Joint Use of the HSM and Human Factors Guide

5th E of Safety

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AASHTO Committee on Safety Annual Meeting, May 8, 2018
Using Human Factors to Improve Road Safety Decisions
What is Human Factors?

Human factors is the “scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.”

As applied to road safety performance, human factors considers and accounts for road user needs, capabilities, and limitations in: (1) the design and operation of roads, vehicles, and pedestrian/bicycle/transit facilities (2) the identification of causal factors underlying conflicts and crashes.
What road user capabilities and limitations does human factors address?

- **Sensation**: Seeing, hearing, feeling
- **Perception**: Reorganizing, organizing, making sense
- **Attention**: Actively processing information
- **Decision-making & Response Selection**: Deciding, selecting
- **Response Execution**: Acting, doing
- **Memory**: Retaining, recalling
Three Factors of Driving

- Human factors approach to driving involves three components:

  - Road User
  - Vehicle
  - Environment
Three Factors of Driving (Cont.)

Road User

- Age
- Training
- Experience
- Capabilities & Limitations
- Impairment
- Expectations
Three Factors of Driving

- Environment
- Road Geometry and Sight Distances
- Level of Service
- Lighting
- Signing/Marking
Three Factors of Driving

Vehicle

- Tires
- Brakes
- Active Safety Systems
- Driver Assistance Systems
Three Factors of Driving

- These three components are inter-dependent
  - Road User
    - Samples information from environment
    - Controls vehicle
    - Maneuvers through environment
  - Environment
    - Provides information to the driver
    - Responds to the driver through actions of other road users
  - Vehicle
    - Triggers some responses in the environment
    - Provides feedback to the driver
## Crash Data - Crashes by Severity and Contributing Factor

<table>
<thead>
<tr>
<th>Contributing Factors</th>
<th>Fatal (K)</th>
<th>Serious Injury (A)</th>
<th>Evident Injury (B)</th>
<th>Possible Injury (C)</th>
<th>PDO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed greater than conditions</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Inattention</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Under influence of alcohol</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Following too closely</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Failure to yield ROW</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Under influence of drugs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Exceeding speed limit</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Driver operating device</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>39</td>
<td>55</td>
</tr>
</tbody>
</table>

### Graphical Representation

- **Speed greater than conditions**
- **Under Influence of Alcohol**
- **Failure to Yield ROW**
- **Exceeding Speed Limit**

Legend:
- Fatal
- Serious Injury
- Evident Injury
- Possible Injury
- PDO
Crash Data - Crashes by Severity and Type

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Fatal (K)</th>
<th>Serious Injury (A)</th>
<th>Evident Injury (B)</th>
<th>Possible Injury (C)</th>
<th>PDO</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear-End</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Vehicle Hit Pedestrian</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Sideswipe</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Vehicle Hits Utility Pole</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Left-Turn (Minor to Major)</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>39</td>
<td>55</td>
</tr>
</tbody>
</table>

**Bar Chart**

- Rear-End
- Vehicle Hit Pedestrian
- Sideswipe
- Vehicle Hits Utility Pole
- Left-Turn (Minor to Major)

**Legend**
- Fatal
- Serious Injury
- Evident Injury
- Possible Injury
- PDO

**Note:** PDO: Property Damage Only
How can we apply human factors to roadway design, operations, and safety?

- Applying human factors is about examining the ‘who’, ‘where’, and the ‘why’ of crashes.
- Human factors is more than the overt, specific behaviors that can lead to crashes, such as speeding, impaired driving, road rage, or intentionally engaging in distracting behaviors.
- Human factors also includes the relationships and compatibilities between: (1) the requirements of the driving task at a particular roadway location and under a specific set of circumstances and (2) the capabilities and limitations of the road user.
What is the ‘Human Factors Guidelines for Road Systems (HFG)’?

