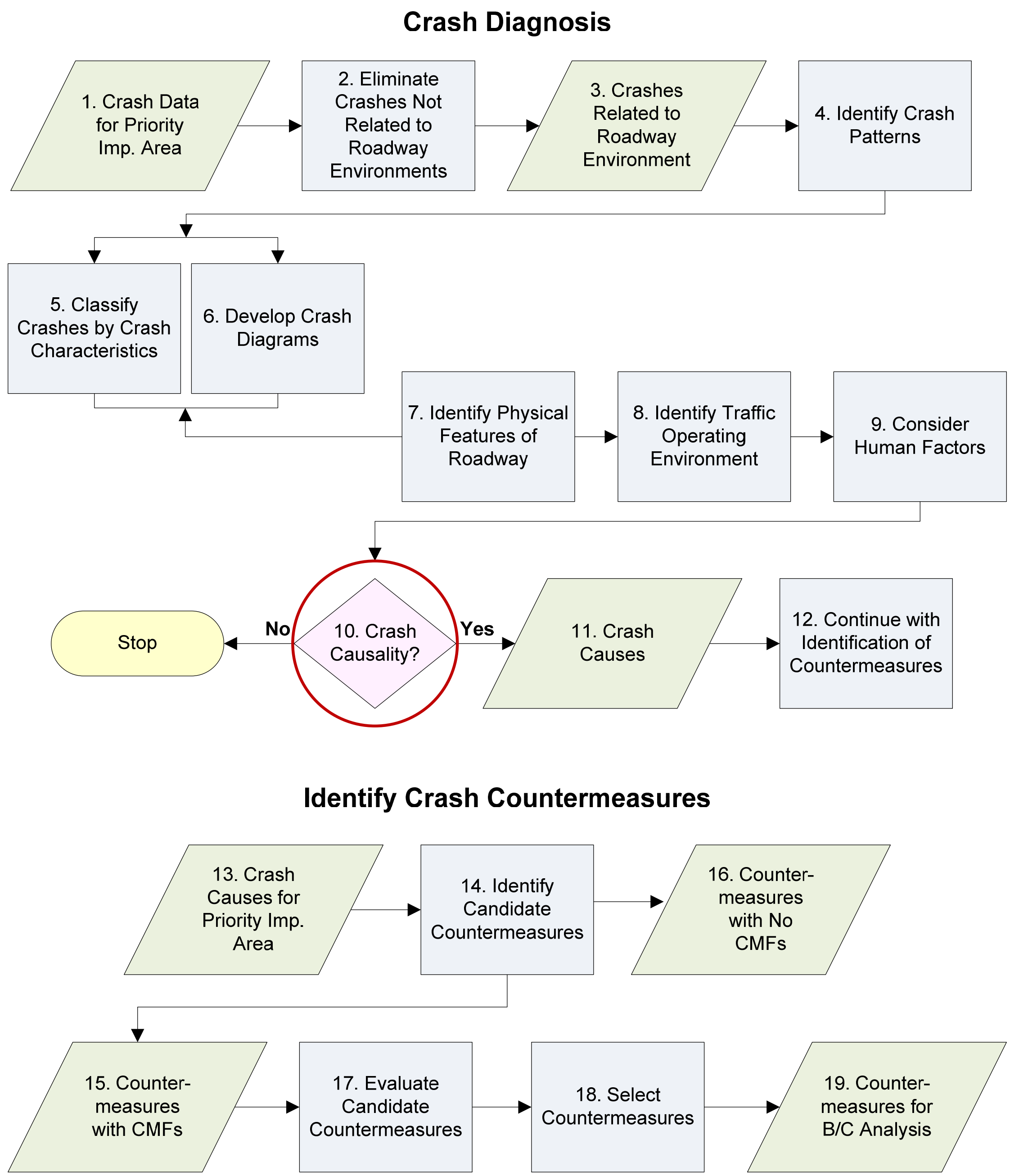
7. **Using the HFG in the ITD Highway Safety Corridor Analysis (HSCA) Program.** A brief refresher on the various elements of the HSCA project was provided to the Idaho Team. Elements of the study in which the HFG could be applied were highlighted, with a description of the application methods for each. This included Road Safety Audits that may be conducted by ITD engineering staff for specific safety priority locations.

Additional input data or analysis requirements for using the HFG in the study was discussed, as well as any additional outputs that may be produced.

8. **Using the HFG to Get Maximum Benefit from Safety Projects.** The total benefit of a safety project is measured by the reduction in fatal and serious injury crashes and the resulting costs. Crash cost is function of crash frequency and severity. Therefore, the maximum benefits can be achieved with safety projects that address both of these factors. Ways in which the HFG can be used identify projects with the highest likelihood of reducing crash frequency and severity was discussed. Examples of crash locations and crash types for which the HFG would be the most useful for this purpose was described.

9. **Using the HFG in Design of Funded Safety Projects.** Once the type of safety project having the maximum potential benefit for a particular location has been identified and funded, the next step in the process is project design. Ways in which the HFG can be used to enhance the safety project design process was outlined. This included the identification of specific project elements and the design features of those elements.

10. **Incorporation of Human Factors Guidelines into the HSCA Project Process.** Applying the HFG in the HSCA planning and prioritization process is currently being done at ITD. The commitment to consider and utilize the HFG is now starting to unfold in the ITD highway safety culture. The work of incorporating the HFG will be a slow and steady process. The attached flow chart on the next 2 pages outlines the HSCA planning and prioritization process and consideration of HFG (see item 9) is incorporated. The Human Factors Guidelines are a huge benefit for highway safety in Idaho and we are making a commitment to continued implementation.



Source: Recreated from ITD Handout

Figure 2. HSCA planning and prioritization process at ITD.

Nevada

Since December 2012, the Nevada Department of Transportation (NDOT) has been participating in the pilot study/evaluation of the HFG. The goal of this activity is to assess the value and efficacy of the HFG with actual end users who are applying the HFG to real day-to-day roadway design projects and issues. The HFG pilot study in Nevada began with detailed discussions between NDOT (Mr. Jaime Tuddao, Senior Safety Engineer at NDOT) and Battelle (Dr. John Campbell) to work out the details of the evaluation; i.e., how HFG would be used, who would be using it, and the schedule for the pilot test. NDOT decided to incorporate the HFG into their Road Safety Audit (RSA) program and to use the HFG as part of two RSA's planned for Nevada in 2013. Battelle staff then conducted two training sessions with approximately 45 end-users in December, 2012 and February, 2013. The 2-hour training sessions covered the purpose, contents and applications of the HFG, and included a training module developed specifically for Nevada that reviewed how the HFG could be used during an RSA.

The "Tropicana" RSA (the first RSA conducted in Nevada using the HFG) examined a 7-mile corridor in Las Vegas, and was intended to look at safety issues from a different perspective and develop recommendations for potential safety enhancements.

