Application of Human Factors Guidelines for Road Systems

June 15, 2016

NCHRP REPORT 600 NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Human Factors Guidelines for Road Systems

Second Edition

TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES



Today's Presenters

- Moderator
 - Dr. Sue Chrysler, Texas A&M Transportation Institute
- Brief Background and Layout of the Human Factors
 Guidelines
 - Dr. John Campbell, Battelle Memorial Institute
- Joint use of the Highway Safety Manual and Human Factors Guidelines
 - Dr. John Milton. Washington State DOT



Today's Presenters

- Past & Future Human Factors Guidelines Applications
 - Arizona DOT, Dr. Kohinoor Kar
 - Wisconsin DOT, Rebecca Szymkowski
 - Idaho and Nevada DOT, Dr. John Campbell
- New Opportunities for Applications
 - Sam Tignor, Chair TRB Joint Subcommittee for the HFG,



NCHRP is...

A state-driven national program

- The state DOTs, through AASHTO's Standing Committee on Research...
 - Are core sponsors of NCHRP
 - Suggest research topics and select final projects
 - Help select investigators and guide their work through oversight panels



NCHRP delivers...

Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, manuals
- Can be directly applied across the spectrum of highway concerns: planning, design, construction, operation, maintenance, safety



A range of approaches and products

- Traditional NCHRP reports
- Syntheses of highway practice
- IDEA Program
- Domestic Scan Program
- Quick-Response Research for AASHTO
- Other products to foster implementation:
 - Research Results Digests
 - Legal Research Digests
 - Web-Only Documents and CD-ROMs



NCHRP Webinar Series

- Part of TRB's larger webinar program
- Opportunity to interact with investigators and apply research findings.



Today's First Presenter

- Brief Background and Layout of the Human Factors Guidelines
 - Dr. John Campbell, Battelle Memorial Institute



TRB Webinar: Application of Human Factors Guidelines for Road Systems

Background and Layout of the Human Factors Guide (HFG)

John L. Campbell, Ph.D. Battelle, Center for Human Performance and Safety

June 15, 2016

Discussion Topics

- Background to the Human Factors Guidelines (HFG) for Road Systems
- Layout of Guidelines in the HFG
- Ways to Use the HFG
- New Applications of the HFG

History and Status of the HFG Effort

- The purpose of the HFG is to provide the best factual information and insight on road users' characteristics to facilitate safe design and operational decisions.
- Development of the HFG has been an ongoing project since 2001.
- 3 subsections (NCHRP 600 A, B, & C) of the HFG were published in 2007, 2009, & 2010.
- 2nd Edition of the full HFG was published in 2012.
 - 90 distinct guideline topics
 - 475+ references
 - PDF version with updated external and internal links
 - 2-hour training course

Specific Requirements for the HFG

- Focus on road user needs, limitations, and capabilities
- Reflect end-user requirements for content, format, and organization (clear, relevant, and easy-to-use)
- Aid and augment the judgment and experience of highway designers and traffic engineers through presentation of factual information and insights from the human factors literature
- Complement existing sources of road design information



Presentation Format Used in the HFG



Ways to Use the HFG

- 1. Enhance initial roadway planning and design activities
- 2. Support road safety audits
- Conduct diagnostic assessments of safety concerns & incidents
- 4. Identify & select safety countermeasures
- 5. Educate traffic engineers & designers on user needs, capabilities, and limitations

Pilot Tests of the HFG

- From 2012-2014, 5 State DOTs participated as test sites to implement the HFG and assess its value.
 - Arizona: As part of 7 rural and urban RSAs.
 - Delaware: Day-to-day use and to diagnose specific trouble spots.
 - Idaho: As part of a new "Highway Corridor Safety Analysis Project" to help prioritize safety improvement needs and projects across the state.
 - Nevada: To assist 4 RSAs and annual reviews of high-crash sites involving intersections.
 - Wisconsin: To support 2 RSAs: an urban planning-level engineering analysis, and a rural high-crash location.