• The HFG is a resource for improving roadway safety performance that provides guidelines, data, and insights on road users’ characteristics to help guide design and operational decisions.
  − Focus on road user needs, limitations, and capabilities
  − 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

• The 2nd Edition of the HFG (NCHRP Report 600) was published in 2012.
  − 90 distinct guideline topics
  − 475+ references
  − PDF version with updated external and internal links
  − 2-hour training course

• A downloadable version of the 2nd Edition HFG can be found here: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf

• Development of the 3rd Edition is underway
Introduction to the HSM/HFG Primer
A Process for Improved Decision-Making
Primer on the Joint Use of the HSM and HFG

- The **HSM** is used to quantify the effects of safety decision-making on crash frequency and severity outcomes thus estimating the safety of roadway infrastructure.
- The **HFG** is used to facilitate safe operational decisions by providing the best factual information and insight on road users’ needs.
- **Joint use** of the HSM and the HFG will improve end users’ ability to select roadway design and operational elements based on the best-available data and promote an improve level of highway safety.
- How can the HSM and the HFG be used together to improve safety performance?
Countermeasures From the Human Factors Guidelines for Road Systems (HFG)
Three Factors of Driving

• These three components are inter-dependent
  • Road User
    – Samples information from environment
    – Controls vehicle
    – Maneuvers through environment
  • Environment
    – Provides information to the driver
    – Responds to the driver through actions of other road users
  • Vehicle
    – Triggers some responses in the environment
    – Provides feedback to the driver
Relative roles of driver, environmental, and vehicle factors in crashes
(from Treat et al., 1979)

- While drivers contributed to 93% of crashes, they were the sole cause of only 57% of crashes.
- It is often the interactions between road users, vehicles, and the environment that lead to errors, conflicts, crashes, and fatalities.
- Errors do not generally reflect the breakdown or occurrence of a single factor but, rather, reflect a confluence of factors that occur more or less simultaneously.
- We need to consider the full range of contributing factors that interact with a specific context and eventually lead to errors and crashes.
General Approach to Conducting Diagnostic Assessments

1. Identify driver information needs or road user limitations that could lead to errors, problems, or crashes (Step 2)

2. Identify/Describe these issues-why is it a opportunity? (Step 2c)

3. Identify/Describe potential interactions across issues (Step 2c)

4. Identify key information and countermeasures in the HFG (Step 3b)
Countermeasures From the Highway Safety Manual (HSM)
The Highway Safety Manual (HSM)

- First edition released in 2010, Updated in 2014
- Three volumes covering four parts
- The HSM focuses on bringing quantitative safety analysis into planning design and operations.
- Both the predictive method and CMF Method yield outcome crash impacts (reductions or increases) for given treatments/conditions
Tools in the HSM-Predictive Method

- Estimates crash frequency as a function of traffic volume and roadway geometry
- Equations are in HSM organized by cross-section total and injury crashes
- Data Requirements
  - Roadway and location data (number of lanes, posted speed limit, etc.)
  - Traffic volume
  - Crash history data
  - Local calibration factors
Tools in the HSM-Crash Modification Factors (CMF)

• Applying CMFs
  – Need to ensure the CMF matches the crash type, severity, traffic conditions, roadway type, etc.
  – CMF's should come from high quality studies

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.06</td>
<td>-6</td>
<td>🌟🌟🌟🌟🌟</td>
<td>All</td>
<td>All</td>
<td>Not specified</td>
<td>Park et. al., 2016</td>
<td>CMF is based on a ... [read more]</td>
</tr>
<tr>
<td>0.99</td>
<td>1</td>
<td>🌟🌟🌟🌟🌟</td>
<td>All</td>
<td>K,A,B,C</td>
<td>Not specified</td>
<td>Park et. al., 2016</td>
<td>CMF is based on a ... [read more]</td>
</tr>
<tr>
<td>0.84</td>
<td>16</td>
<td>🌟🌟🌟🌟🌟</td>
<td>All</td>
<td>K,A</td>
<td>Not specified</td>
<td>Park et. al., 2016</td>
<td>CMF is based on a ... [read more]</td>
</tr>
</tbody>
</table>
Primer on the Joint Use of the HSM and HFG (cont.)