The results from the "Tropicana" RSA were very positive. Overall, the RSA team found that many chapters in the HFG were especially relevant to this RSA including: Signalized and Non-signalized intersections (Chapters 10 & 11), Urban environments (Chapter15), Speed (Chapter 17), Signing (Chapter 18), Markings (Chapter 20), and Lighting (Chapter 21), resulting *in "numerous applications of the HFG to this RSA" in terms of both "identification of issues as well as associated recommendations."* Three very specific benefits to using the HFG were reported during the Tropicana RSA:

1. Vehicles making the eastbound to southbound movement on Tropicana Ave. appear to have limited visibility prior to entering a merge situation. A potential human factors contributor to the eastbound to southbound merge condition was the high speed right turn into a merge point with possible limited site visibility. *Recommendation: Add a deceleration lane; conduct speed study for possible design speed reduction of the eastbound to southbound movement; improve visibility of the merge and/or add signing alerting eastbound drivers to the yield/merge condition.*

2. Red Light running for vehicles traveling westbound to southbound was observed. Human factors issues identified on the westbound to southbound movement were limited visibility of the traffic signal due to the vertical geometry of the bridge and due to the flyover ramp. This visibility issue can be compounded when vehicles are traveling behind larger vehicles. *Recommendation: add an additional signal head for the westbound to southbound left turn either on the median island before or after the turn or in front of the flyover ramp (consider attaching to structure); and move the eastbound stop bar further back from the intersection to provide additional visibility of possible red light running vehicles for eastbound traffic.*

3. It appears to be challenging for drivers traveling eastbound on Tropicana Avenue to know the appropriate lane to be in for entrance onto the I-15, eastbound Tropicana, and Las Vegas Boulevard (See Figure 3 below). Additionally, there might be limited space to make lane changes and traffic was heavy. *Recommendation: Add an overhead sign structure specifying the lane assignments for I-15 entrance ramps, eastbound Tropicana Avenue and Las Vegas Boulevard.*

Source: Nevada DOT

Figure 3. Looking eastbound on Tropicana Avenue at Dean Martin Drive towards I-15.

As noted above, Nevada used the HFG to conduct 3 more RSAs: (1) Swenson Twain Road, (2) Blue Diamond Road, and (3) Elkhorn Road & Cimarron Road. For each of these RSAs, the projects leads indicated the chapters/guidelines within the HFG that were most useful and valuable, as follows.

- Swenson Twain Road Safety Audit
  - Chapter 5 Sight Distance: • Stopping Sight Distance • Intersection Sight Distance - Replace direct left-turn with right-turn/U-turn (CMF-0.8)
  - Chapter 6 Curves (Horizontal Alignment) • Speed Selection on Horizontal Curves • Improving Steering and Vehicle Control • Improve Pavement Delineation - Install edgelines, centerlines, and post-mounted delineators (CMF-0.55)
  - Chapter 10 Non-Signalized Intersections • Acceptable Gap Distance
  - Chapter 11 Signalized Intersections • Reducing Red Light Running • Restricting Right Turns • Selecting Yellow Time Intervals - Changing left turn phasing from at least one permissive approach to flashing yellow arrow (FYA) (All crash types CMF-0.753, Left Turn CMF-0.635) - Changing left turn phasing from protected-permissive to flashing yellow arrow (All crash types CMF-0.922, Left Turn CMF-0.806) - Increase total change interval (greater than ITE recommended practice) (Rear end CMF-0.643)
  - Chapter 15 Special Considerations for Urban Environment • Reducing Driver Speeds in School Zone • Sight Distance Considerations for Bus Stop Locations

- Chapter 17 Speed Perception, Speed Choice, and Speed Control • Speed Perception and Driving Speed • Roadway Factors on Speed • Post Speed Limits on Speed Decisions • Communicating Appropriate Speed Limits - Install changeable speed warning signs for individual drivers (CMF-0.54) - Install variable speed limit signs (CMF-0.92) • Using Roadway Design and Traffic Control to Address Speeding - Traffic Calming (CMF-0.68) - Install transverse rumble strips as traffic calming device (CMF-0.66)
- Chapter 18 Signing • Drivers Comprehension of Signs - Advance street name sign (CMR-0.984)
- Chapter 20 Markings • Visibility of Lane Markings - Install wider marking without resurfacing (CMF-0.78) • Marking for Pedestrian and Bicycle Safety
- Chapter 21 Lighting • Mitigating Headlamp Glare • Nighttime Driving - Provide highway lighting (CMF-0.72) • Effective Lighting at Intersections - Provide intersection illumination (CMF-0.62)

- Blue Diamond Road Safety Audit:
  - Chapter 6 Curves (Horizontal Alignment) • Speed Selection on Horizontal Curves • Improving Steering and Vehicle Control • Improve Pavement Delineation - Install edgelines, centerlines, and post-mounted delineators (CMF-0.55)
  - Chapter 8 Tangent Sections and Roadside (Cross Section) • Lane Changes on Tangent Sections /
  - Chapter 9 Transition Zones between Varying Road Designs • Perception and Physical Elements to Support Rural-Urban Transitions
  - Chapter 10 Non-Signalized Intersections • Acceptable Gap Distance
  - Chapter 11 Signalized Intersections • Reducing Red Light Running - Install red-light cameras at intersections (CMF-0.87 Fatal) - Install red-light camera (red light running crashes CMF-0.76) • Restricting Right Turns - Providing a right-turn on both major-road approaches (CMF-0.92) - Permit right-turn-on-red (CMF-1.07) • Selecting Yellow Time Intervals - Changing left turn phasing from at least one permissive approach to flashing yellow arrow (FYA) (All crash types CMF-0.753, Left Turn CMF-0.635) - Changing left turn phasing from protected-permissive to flashing yellow arrow (All crash types CMF-0.922, Left Turn CMF-0.806) - Increase total change interval (greater than ITE recommended practice) (Rear end CMF-0.643)
  - Chapter 16 Special Considerations for Rural Environments • Passing Lanes - Installing periodic passing lanes on rural two-lane highways (CMF-0.58) • Rumble Strips
  - Chapter 17 Speed Perception, Speed Choice, and Speed Control • Speed Perception and Driving Speed • Roadway Factors on Speed • Post Speed Limits on Speed Decisions • Communicating Appropriate Speed Limits - Install changeable speed warning signs for individual drivers (CMF-0.54) - Install variable speed limit signs (CMF-0.92) • Using Roadway Design and Traffic Control to Address Speeding - *Traffic Calming (CMF-0.68)* - Install transverse rumble strips as traffic calming device (CMF-0.66)