Road Safety Audits

Key Steps in the RSA Process	Ways to use the HFG
Conduct Pre-audit Review	Identify appropriate guidelines in the HFG that could address safety issues in your road system project
Conduct Review of Project Data and Field Review	Identify HFG guidance corresponding to the roadway characteristics
Conduct Audit Analysis and Prepare Report	Assess risks between any differences between the "as-built" specifications and the HFG recommendations

Conducting Diagnostic Assessments

- 1. Identify driver information needs or road user limitations that could lead to errors, problems, or crashes
- 2. Describe these issues-why is it a problem?
- 3. Describe potential interactions across issues
- 4. Identify key information and/or design solutions in the HFG



Example Problem Using Human Factors Interaction Matrix (HFIM)



Difficult left turn, aerial view



Difficult left turn, street view

Human Factors Interaction Matrix (HFIM)

Infrastructure	Vehicle	Road User	Interaction	HFG Help	
4-lane divided, 40,000 AADT	Cars	To and from work	Unfamiliar drivers create indecision	Ch. 3 & 4	
13'+ median	Light vehicles	Heavy peak users	Left turns gaps hard to assess	10-2,10-4	
Left & rt. turn lanes	Few trucks	Few pedestrians	Intersection crashes		
12' shoulders	Buses	School travelers	LT during school starts and ends	15-6	
Bus stops on River Road		Few bicycles	Approach signing needed	18-2, 18-6, 19-2, 19-12, MUTCD	
No left turn from Braeburn Parkway			Opposing left turn vehicles restrict gap finding	5-2	
Wide intersection, 85' for LT			LT travel across 3- lanes & shoulder	10-2, 10-4	
45 mph speed limit			Curve & speeds hinder gap finding	5-2, 5-12	
NB curve prior to intersection at bottom of -3.5% grade			Approach speed towards intersection high	17-10, 17-12, 17-14	
35' pedestrian Xing on River Rd.			School pedestrian. Crossing	20-6, 21-8, 21-12	

HFIM with Factors that Might Contribute to Reduced Roadway Safety

Road User	Vehicle	Environment	
 Age Capabilities Sensory/Visual Cognitive Physical Experience Road familiarity Impairment Training Attitudes 	 Vehicle type Steering capabilities Braking capabilities Engine characteristics Safety features Vehicle height Headlamps Distractions 	 Speed Traffic volume One-way flow Two-way flow Control type Functional class Lane width Shoulder width Sight distance Pavement type and condition Bicyclists Distractions Enforcement 	 Roadside Grades Curvature Signs and markings Weather Land use Pedestrians Urban Rural Time of day Light condition Scenic/interest attractions

New Applications of the HFG

• A New Human Factors Training Course from NHI.

- Developed a 2-day training course based on the *Human Factors Guidelines (HFG) for Roadway Systems* (NCHRP Report 600).
- The training will assist practitioners in identifying the value of human factors in operations and design, and demonstrate how to apply human factors in practice.
- Available now FHWA-NHI-380120: Introducing Human Factors in Roadway Design and Operations
- Specific Goals of the Course
 - Describe basic human characteristics relevant to being a road user.
 - List ways in which the vehicle, road user, and roadway elements interact to influence operations and safety outcomes.
 - Identify how individual characteristics impact a road user's experience of the road environment.
 - Describe how the HFG relates to reference sources such as the HSM, MUTCD, and AASHTO's Policy on Geometric Design of Highways and Streets.
 - Select and apply specific human factors guidelines for traffic engineering elements to common scenarios.

Summary

- The Human Factors Guidelines (HFG) for Road Systems provides information and insight on road users' characteristics to facilitate safe design and operational decisions.
- The guidelines provided in the HFG reflect the bestavailable scientific evidence and are supported by over 475 citations.
- The HFG is designed to be clear and easy to use.
- The HFG can be used to support RSAs and to conduct diagnostic assessments.
- The HFG was successfully piloted in 5 states.
- A new Human Factors training course based on the HFG is available from NHI.

For More Information...