- Purpose & Approach:
  - facilitates the combined use of the HSM and the HFG to support improved countermeasure identification and selection
  - a short, instructive, and readily useful document that explains the joint use of these resources, and provides state and local agencies a tool to enhance data-driven decision-making
  - provides: (1) a general step-by-step description of joint use and (2) specific examples that will illustrate how the HSM and HFG can be used together in project development to promote the highest level of safety for new or upgraded roadways
A Process for Joint Use of the HSM and HFG (cont.)
The Human Factors Interaction Matrix (HFIM)

- The HFIM is a modified Haddon Matrix that we use starting in Step 2c to help identify road user and other factors that could be contributing to a reduction in road safety across a range of various scenarios and driving situations.

<table>
<thead>
<tr>
<th>Road User</th>
<th>Vehicle</th>
<th>Environment</th>
<th>Interactions</th>
<th>Relevant Sections in the HFG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- The HFIM is completed as we work our way through individual safety issues/contributing factors/crash sites
HFIM with factors that might contribute to reduced roadway safety performance

<table>
<thead>
<tr>
<th>Road User</th>
<th>Vehicle</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Age</td>
<td>• Vehicle type</td>
<td>• Roadside</td>
</tr>
<tr>
<td>• Capabilities</td>
<td>• Steering capabilities</td>
<td>• Grades</td>
</tr>
<tr>
<td>• Sensory/Visual</td>
<td>• Braking capabilities</td>
<td>• Curvature</td>
</tr>
<tr>
<td>• Cognitive</td>
<td>• Engine characteristics</td>
<td>• Signs and markings</td>
</tr>
<tr>
<td>• Physical</td>
<td>• Safety features</td>
<td>• Weather</td>
</tr>
<tr>
<td>• Experience</td>
<td>• Vehicle height</td>
<td>• Land use</td>
</tr>
<tr>
<td>• Road familiarity</td>
<td>• Headlamps</td>
<td>• Pedestrians</td>
</tr>
<tr>
<td>• Impairment</td>
<td>• Distractions</td>
<td>• Urban</td>
</tr>
<tr>
<td>• Training</td>
<td></td>
<td>• Rural</td>
</tr>
<tr>
<td>• Attitudes</td>
<td></td>
<td>• Time of day</td>
</tr>
<tr>
<td>• Behaviors</td>
<td></td>
<td>• Light condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Scenic/interest attractions</td>
</tr>
</tbody>
</table>
Using the HFIM to Identify Potential Opportunities

• **Objective:** consider and document the possible road user, vehicle, and environment issues that could be contributing to confusion, errors, and crashes at the site or traffic situation that you are evaluating.

• **Key Inputs:**
  – the basic crash or conflict data compiled in Step 1
  – the site visit results from Step 2a (including relevant data such as the types of vehicles, cross section dimensions, traffic volumes, speed limits, kinds of traffic control)
  – the crash data trends from Step 2b

• **Approach:**
  – the HFIM should include any factors and combinations of factors (interactions) that could reasonably contribute to the known or suspected opportunities for improving safety at the site under investigation.
  – Identifying interactions will be crucial – *how could the individual factors – in combination - create confusion, distraction, uncertainties, or misperceptions on the part of road users.*
Using the HFIM to Identify Potential Contributing Factors (cont.)

- What is the nature of the crashes/conflicts observed?
- What can the most common crash types tell us about the relative contribution of road user, vehicle, and environment issues to the crashes?
- What are the most common contributing factors cited in the crash records?
- From the perspective of a road user, what might be some sources of confusion when trying to extract the most meaningful information (MMI) from the road geometry and traffic control information?
- How might unique issues associated with vehicle type be contributing to crashes or conflicts?
- Are there any unique environmental and road conditions that cause undue road user stress, additional comprehension time, or unrealistic responsive maneuvers?
- In general, are there any unclear or misleading cues between the roadway and user?
- Consider not just the factors that were present at the exact time of a crash, but also factors or events that could have occurred prior to the crash.
## Partially-Completed HFIM for the ‘Rural Multilane’ Example