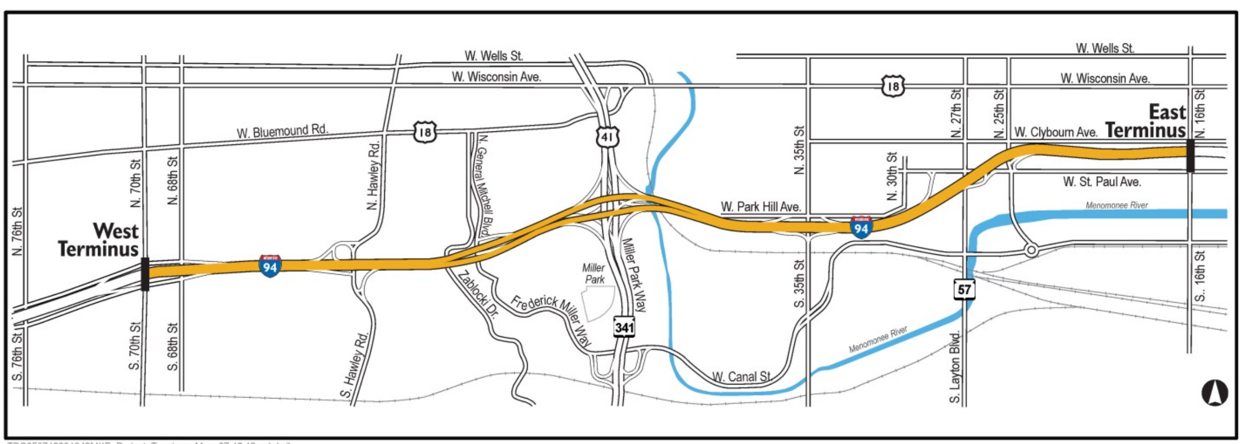
- Chapter 18 Signing • Drivers Comprehension of Signs - Advance street name sign (CMR-0.984)
- Chapter 20 Markings • Visibility of Lane Markings - Install wider marking without resurfacing (CMF-0.78) • Marking for Pedestrian and Bicycle Safety
- Chapter 21 Lighting • Mitigating Headlamp Glare • Nighttime Driving - Provide intersection illumination (CMF-0.62) - Provide highway lighting (CMF-0.72) • Lighting that Enhances Pedestrian Visibility • Effective Lighting at Intersections - Provide intersection illumination (CMF-0.62)

■ Elkhorn Road/Cimarron Road Safety Audit

- Chapter 5 Sight Distance • Sight distance issues
- Chapter 9 Transition Zones between Varying Road Designs • Transition between the bridge and the roadway on Elkhorn Road
- Chapter 10 Non-signalized Intersections
- Chapter 11 Signalized Intersections
- Chapter 15 Special Considerations for Urban Environments • Marked and unmarked pedestrian crosswalks • School zones
- Chapter 17 Speed Perception, Speed Choice, and Speed Control • Vehicle speeds
- Chapter 18 Signing • Signage
- Chapter 20 Markings • Pavement markings and markers
- Chapter 21 Lighting • Intersection and corridor lighting

Wisconsin

In Wisconsin, the initial focus for using the HFG was on the I-94 East/West project, which is a planning-level engineering analysis. The project includes a 3-mile corridor in Milwaukee (see Figure 4) with one system interchange and five service interchanges.



Source: Wisconsin DOT http://www.dot.wi.gov/projects/seregion/94stadiumint/docs/ew-project-terminus-map.pdf

Figure 4. Location of the I-94 East/West project in Milwaukee.

The following feedback was provided on this application of the HFG: *"The consensus amongst the RSA team was that the HFG was a very good document and seemed to be aimed at getting designers to think like traffic engineers. The benefit to the team was that as traffic engineers we were able to point directly to the HFG as support for what we were recommending in our audit. It was also a way for us to take what we "know/feel" to be true as long time practicing engineers and have it quantified in a document. Or in other words, we feel it added credibility to our recommendations. As an example of how we used it, the HFG contains some specific information in Chapter 7-6 on Preview Sight Distance and Grade Perception at Vertical Curves that we cited in our report to support the realignment of the reverse curves on the mainline between 35th and 13th Streets. We also used Chapter 12-4 on Reducing Wrong-Way Entries onto Freeway Exit Ramps when evaluating the Hawley Road interchange."*

The second application of the HFG in Wisconsin was to an RSA associated with a high-crash site in north-central Wisconsin – a rural intersection at STH-29 and STH-49 / Willow Drive in Marathon County. A portion of the analysis for this RSA took place as part of the second HFG training session help on October 29, 2013. The HFG instructor, John Campbell, along with the 5 participants from the second Wisconsin training session took a field trip to examine this site. Table 4 below summarizes the possible safety issues associated with this intersection, as well as the chapters/guidelines within the HFG that were deemed valuable to the Wisconsin DOTs assessment activities.

Table 4. Possible safety issues at STH-29 and STH-49/Willow Drive, as well as relevant HFG chapters and guidelines.

Candidate Safety Issues	
Relevant HFG Page and Guideline	**How the HFG Might Help**
Are drivers turning on to STH-29 from STH-49/Willow Drive adequately judging oncoming vehicle speeds/gaps? This applies to both left and right turners. There are a number of factors that will impact drivers' ability to judge the speed/distance of vehicles on STH-29 as they wait to turn, including perceived speed and distance, but also changes in speed, angle of heading (curvature of the roadway, as well as skew in the intersection), changes in lighting/contrast, and differences in elevation between the stopped vehicles and the moving vehicles (the stopped vehicles are lower). Drivers may be misjudging the speed and distance of oncoming vehicles and the amount of time they have to safely make their turn. They may have a hard time judging which lane the oncoming vehicles are in. This problem is made worse if the stopped vehicles are "in a hole" at the stop sign and take longer to get up to speed once they have committed to their turn. A related issue is that drivers turning left may not be taking advantage of the safety and extra time offered by the median; i.e., they are thinking of the left as a single stage activity (decide to turn, then drive through the median and enter a driving lane) rather than as a two-stage activity (decide to drive through oncoming traffic to the left to get to the median, stop or slow down inside the median to re-assess speed/distance/gaps of oncoming traffic, and then decide to enter a driving lane). Placing a stop sign or at least a yield sign or an on-coming traffic sign in the median might help.	
10-2 Acceptable Gap Distance	Gives values and rationales for the gaps required by different vehicles for left and right turns.
10-4 Factors Affecting Acceptable Gap	Discusses factors influencing gap acceptance and also includes a task analysis of the steps of performing a turn across traffic onto a four-lane highway. As noted in the report, observed turning speeds seemed slower than expected as well – the uphill nature of the turn may be accounted for in drivers' gap judgments.