 2nd Edition of the full HFG; NCHRP Report 600 available at:

http://www.trb.org/Main/Blurbs/167909.aspx

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Joint use of the Highway Safety Manual (HSM) & the Human Factors Guide (HFG)

John Milton, P.E., Ph.D., Director: Quality Assurance and Transportation System Safety, WSDOT Transportation System Safety

Ida van Schalkwyk, Ph.D., Traffic Safety Research Engineer, WSDOT HQ Traffic Operations

Roger Millar, Acting Secretary of Transportation, WSDOT

June 15, 2016

TRB Webinar

Application of Human Factors Guideline for Road Systems

NCHRP REPORT 600

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HIGHWAY SAFETY MANUAL

1st Edition Volume 1 • 2010



AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS







Standards based approach with some quantification with the HSM Designing *self-explaining* roadways using knowledge about the **user & quantitative analysis** to inform our decisions about design element choices,

What the HSM brings to the table



- Quantification of safety performance across facility types
- Anticipated impacts of countermeasures
- Processes & methods to support quantitative safety management process

What the HFG brings to the table



- Ability to **start with human** capabilities and limitations & develop projects/ evaluate sites with that focus
- Dovetails with the HSM: selfexplaining roadways → humans make choices (such as speed) & what we know
- Supplements other tools with human factors component (e.g. MUTCD)

Crashes/Yr in Study Area



Methodology

- Divide roads into segments (and intersections) with uniform conditions
- Use regression equations to estimate road crashes (baseline case), N_{SPF} (SPF= safety performance function)

 $N_{spf\ ru} = e^{(a+b \times \ln(AADT) + \ln(L))}$

(11-7)

- Apply modification factors & adjust for non-base case conditions (lane width, shoulder width, side slopes, lighting, etc.) in crashes/yr; CMF_i
- Compute crashes/yr/segment (or intersection): Predicted Crashes =N_{SPF}xCMF₁x CMF₂ xCMF₃ xCMF₄...xCMF_i
- Add crashes/yr for all roadway segments & intersections

Methodology, cont.

- Assess improvements using HFG, AASHTO, MUTCD & re-do HSM crash estimate/yr/segment
- Summarize improvements for potential safety benefit (crashes/yr)

HSM	Highway Safety Manual
HFG	Human Factors Guideline
AASHTO	American Assoc. of State Highway & Transportation Officials
MUTCD	Manual on Uniform Traffic Control Devices

Project Summary

	Location	Project Summary Treatment	Expected crashes before/ yr	Expected crashes after/ yr	Expected change in crashes
⇒	Inter., Node B	Change skew to 90 degrees (HFG10-6)	10.0	9.2	8%
	Inter., Node B	Install intersection warning signs on D-B and A-B approaches (<i>HFG 16-8, 18-8</i>)	10.0	n/a	n/a
	Inter., Node B	Install Right turn lane on C-B and A-B approaches (HFG 11-2)	10.0	8.6	14%
⇒	Signal inter. in BD	Change to Protected side street phasing (HFG 11-2)	11	9.68	12%
	Signal inter. in BD	Modify Change plus Clearance interval (HFG 11-6)	11	8.58 or 11.66	22% or -6%
⇒	Segment AB	Install 4' raised median	66.98	45.4 or 50.0	32-25%
	Segment AB	Install continuous shoulder rumble strips (HFG 16-6)	66.98	39.3 or 63.8	41-5%
→	Segment BD	Install 4' raised median	88.44	72.52 or 65.45	18-26%
	Segment BD	Reduce access point density to < 10/mile	88.44	71.64 or 61.02	19-31%
⇒	Segment BC	Add warning signs (HFG 16-8, 18-8)	10.43	10.95 or 7.20	31% or -5%
	1.25 mi. curve	Add raised pavement markers	3.42	4.24 or 4.38	not effective
	1.00 mi. curve	Add raised pavement markers	2.66	2.95 or 2.31	13% or -11%
	1.25 mi. curve	Increase super-elevation	3.42	3.21	6%

Concluding thoughts:

So why use the HFG with the HSM?

- Design solutions based on user-needs research
- Eliminates searching and integration of published research
- Eliminates guesswork about user needs
- Aids designers in project development: enhances the final safety solutions

Thank you

John Milton, Ph.D., P.E.