<table>
<thead>
<tr>
<th>Road User</th>
<th>Vehicle</th>
<th>Environment</th>
<th>Interactions</th>
<th>Relevant Sections in the HFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speeding behaviors</td>
<td>Possible glare from on-coming headlamps</td>
<td>No barriers or cables on center median</td>
<td>No lighting</td>
<td></td>
</tr>
<tr>
<td>Impairments due to alcohol or distraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future increase in younger drivers</td>
<td></td>
<td>No lighting</td>
<td>High posted speed limit (75 MPH)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increased future traffic volumes due to college expansion</td>
<td></td>
</tr>
</tbody>
</table>
### Partially-Completed HFIM for the ‘Rural Multilane’ Example

<table>
<thead>
<tr>
<th>Road User</th>
<th>Vehicle</th>
<th>Environment</th>
<th>Interactions</th>
<th>Relevant Sections in the HFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speeding behaviors</td>
<td>Possible glare from on-coming headlamps</td>
<td>No barriers or cables on center median</td>
<td>Lack of barriers or cables across median combined with high speeds contributes to crashes and injuries due to road departures.</td>
<td></td>
</tr>
<tr>
<td>Impairments due to alcohol or distraction</td>
<td>No lighting</td>
<td>High posted speed limit (75 MPH)</td>
<td>Lack of lighting interacts with high speeds to decrease visibility of lane edges and increase perception-reaction time and likely contributes to road departures at night</td>
<td></td>
</tr>
<tr>
<td>Future increase in younger drivers</td>
<td>Increased future traffic volumes due to college expansion</td>
<td>No lighting</td>
<td>Speed limits may be too high for conditions, especially with a future influx of younger drivers</td>
<td></td>
</tr>
</tbody>
</table>
Tools in the HSM-Predictive Method

- Roadways currently covered by the HSM
  - Rural two-lane, two-way roads,
  - Rural multilane highways,
  - Suburban arterials, and
  - Urban arterials.
- Excel workbooks available to aid in calculations
- Refer to HSM Volume 2 for further information
## Completed HFIM for the ‘Rural Multilane’ Example

<table>
<thead>
<tr>
<th>Road User</th>
<th>Vehicle</th>
<th>Environment</th>
<th>Interactions</th>
<th>Relevant Sections in the HFG</th>
</tr>
</thead>
</table>
| Speeding behaviors | Possible glare from on-coming headlamps | No barriers or cables on center median | Lack of barriers or cables across median combined with high speeds contributes to crashes and injuries due to road departures. | Chapter 6: Curves (Horizontal Alignment)  
○ 6-10  
○ 6-12 |
| Impairments due to alcohol or distraction | | No lighting | | Chapter 8: Tangent Sections and Roadside  
○ 8-4 |
| Future increase in younger drivers | | High posted speed limit (75 MPH) | Lack of lighting interacts with high speeds to decrease visibility of lane edges and increase perception-reaction time and likely contributes to road departures at night | |
| | | Increased future traffic volumes due to college expansion | | Chapter 17: Speed Perception, Speed Choice, and Speed Control  
○ 17-10, 17-12 |
| | | | Speed limits may be too high for conditions, especially with a future influx of younger drivers | Chapter 20: Markings  
○ 20-8 |
| | | | | Chapter 21: Lighting  
○ 21-2, 21-4 |
Using the HFG to Identify Potential Countermeasures (Step 3b)

• **Key Steps (continued):**

  5. Go back to the individual Chapters/Guidelines/Tutorials cited in the HFIM and – for each candidate guidelines being considered for application – more closely examine the Design Guidelines, Discussion, and Design Issues subsections from the HFG in more detail.

  6. For each safety issue or risk listed in the HFIM, identify/list – as appropriate:
     - relevant road user needs, capabilities, or limitations,
     - relevant road user perception or performance issues,
     - specific HFG recommendations, countermeasures, or design options, and
     - relevant data sources or research studies that could support specific design changes or enhancements.

  7. Review and consider:
     - the cross-references within the HFG and whether related guidelines beyond the initial list might contain useful information,
     - relevant tutorials to identify useful information,
     - trade-offs related to design and road user performance, and
     - whether the differences between the “as-built” roadway and the HFG recommendations are likely to result in safety improvements.
QUESTIONS?