Candidate Safety Issues	
Relevant HFG Page and Guideline	**How the HFG Might Help**
17-4 Speed Perception and Driving Speed	This guideline discusses how various cues can cause drivers to overestimate or underestimate their own or another vehicle's speed. This applies more to own-vehicle speed that others', but it is still helpful
10-6 Sight Distance at Left-Skewed Intersections	Drivers at these intersections need to look backwards over their right shoulder and past parts of their own vehicle. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle, set back distance, and properties of typical vehicles.
10-8 Sight Distance at Right-Skewed Intersections	Vision of drivers at these intersections is limited by their ability to turn their eyes and neck to look backwards over their left shoulder. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle and set back distance, with special considerations for the restricted movement of older drivers.
Is the intersection sight distance adequate as vehicles approach STH-29 from STH-49 and Willow Drive?	
5-6 Determining Intersection Sight Distance	Provides references to formulas in the AASHTO green book for selecting the proper sight distance. This issue and some possible countermeasures already seem to be addressed in the current report.
Is the stopping sight distance adequate as vehicles on STH-29 approach STH-49 and Willow Drive?	
5-4 Determining Stopping Sight Distance	Provides standard formulas for calculating stopping sight distance, and discusses how human factors reduce typical performance below what is optimally possible. This issue and some possible countermeasures already seem to be addressed in the current report.
Are the stop-ahead rumble strips on STH-49 approaching STH-29 effective?	
16-6 Rumble Strips	Lists levels of various sounds in a vehicle and recommends values for the shape and location of rumble strips. From the photo in the report, this doesn't look to be an issue, but may be worth checking.
Could on-road signing or other measures be used on STH-49/Willow Drive to draw drivers' attention to the upcoming intersection?	
6-10 Countermeasures to Improve Pavement Delineation	Discusses combinations of treatments – including adding signs - to communicate the need to reduce speed. This issue and some possible countermeasures already seem to be addressed in the current report.
20-4 Effectiveness of Symbolic Markings	Horizontal signing is sign text painted on the roadway. This guideline explains how these markings can alert drivers.
Are vehicles being glared by opposing traffic as they approach STH-2? Is glare interfering with vehicle conspicuity and/or gap judgment?	
21-2 Countermeasures for Mitigating Headlamp Glare	Discusses approaches to reducing glare from other vehicles' headlamps. There is mention of grades on the roads approaching STH-29 (e.g., "both approaches slope upwards") and such grades can create optimal conditions for producing glare for on-coming vehicles. Are a large proportion of the vehicles on the approaches SUVs or otherwise equipped with higher-mounted headlamps?
Would adding overhead lighting to the intersection help reduce/mitigate crashes?	
21-4 Nighttime Driving	Lists the respective benefits and suggested conditions for using seven treatments, ranging from continuous lighting to advance warning signs.
21-12 Characteristics of Effective Lighting at Intersections	Provides principles for improving nighttime visibility of pedestrians, vehicles, roadway features, and obstacles at intersections. It recommends luminance values and luminaire placement.

SECTION 4: CONCLUSIONS

Overall, the pilot studies and evaluations of the HFG conducted by the participants in Arizona, Delaware, Idaho, Nevada, and Wisconsin were extremely valuable in assessing the content, format, and organization of the HFG, as well as its general value and efficacy for real-world application and use. Based on the results presented in Section 3 above, we have developed the following 6 conclusions:

1. The format and organization of the HFG facilitated understanding of the content and ease-of-use.
2. The ways in which the participating states and end-users used the HFG was entirely consistent with the original goals and objectives for the HFG.
3. Across the RSAs, planning exercises, and diagnostic assessments that were the main application of the HFG, the contents and materials presented in the HFG provided consistent value and aid.
4. The HFG has changed the way that traffic safety and roadway design is accomplished within the pilot states.
5. Users were able to provide a number of valuable recommendations for improving the HFG.
6. Overall, the states and participants in the pilot study reported the HFG to be very valuable and useful.

These conclusions are discussed in more detail below.

1. **The format and organization of the HFG facilitated understanding of the content and ease-of-use.** Both the results from the completed evaluation forms, as well as the qualitative feedback obtained from the real-world applications gave very high marks to the HFG with respect to layout, clarity, support for finding topics of interest, and ease-of-use relative to other information sources . In this regard, examples of specific comments received included:

   - **"***The HFG consists of a very useful format that clearly identifies useful information and summarizes that information very well for the practitioner;"*
   - *"The information was clearly laid out for the practitioner and summarized in a manner that was easy to understand; and*
   - *"The information is organized very well into the various chapter contents, so it is easy to find."*

   The consistently positive ratings and comments for the HFG provide strong support for the current format and organization of the HFG. Future additions to the current HFG should maintain and extend these features of the document.

2. **The ways in which the participating states and end-users used the HFG was entirely consistent with the original goals and objectives for the HFG**. The HFG has always been intended to support roadway design and traffic engineering in very specific ways; each of the training sessions provided to the 5 states participating in the pilot study included training materials and discussions on "ways to use the HFG". The results from the pilots provided confirmation for each of these intended uses. Below, we identify each of the ways in which

the HFG was intended to be used and highlight examples from the pilot studies for each of these uses.

- *Enhance initial roadway planning and design activities*: **Wisconsin** DOT successfully used the HFG to conduct a planning-level engineering analysis in their I-94 East/West project, a 3-mile freeway corridor in downtown Milwaukee.
- *Conduct diagnostic assessments of safety concerns & incidents:* This was a frequent use of the HFG across the pilot studies. **Delaware** used the HFG to assess safety issues at 2 intersections in very close proximity to one another at US 113 at Kruger Road/Wood Branch Road & US 113 AT Alms House Road/Speedway Road. **Idaho** went so far as to formally incorporate the HFG into their statewide process for evaluating and prioritizing safety improvements at high risk/high-crash highway corridors and using HFG to identify highest priority locations for safety improvements.
- *Support road safety audits*: Using the HFG as part of an RSA was perhaps the most frequent application of the HFG across the 5 pilot states. For example, **Nevada** used the HFG to support three separate RSAs, while **Arizona** uses the HFG to support seven separate RSAs. Importantly, a considerable amount of valuable information was obtained across all of the RSAs, including diagnostic insights into know safety concerns, identification on candidate driver behavior/driver performance issues reflecting comparisons between the current roadway designs and guidelines provided in the HFG. The HFG was generally found to be highly usable within the context of typical RSA procedures.
- *Identify & select safety countermeasures*: For most of the RSAs noted above in **Nevada** and **Arizona**, the HFG was also valuable in identifying and describing specific countermeasures that could be applied to improve roadway design and traffic engineering elements. In this regard, the literature reviews and discussions provided within each guidelines were useful to the states in providing empirical support to the design recommendations.
- *Educate traffic engineers & designers on user needs, capabilities, and limitations*: While **Wisconsin** made a specific point of highlighting the broader educational value associated with the HFG ("the HFG was a very good document and seemed to be aimed at getting designers to think like traffic engineers"), this was clearly a benefit experienced in each of the state participating in the pilot study Many of the qualitative comments provided in the HFG evaluation form highlighted the value of learning about human factors in general and in the HFGs informative presentations of driver capabilities and limitations.

3. **Across the RSAs, planning exercises, and diagnostic assessments that were the main application of the HFG, the contents and materials presented in the HFG provided consistent value and aid.** A consistent feature in the feedback provided by the states was that the HFG provided end-users with practical, implementable solutions to real-world problems. For example, in each of the three RSAs conducted in Nevada, the end-users were able to identify numerous (even dozens) of individual guidelines in the HFG that provided useful information to the RSA process. Crash site evaluations in Wisconsin and Delaware similarly yielded numerous insights into potential design issues and engineering countermeasures at high-risk locations. The results presented above include many examples

of the information presented in the HFG being readily adopted as a useful and authoritative source by roadway designers, traffic engineers, and other highway safety specialists.

4. **The HFG has changed the way that traffic safety and roadway design is accomplished within the pilot states.** The adoption of the HFG in **Idaho** as part for their standard highway safety analysis process is perhaps the best example of this conclusion. The Idaho Transportation Department has formally incorporated the HFG into the way they do their planning business, is using it to complement their RSA process within the state and is confident that the HFG incorporates the behavioral elements into the planning and prioritization of highway safety projects where none existing before. In future project charters within **Idaho**, human factors must be examined and considered as part of the safety analysis / design process. Many of the qualitative comments provided in the HFG evaluation form indicated that the HFG is now considered to be the "go-to" source among the user community for human factors information and answers.