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Human Factors Guidelines (HFG) Applications Past and Future – Arizona Perspective



Transportation Research Board

Webinar Series

June 15, 2016

Kohinoor Kar, Ph.D., P.E., PTOE Arizona Department of Transportation

Why HFG? Human Contributions to Crashes

- Psychological
- Physiological
- Not temporary conditions
 - Intoxication
 - Heart attack
 - Alcohol
 - Other mental or physical conditions

Why HFG? Sequential Event in a Crash



Source: TRaffic Accident Causation in Europe (TRACE), Project 027763, May 2009.

Potential HFG Applications Better Safety Performance

- Expected to result in better:
 - Planning
 - Design
 - Construction
 - Operation & Maintenance

Arizona Experience HFG in RSAs

- Used HFG principles in an "ad-hoc" fashion staff had HFG training and used them routinely
- Used the HFG principles during RSAs on rural and urban freeways and arterials

Examples of HFG Applications

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

Future of HFG Arizona Perspective

- Highway Designers ensure the design addresses human factor elements
- Include in all phases of Project Development and Operations & Maintenance
- Continue using HFG principles on RSAs

What Can You Do? Utilize HFG

Obtain a copy of the HFG*

 Identify opportunities and apply HFG guidelines in order to enhance safety performance of future or existing facilities

- During All Phases of Project Development
- Operations and Maintenance
- Road Safety Audits
- Review Network Screening Locations
- Other Safety Reviews

*Available at TRB

http://www.trb.org/Main/Blurbs/167909.aspx

Thank You! Questions?

Contacts for additional information: Kohinoor Kar <u>kkar@azdot.gov</u>

Disclaimer: Information contained in this presentation are for informational purpose only and may not necessarily reflect current ADOT policies or guidelines.

Wisconsin DOT Pilot Study of Human Factors Guidelines for Road Systems

Rebecca Y. Szymkowski, P.E., PTOE Wisconsin Department of Transportation

June 15, 2016

Purpose of Pilot Studies

- To apply the HFG to two road safety audits
 - 1. Planning-level environmental document
 - 2. Existing intersection
- To introduce the HFG to DOT and consultant staff and learn how to apply to projects



Planning – level environmental document

- Milwaukee-area
- 3.5 mile corridor with 1 system interchange and 5 service interchanges
- I-94 corridor study/urban interstate
- Segment has over 300 crashes/year
- ► ADT ~138,000 156,000
- Project end points are 2 major system interchanges
- Major link for commuters, tourists, and freight
- Near major event traffic generator
- Capacity expansion





Planning – level environmental document

- HFG chapters used
 - Chapter 7-6: Preview Sight Distance and Grade Perception at Vertical Curves



 Chapter 12-4: Reducing Wrong-Way Entries onto Freeway Exit Ramps



Existing intersection road safety audit

- Rural 4-lane divided expressway
- Speed limit = 65 mph
- Intersection on large sweeping curve
- "Far-side" intersection crashes
- HFG Chapters Used
 - Chapter 6-2 Task Analysis of Curve Driving
 - Chapter 6-4 The Influence of Perceptual Factors on Curve Driving





HFG Comments

Comments from project teams

- "...the document was useful and added credibility to some of the points we were trying to make with the design team."
- "...a good tool to get designers to think like traffic engineers."
- "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."
- "Logical to incorporate the HFG with RSAs."



Wisconsin HFG Next Steps and Considerations

- Consider HFG incorporation into road safety audit policies and procedures
- Consider HFG use with Highway Safety Manual implementation
- Generate HFG awareness within WisDOT and with other agencies/consultants



Questions?

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TRB Webinar: Application of Human Factors Guidelines for Road Systems

Past & Future HFG Applications: Idaho and Nevada

John L. Campbell, Ph.D. Battelle, Center for Human Performance and Safety

June 15, 2016

Discussion Topics

- Overview of the State Pilot Projects
- Applying the HFG in Idaho
- Applying the HFG in Nevada
- Future Opportunities for States to Apply the HFG

Implementing the Pilot Studies

- Key Steps:
 - 1. Announce the availability and general nature of the HFG Pilots/State DOT support
 - 2. Work with State PoCs to obtain approvals and outline pilot test activities
 - 3. Define details of the pilot test: HFG application, user group, schedule
 - 4. Conduct on-site training, provide on-going support
 - 5. Evaluate overall usefulness and value, contents, presentation format, specific strengths and weaknesses

Piloting the HFG in Idaho

Idaho Transportation Department (ITD; Brent Jennings, PoC)

- 2 HFG training sessions were conducted in 2013
- ITD performed a 6-district review encompassing 5,000 miles of roadway.
- Consideration of human factors was formally incorporated into the process.
- Currently applying the HFG in the planning and prioritization process.
- A commitment to consider and utilize the HFG is now starting to unfold in the ITD highway safety culture.