5. **Users were able to provide a number of valuable recommendations for improving the HFG.** A key goal of the pilot studies was to obtain constructive feedback on how the HFG could be improved in the future, particularly with respect to important topics that were absent or underrepresented in the HFG. Specific recommendations for new content in future editions of the HFG included:

   - Information on vehicle interaction with other road users, such as bicycles and pedestrians,
   - More information related to highway work zones and driver lane changes,
   - Interaction between vehicles and bicycles beyond a shared lane scenario, and
   - Existing barrier influence on the road user characteristics.

   During the HFG training sessions, the lack of information in the HFG on pedestrians, bicyclists, and roundabouts in particular was frequently highlighted as something to address in the future. Also, it is clear from the ways that the HFG was used and from some of the more general feedback, that future editions of the HFG would benefit from tutorials that explain:

   - How to use the HFG to support RSAs,
   - The joint use of the HFG and the HSM,
   - Using the HFG as a diagnostic tool, and
   - Using the HFG as a checklist to aid design (in this regard, the information in Appendix A provides a good start).

6. **Overall, the states and participants in the pilot study reported the HFG to be very valuable and useful.** The pilot studies clearly demonstrated the value and efficacy of the HFG as an important and credible resource for roadway design and traffic engineering. The results presented in Section 3 above provide numerous, specific examples of end-users obtaining valuable information from the HFG to improve highway safety in their state. Some specific comments about elements of the HFG that end-users particularly liked from the qualitative section of the HFG evaluation form included:

- *Topic layout and illustrations. References quoted.*
- *Exposing audience with a better organize guidebook.*
- *The bar scale system provides a good visual determine what each design guideline is based upon.*
- *Information is very easy to find within the manual.*
- *Easy to use and find information.*
- *Provides human factor underpinning of engineering guidelines.*
- *Good summary on specific topics, all in one guide, pulling together different subject areas (geometry, signing, striping, signals, etc.).*
- *References to available research papers for additional information.*
- *I like how the HFG combines all the reference materials into one useful resource.*
- *I like the layout of the HFG and the presentation of the material.*
- *There is not too much material that deters someone from reading and understanding the concepts.*
- *There is just enough material presented to get an understanding of the issues around a particular subject and then additional source information in order to perform additional research if necessary. The HFG combines a lot of issues into one easy to use document.*
- *I like how concise the subsections in the chapter are laid out, the cross references and references provided at the end of the chapter, and the ratings of the design guidelines (i.e. based on expert judgment, empirical data).*
- *The HFG is a good set of guidelines that looks at potential safety issues even if a roadway is designed to standards. It is set up in an easy to use format with good practical information.*
- *As a facilitator of RSAs, the HFG has helped me guide the team into looking at things in a way other than engineering terms. This helps convey the message that HF plays a role in safety and there are more ways we can improve safety than by just following engineering guidelines.*

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APPENDIX A:
HUMAN FACTORS GUIDELINES (HFG) FOR ROAD SYSTEMS – TOPIC SUMMARIES

Part III HF Guidance for Roadway Location Elements
5-1 Chapter 5: Sight Distance Guidelines
5-2 Key Components of Sight Distance *The required sight distance is the sum of the distance traveled during Perception-Reaction Time (PRT) while the driver notices a hazard or situation, decides what to do, and begins a response plus the Maneuver Time (MT), during which the driver completes the response. This guideline reviews factors that affect PRT and MT.*
5-4 Determining Stopping Sight Distance *Stopping sight distance (SSD) is the sum of the time required for a driver to notice a need to stop (such as an object in the road), to decide to stop, and to bring the vehicle to a stop. This guideline provides standard formulas for calculating stopping sight distance, and discusses how human factors reduces typical performance below what is optimally possible.*
5-6 Determining Intersection Sight Distance *This guideline explains how the sight distance required at an intersection depends on how the intersection is controlled (e.g., by signals or signs) and by the intended maneuver. It provides references to formulas in the AASHTO green book for selecting the proper sight distance.*
5-8 Determining When to Use Decision Sight Distance *Decision sight distance (DSD) represents a longer sight distance than is usually necessary. This guideline provides examples and formulas for complicated or non-standard highway situations in which drivers might require extra distance to make a decision.*
5-10 Determining Passing Sight Distance *Passing sight distance (PSD) is how far ahead a driver must be able to see to successfully complete a passing maneuver. This guideline provides the design values for passes made at different speeds provided in AASHTO and summarizes the research behind them.*
5-12 Influence of Speed on Sight Distance *The design of a road affects drivers' speeds, which in turn affect required sight distance. This guideline quantitatively discusses how features such as lane width and pavement surface affect the operating speed.*
5-14 Key References for Sight Distance Information *Sight distance issues have been covered extensively in a range of standard references. This guideline points to chapters in six standards where traffic engineers can find primary sources of sight distance information.*
5-16 Where to Find Sight Distance Information for Specific Roadway Features *This guideline cites references for calculating the sight distance for eight specific non-intersection features.*
5-18 Where to Find Sight Distance Information for Intersections *This guideline cites references for calculating the sight distance for nine types of intersections.*
6-1 Chapter 6: Curves (Horizontal Alignment)
6-2 Task Analysis of Curve Driving *This guideline identifies the basic activities that drivers typically perform while navigating a single horizontal curve. It explains how design aspects such as consistency, curvature, and lane width affect the driver's workload, and where and how driving tasks should be made easier to perform.*
6-4 The Influence of Perceptual Factors on Curve Driving *Visual information around a horizontal curve can cause drivers to perceive the radius to be different from the actual radius. This guideline provides graphs of recommended combinations of horizontal curvature and vertical sag curvature, and discusses the effects of vertical crests, cross slope, and other features.*
6-6 Speed Selection on Horizontal Curves *Drivers' speed selection on horizontal curves reflects a variety of vehicle, driver, and roadway factors. Use this guideline in combination with the previous one to learn about factors that affect how drivers select their speed.*
6-8 Countermeasures for Improving Steering and Vehicle Control Through Curves *This guideline describes how to select curve geometries that help drivers maintain proper lane position, speed, and lateral control through curves. It includes quantitative guidance on curvature, spiral length, and reverse curves.*
6-10 Countermeasures to Improve Pavement Delineation *This guideline describes how pavement markings can help driver performance in curves maneuvers. It includes guidance on edge and center lines, raised reflective pavement markers, and markers on signs.*

6-12 Signs on Horizontal Curves *The key to effective curve negotiation is to notify the driver of the upcoming curve so that the driver can change the speed or path of the vehicle. This guideline summarizes research results on sign placement, chevrons, flashers, and dynamic message signs.*
7-1 Chapter 7: Grades (Vertical Alignment)
7-2 Design Considerations for Turnouts on Grades *Turnouts are widened, unobstructed shoulder areas that allow slow-moving vehicles to pull out of the through lane to give passing opportunities to following vehicles. This guideline provides design recommendations for use of signs, sight distance, entry speed, and exits.*
7-4 Geometric and Signing Considerations to Support Effective Use of Truck Escape Ramps *The AASHTO Green Book has comprehensive guidance for the design and location of emergency escape ramps. This guideline emphasizes its key aspects and adds guidance from additional sources.*
7-6 Preview Sight Distance and Grade Perception at Vertical Curves *Preview sight distance applies to horizontal curves near the top of crest vertical curves or at the bottom of sag vertical curves, where the horizontal curve is initially out of the driver's line of sight. This guideline explains the need for preview sight distance and how to calculate it.*
8-1 Chapter 8: Tangent Sections and Roadside (Cross Section)
8-2 Task Analysis of Lane Changes on Tangent Sections *In this guideline, the perceptual, cognitive, and psychomotor tasks before and during a lane change are identified and analyzed; workload levels for various activities are estimated.*
8-4 Overview of Driver Alertness on Long Tangent Sections *Fatigue is a combination of boredom, sleep disruption, and other factors that reduce vigilance. Although data are not definitive on the relationship between length of a tangent and the fatigue-related crash risk, this guideline explains how to break the monotony, such as adding visual complexity, or provide countermeasures, such as shoulder rumble strips.*
9-1 Chapter 9: Transition Zones Between Varying Road Designs
9-2 Perceptual and Physical Elements to Support Rural-Urban Transitions *This guideline deals with transitions between rural and more densely settled areas. Use it to understand how to use treatments beyond signs to slow vehicles for a town along an otherwise rural highway.*
10-1 Chapter 10: Non-Signalized Intersections
10-2 Acceptable Gap Distance *The acceptable gap is the minimum vehicle-to-vehicle time typically accepted by drivers turning from a minor road to a major road. This guideline gives values and rationales for the gaps required by different vehicles for left and right turns.*
10-4 Factors Affecting Acceptable Gap *Driver age, wait time, direction of the turn, familiarity with the roadway, size of the oncoming vehicle, and headlight glare all affect acceptable gap size. This guideline discusses these factors and also includes a task analysis of the steps of performing a turn across traffic onto a four-lane highway.*
10-6 Sight Distance at Left-Skewed Intersections *Drivers at these intersections need to look backwards over their right shoulder and past parts of their own vehicle. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle, set back distance, and properties of typical vehicles.*
10-8 Sight Distance at Right-Skewed Intersections *Vision of drivers at these intersections is limited by their ability to turn their eyes and neck to look backwards over their left shoulder. This guideline presents the geometry and tables to calculate the available sight distance from the skew angle and set back distance, with special considerations for the restricted movement of older drivers.*
10-10 Countermeasures for Improving Accessibility for Vision-Impaired Pedestrians at Roundabouts *Roundabouts are a challenge for vision-impaired pedestrians, due to the absence of cues that they typically use for safe navigation. This guideline discusses the efficacy of several countermeasures that have been investigated to address this problem.*

11-1 Chapter 11: Signalized Intersections
11-2 Engineering Countermeasures to Reduce Red Light Running *This guideline lists countermeasures regarding traffic characteristics, signal operations, and motorist information that have been shown to reduce red light running.*
11-4 Restricting Right Turns on Red to Address Pedestrian Safety *This guideline describes when right turn on red movements need to be restricted to protect pedestrians. It summarizes research on signage and geometry treatments improve safety.*
11-6 Heuristics for Selecting the Yellow Timing Interval *This guideline contains formulas for calculating the duration of the yellow interval and the red clearance time. It also discusses the decisions and actions of drivers faced with the "dilemma zone."*
11-8 Countermeasures for Improving Accessibility for Vision-Impaired Pedestrians at Signalized Intersections *Accessible pedestrian signals and curb treatments improve the ability of vision-impaired pedestrians crossing at signalized intersections. Use this guideline to identify recommendations for the location and design of curb ramps, signal timing, and push buttons.*
12-1 Chapter 12: Interchanges
12-2 Task Analysis of Driver Merging Behavior at Freeway Entrance Ramps *This guideline lists the steps followed by a driver while merging to a freeway and discusses the challenges of each step. Differences between light and heavy traffic and between older and younger drivers are noted.*
12-4 Reducing Wrong-Way Entries onto Freeway Exit Ramps *This guideline covers treatments to reduce the frequency of drivers entering freeways by using the exit ramps. It can be used to identify appropriate countermeasures for visibility, signing, and road geometry.*
12-6 Driver Expectations at Freeway Lane Drops and Lane Reductions *Lane drops may violate driver expectations and cause confusion when the driver expects the lane to continue. This guideline describes visual, geometric, and signing principles to prepare drivers for lane drops and reductions.*
12-8 Driver Information Needs at Complex Interchanges *Complex interchanges should be designed to give drivers the information they need and expect. Use this guideline to identify specific features of geometric elements, signing, and sight distance that can be used to minimize violations of driver expectations.*
12-10 Arrow-per-Lane Sign Design to Support Driver Navigation *Destination information and sign design must allow drivers to pair the destination with an arrow that points to a particular lane. This guideline helps designers avoid pitfalls associated with sign placement and how information is presented on a sign.*
12-12 Driver Behavioral Trends Based on Exit Ramp Geometry *Well-designed exit ramps support the intended behaviors of an exiting driver. This guideline itemizes the steps a driver performs in a safe exit and discusses how drivers use the available taper and deceleration lane.*
13-1 Chapter 13: Construction and Work Zones
13-2 Overview of Work Zone Crashes *This guideline characterizes work zone crashes and provides a framework for work zone design. It specifies the need for additional driver guidance in work zones based on the number, type and severity of crashes occurring in work zones.*
13-4 Procedures to Ensure Proper Arrow Panel Visibility *Arrow panels are used ahead of work zones to inform drivers of the need to move out of a closed lane. This guideline has values for the use, intensity, and position of flashing arrow panels.*
13-6 Caution Mode Configuration for Arrow Panels *This guideline provides recommendations for how to use the non-directional Caution Mode of an arrow panel configuration during temporary traffic control. It summarizes research on the shape of the flashing symbol.*
13-8 Changeable Message Signs *This guideline has principles for keeping messages terse and legible so their information can be quickly processed by drivers.*