Piloting the HFG in Idaho (Cont.)

Crash Diagnosis



Piloting the HFG in Idaho (Cont.)

Identify Crash Countermeasures



Piloting the HFG in Nevada

- Nevada Department of Transportation (NDOT; Jaime Tuddao & Chuck Reider PoCs)
 - 2 HFG training sessions were conducted in 2013
 - Incorporated the HFG into NDOTs Road Safety Audit program
 - Roadway sections in both northern (Carson City) and southern (Las Vegas) Nevada were selected as sites for the pilot testing
 - An urban RSA examined a 7-mile arterial in Las Vegas, and was intended to look at safety issues from a different perspective and develop recommendations for potential safety enhancements.

Piloting the HFG in Nevada (Cont.)

- Nevada Department of Transportation (NDOT; Chuck Reider and Jaime Tuddao, PoCs) (Cont.)
 - Key HFG chapters considered especially relevant to this RSA were: Signalized and Non-signalized intersections (10 & 11), Urban environments (15), Speed (17), Signing (18), Markings (20), and Lighting (21), resulting in "numerous applications of the HFG to this RSA" in terms of both "identification of issues as well as associated recommendations."
 - <u>Problem</u>: Limited sight distance combined with high speed right turns at an intersection may be contributing to a high number of crashes, from the HFG:
 - <u>Solution</u>: Add deceleration lane, improve visibility of the merge, add signing
 - <u>Problem</u>: Poor visibility of a traffic signal is leading to red light running , from the HFG:
 - <u>Solution</u>: Add additional signal head to median island; move stop bar further back
 - <u>Problem</u>: Drivers are confused about the proper lane to be in near freeway entrance ramps, from the HFG:
 - <u>Solution</u>: Add overhead signs specifying lane assignments

Future Opportunities for States to Apply the HFG

- NCHRP is supporting another opportunity for States to use and apply the HFG
- Timeframe: 2016-2017
- We anticipate a similar process as before; i.e., approve, plan, train, implement, evaluate
- How the participating States use & apply the HFG is open-ended

For More Information...

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 - campjohn@battelle.org
- Mark S. Bush, TRB/NCHRP
 - 202-334-1646
 - MBush@nas.edu

New HFG Opportunities

Sam Tignor, Chair TRB Joint Subcommittee for HFG June 15, 2016

Short History

- Initial HFG published December 2012
- Primer for using the HFG and HSM should have started (it is **in** NCHRP contract office).
- Work on the next edition of the HFG is expected to start in **July (?)**
- HFG article in ITE Journal will be published, fall
 2016 (emphasis on use of the HFG alone, with the HSM, and description of the HF interaction matrix)
 - Note: ITE May 2016 article on HF –Part 1—very good! Part 2 August (<u>http://library.ite.org/resources/library/</u>)

Opportunity to Help

- Preliminary TRB committee input is available from the 2016 TRB conference session.
- The HFG is a excellent source of relevant, quickly obtained guidance in 21 chapters
- TRB committees (and others) can submit suggestions on needed guidelines for the HFG
- The submissions are sent to the JSC, then to NCHRP, and finally to the contractor.

How to submit suggestions

- Send them to stignor@aol.com
- Subject title: HFG Suggestions from: _____ (give TRB Committee number, your name, or other identification)
- I will bundle them for transmission to NCHRP and contractor
- You will receive feedback on how the suggestions are used. (Note supporting research is mandatory for guideline development.)

Short Reminders

- Use the HFG with the HSM reviews!
- Use the HFG in design, traffic engineering & RSA, etc.
- Contact Mark Bush (NCHRP) for Pilot Study assistance.
- Submit suggestions for new guidelines for HFG
- Provide HFG feedback to TRB JSC, AND10(2)
- ITE HFG article fall 2016

Questions