13-10 Sign Legibility *A number of design characteristics of work zone signs contribute to drivers' ability to perceive and understand a sign's message. This guideline explains factors that determine signs' legibility including retroreflectivity (sheeting type), color, letter font, and location (roadside or overhead).*
13-12 Determining Work Zone Speed Limits *Speed limits are reduced in work zones to maintain safe traffic flow. This guideline provides results from crash studies on what speed limit reductions are most desirable. It also discusses how lane width, speed displays, and the amount of reduction itself affect the mean and variance of actual traffic speed.*
14-1 Chapter 14: Rail-Highway Grade Crossings
14-2 Task Analysis of Rail-Highway Grade Crossings *This guideline addresses the key factors found to affect driver decisions whether to obey control devices at grade crossings. Many of the factors are covered in more detail in the following guidelines.*
14-4 Driver Information Needs at Passive Rail-Highway Grade Crossings *This guideline covers the information that drivers need at grade crossings not protected by gates or lights. It explains what is required beyond the traditional crossbuck.*
14-6 Timing of Active Traffic Control Devices at Rail-Highway Grade Crossings *This guideline has quantitative recommendations on the time that should elapse between the initiation of the flashing light and the arrival of the train. It discusses driver expectations and behaviors observed at crossings for a range of delays.*
14-8 Four-Quadrant Gate Timing at Rail-Highway Grade Crossings *This guideline discusses the time interval between the entrance gate's beginning to descend and the exit gate's beginning to descend. Use it to find formulas and standards to calculate the interval.*
14-10 Countermeasures to Reduce Gate-Rushing at Crossings with Two-Quadrant Gates *This guideline discusses countermeasures against driving under or around gates at grade crossings. They include physical barriers (four-quadrant gates or centerline barriers prior to the gate), engineering changes to improve the credibility of warning devices, and wayside horns.*
14-12 Human Factors Considerations in Traffic Control Device Selection at Rail-Highway Grade Crossings *This guideline discusses factors to consider when selecting a yield sign, stop sign, or active control at a grade crossing.*
15-1 Chapter 15: Special Considerations for Urban Environments
15-2 Methods to Increase Driver Yielding at Uncontrolled Crosswalks *Uncontrolled crosswalks are those without regular signals to control traffic, though they might have a pedestrian-actuated half signal or HAWK signal. Use this guideline to learn how to improve sight lines and convey to drivers the need to look for pedestrians.*
15-4 Methods to Increase Compliance at Uncontrolled Crosswalks *This guideline discusses several treatments available for uncontrolled crosswalks and provides statistics for driver and pedestrian compliance with each.*
15-6 Methods to Reduce Driver Speeds in School Zones *Traffic control devices and pavement markings are used to encourage drivers to slow for school zones. This guideline summarizes research on a variety of methods for reducing speeds.*
15-8 Signage and Markings for High Occupancy Vehicle (HOV) Lanes *Signage is necessary to inform drivers of lanes in congested areas that are reserved for HOVs. This guideline summarizes research on how to word and place signs and markings to maximize understanding by drivers and minimize crashes.*
15-10 Sight Distance Considerations for Urban Bus Stop Locations *Bus stops can be located immediately before an intersection (near-side stop), after an intersection (far-side stop) or midblock. This guideline discusses relative advantages and disadvantages of each location with respect to sight distance and pedestrian traffic conflicts.*

16-1 Chapter 16: Special Considerations for Rural Environments
16-2 Passing Lanes *A passing lane is a lane added in one or both directions of travel on a two-lane, two-way highway to improve passing opportunities. Recommended lengths and spacing of passing lanes are provided for various conditions, and signage is discussed.*
16-4 Countermeasures for Pavement/Shoulder Drop-offs *This guideline provides maximum vertical drop-off heights as a function of lane width. If vertical pavement edges are less than the recommended heights or if they are beveled as recommended, then drivers who inadvertently drift over the edge and on to the shoulder can more safely return to the roadway.*
16-6 Rumble Strips *Shoulder rumble strips are a narrow line of indentations in the pavement immediately outside the traveled way, alerting drowsy drivers who drift out of their lane. This guideline lists levels of various sounds in a vehicle and recommends values for the shape and location of rumble strips.*
16-8 Design Consistency in Rural Driving *Drivers generally make fewer errors when geometric features are predictable and consistent with their expectations. A list of design factors that should be considered during a design consistency review is presented.*
17-1 Chapter 17: Speed Perception, Speed Choice, and Speed Control
17-2 Behavioral Framework for Speeding *This guideline provides an overview of the key factors relevant to speed selection. It includes a comprehensive list of the many situational, demographic, and environmental factors that can contribute to drivers' decisions about speeding, and identifies the many studies that have aided our understanding of speeding.*
17-4 Speed Perception and Driving Speed *While a direct measure of speed is available from the speedometer, drivers rely on a number of cues for their sense of speed. This guideline discusses how various cues can cause drivers to overestimate or underestimate their own or another vehicle's speed.*
17-6 Effects of Roadway Factors on Speed *Geometric factors affect the free-flow speed. Use this guideline to learn which factors have proven effects on speed on rural highways and urban streets.*
17-8 Effects of Posted Speed Limits on Speed Decisions *Advisory speeds have at best a modest effect on speed, particularly for drivers familiar with the road. This guideline discusses light-vehicle driver compliance with posted speed limits on non-limited access rural and urban highways.*
17-10 Speeding Countermeasures: Setting Appropriate Speed Limits *This guideline discusses how to set an appropriate speed limit accounting for the unique traffic, design, and environmental aspects of a roadway. It includes standard conditions, variable speed limits, and heavy truck traffic.*
17-12 Speeding Countermeasures: Communicating Appropriate Speed Limits *This guideline discusses best practices for communicating posted speed limits to drivers and explains when to use approaches such as redundant signs, active speed warning, and in-pavement measures.*
17-14 Speeding Countermeasures: Using Roadway Design and Traffic Control Elements to Address Speeding Problems *Geometric elements and traffic control devices both affect speed-related crashes. Like the others in this chapter, this guideline should be used in consultation with the original NCHRP reports for a full appreciation of the factors.*
Part IV HF Guidance for Traffic Engineering Elements
18-1 Chapter 18: Signing
18-2 General Principles for Sign Legends *Sign legends (the text and symbols on a sign) must be short and simple to maximize driver comprehension. Use this guideline for information on the content of common signs and on the distance ahead of a decision point where a sign should be placed.*
18-4 Sign Design to Improve Legibility *Signs must be designed so that the text is legible. This guideline summarizes research on characteristics including the color, size, and style of letters, with special considerations for older drivers and nighttime visibility.*

18-6 Conspicuity of Diamond Warning Signs under Nighttime Conditions *A critical factor in the driver's ability to see, locate, and comprehend warning signs at night is to maximize sign conspicuity relative to surrounding background elements. This guideline provides desirable characteristics about the sign itself and its environment to improve its conspicuity.*
18-8 Driver Comprehension of Signs *There are three stages of comprehension—legibility, recognition, and interpretation. This guideline explains when to use text, icons, and a combination of the two, and other ways to maximize comprehension.*
18-10 Complexity of Sign Information *The complexity of sign information refers to the number of information units (words or numbers) in the message on a roadway sign. This guideline gives comprehension rates and reading times for messages of different complexity and explains when short (sometimes only one word) messages are important.*
19-1 Chapter 19: Changeable Message Signs
19-2 When to Use Changeable Message Signs *Changeable message signs (CMSs) allow for the display of time-sensitive or temporary information that affects travel and, in many cases, requires drivers to take an action. This guideline provides general principles for when to use CMSs and how to maintain their credibility.*
19-4 Presentation to Maximize Visibility and Legibility *This guideline discusses lighting and shape characteristics of changeable message signs to maximize their readability. It contains the results of research on the contrast ratio, luminance, character spacing, and dot matrix size, noting differences for older drivers and nighttime conditions.*
19-6 Determining Appropriate Message Length *Messages must be short enough that drivers can comprehend them in the limited time they have while passing the sign. This guideline includes recommendations and quantitative research on the length, content, and arrangement of messages and placement of the changeable message sign.*
19-8 Composing a Message to Maximize Comprehension *The way a message is worded and formatted can significantly affect the ability of a driver to comprehend it. Guidance on abbreviations, date format, and word choice is provided.*
19-10 Displaying Messages with Dynamic Characteristics *The guideline has formulas for the timing of messages and the blank intervals between them. It also explains how some attempts to draw drivers' attention can increase reading time.*
19-12 Changeable Message Signs for Speed Reduction *Changeable message signs can be used to alert drivers to the need to reduce their speed for temporary conditions such as work zones, adverse weather, incidents, or heavy congestion. This guideline provides principles on the wording and placement of changeable message signs to achieve speed reductions.*
19-14 Presentation of Bilingual Information *Bilingual information may be required in areas with culturally diverse populations or heavy international tourism; however, bilingual signs must be used cautiously because they can increase the reading time of both monolingual and bilingual drivers. This guideline discusses ways to distinguish the two languages.*
20-1 Chapter 20: Markings
20-2 Visibility of Lane Markings *Lane markings help drivers align their vehicle with the lane. This guideline discusses preview time and the use of peripheral vision, the required luminance of the markings, and the width of the stripe.*
20-4 Effectiveness of Symbolic Markings *Horizontal signing is sign text painted on the roadway. This guideline explains how these markings can alert drivers to speed reductions for horizontal curves or to impending lane drops, and prevent wrong-way movements.*
20-6 Markings for Pedestrian and Bicyclist Safety *These markings encourage safe practices of motor vehicles, pedestrians, and bicyclists. The guideline has a table for which roads are candidates for marked crosswalks, and it summarizes research on markings for shared bicycle lane.*

20-8 Post-Mounted Delineators *Post-mounted delineators are a series of retroreflective marking devices above the pavement surface to indicate alignment. They are useful when the alignment might be confusing or unexpected. This guideline provides recommendations for delineator use, including spacing.*
20-10 Markings for Roundabouts *This guideline covers pavement markings at the entrances and exits of roundabouts. Refer to it for suggestions on lighting, pavement marking, spacing, stopping sight distances, and accommodations for bicyclists and pedestrians.*
21-1 Chapter 21: Lighting
21-2 Countermeasures for Mitigating Headlamp Glare *Glare occurs when the intensity of a light source is greater than the adaptation level to the surrounding view. This guideline discusses approaches to reducing glare from other vehicles' headlamps.*
21-4 Nighttime Driving *Visibility at night in rural areas is limited by the lack of ambient light, the reach of headlamps, and the minimal contrast of persons and objects in the roadway. This guideline lists the respective benefits and suggested conditions for using seven treatments, ranging from continuous lighting to advance warning signs.*
21-6 Daytime Lighting Requirements for Tunnel Entrance Lighting *Lighting at tunnel entrances requires special consideration because of the contrast between illumination inside the tunnel and the surroundings. This guideline provides recommendations for minimum lighting, the spacing and direction of lights within the tunnel, and treatments outside the entrance.*
21-8 Countermeasures for Improving Pedestrian Conspicuity at Crosswalks *This guideline contains information on the effective use of flashing lights mounted to a crosswalk sign, the pole supporting the sign, or the pavement.*
21-10 Characteristics of Lighting that Enhance Pedestrian Visibility *This guideline addresses the positioning and spectral contentment (i.e., kind of light) of luminaires to enhance the visibility of pedestrians. The discussion includes colors of clothing and function of the eye.*
21-12 Characteristics of Effective Lighting at Intersections *This guideline provides principles for improving nighttime visibility of pedestrians, vehicles, roadway features, and obstacles at intersections. It recommends illuminance values and luminaire placement.*

APPENDIX B:
USING THE HFG DURING A ROAD SAFETY AUDIT (RSA)

Using the HFG During a Road Safety Audit[4]

Step 1: Identify Project or Existing Road to be Audited

The HFG should be applicable to any roadway incorporated into an RSA.

Step 2: Select RSA Team

Adding a human factors researcher or practitioner to the RSA team would aid in the interpretation and implementation of the HFG

Step 3: Conduct Pre-audit Review	
Create list of HFG contents corresponding to design characteristics or safety issues within the road system	
RSA: List roadway and traffic engineering elements contained within the road to be audited.	HFG: Using the Glossary and the Table Of Contents, identify Chapters, Guidelines, and Tutorials that seem most relevant.
RSA: Review crash data or previous safety evaluations and summarize findings	HFG: List relevant road user performance issues and corresponding sections within the HFG

[4] Based on the “FHWA Road Safety Audit Guidelines”, FHWA-SA-06-06

Step 4: Conduct Review of Project Data and Field Review

Identify HFG guidance corresponding to the roadway characteristics

RSA: For each roadway and traffic engineering elements contained within the road to be audited, list or describe the "as-built" specification.	HFG: Using the checklist of HFG materials generated previously, list HFG recommendations corresponding to each "as-built" specification.
RSA: During the field review, consider driving scenarios and driver/road user behaviors, especially in light of the site-specific crash and safety data.	HFG: List relevant HFG recommendations contained within individual guidelines, as well as relevant *Discussion*, *Design Issues*, and *Cross References* subsections. List relevant information from the *Tutorials*.

Step 5: Conduct Audit Analysis and Prepare Report

Assess risks between any differences between the "as-built" specifications and the HFG recommendations

Evaluate risks and prioritize safety concerns

List those differences between the "as-built" specifications and the HFG recommendations that are likely to result in safety consequences.	Do the HFG materials provide other insights or countermeasures into known or likely safety issues?

Prepare safety report

List each safety issue/risk	For each, provide relevant details from the HFG: road user capabilities or limitations, key perceptual or behavioral issues, known trade-offs, countermeasures or design options, data sources or relevant studies.

APPENDIX C:
HFG EVALUATION QUESTIONS

Human Factors Guidelines (HFG) for Road Systems
Assessment of the HFG

General Information

Name (optional):

Your Professional Title:

Please describe your job responsibilities in 1-2 sentences:

Training/Degree Areas:

Years of Experience:

General Use of Reference Materials

What are the key standards and reference materials relating to roadway design and safety that you use in your job?

To what extent to you think that these sources address human factors topics?

In general, what do you do when you have a human factors question? Where do you go for help?

Questions about the HFG

Was the presentation format used in the HFG easy to understand? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No

Was the information presented in the individual guidelines easy to use? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No

How easy is it to find individual topics of interest in the HFG? (circle answer and add any additional thoughts below)

Easy	Somewhat Easy	Average	Somewhat Difficult	Difficult

Overall, how would you rate the HFG in terms of clarity and ease-of-use relative to other information sources that you use? (circle answer and add any additional thoughts below)

Better	Somewhat Better	About the Same	Somewhat Worse	Worse

Was the information presented in the individual guidelines useful and valuable to you? (circle answer and add any additional thoughts below)

Yes	Mostly	Average	Somewhat	No

Did you try and apply the HFG to a real-world roadway design issue or problem? (Yes / No) If so, describe the problem and whether or not / how the HFG helped you

What chapters/guidelines/topics in the HFG were <u>most</u> useful to you?

What chapters/guidelines/topics in the HFG were <u>least</u> useful to you?

Explain in your words what you like most about the HFG:

Explain in your words what you like least about the HFG:

Do you have any specific recommendations on how the HFG can be improved?

Additional Thoughts or Recommendations: