The Dark Side of Road Safety:
Dealing with uncertainty and risk in VE

John B. L. Robinson
A life without adventure is likely to be unsatisfying. But a life in which adventure is allowed to take whatever course it will is likely to be...short

Bertrand Russell
What we’ll talk about

- Road safety analysis in VE
- The dark side: Uncertainty
- A proxy approach
- Benefits & stakeholder perceptions
- Concluding thoughts
Road safety analysis in VE

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Road safety analysis in VE

Limitations:

- Road safety & human factors only
- Explicit evaluation
  - Some quantitative
  - Some qualitative
- Uncertainty is usually relatively undefined:
  - Pessimistic, most likely, optimistic
The Dark Side... Uncertainty
Uncertainty breeds risk ...
Two terms you should know ...

- **Deterministic:**
  - *The answer is a single number*

- **Probabilistic:**
  - *The answer is a probability distribution*
Another example

- Countermeasure or VE suggestion effects:

**Collision frequency after = SPF \times CMF**

*SPF: safety performance function*

*CMF: collision modification factor*
Quantifying risk …

- **Requires:**
  - Specific data on variability of inputs
    - Distribution & standard error
  - Knowledge & skill:
    - Monte Carlo techniques most common
- **Policies:**
  - What risk levels are we prepared to accept?
    - Eg. AASHTO flexible pavement design …
  - What risk management measures?
Risk

- Old Oxford Dictionary:
  - To expose to the chance of injury or loss

- So – there is:
  - A potential loss
  - A **chance** of loss (a sure loss is not a risk)
  - Decision maker can affect the magnitude or chance of loss
Risk issues

- Risk involves 2 key issues:
  - The frequency of the loss (how often)
  - The consequences of the loss (how large)

- The perception of the loss:
  - Also important – effects on stakeholders

- Mitigating measures
  - May create new risks
A Proxy Approach
Overview

1. Identify collision vectors
2. Develop risk profiles
3. Quantitative risk analysis
4. Interpretation
5. Developing risk management plan
Identification of risk feature

Assessment of potential “impact”:
- 0 to 1 scale reflecting collision severity

Assessment of “likelihood” of occurrence
- 0 to 1 scale reflecting relative likelihood

Development of a quantitative index:

**Risk Index = Impact x Likelihood**
Some comments on Risk Index

- Scaling is “probability-like” (0 to 1)
  - Not real probabilities
- Can be subjective or statistically based
- Relative differences are key
  - Lower values are “more safe”
  - Higher values are “less safe”
Identifying Risk Features: Collision vectors
Collision vectors

- A design or operational feature
- Other element
- Associated with risk of collisions

Examples:
- Horizontal curve
- Aggressive roadside
- Insufficient gap search & manoeuvre distance
A case study sample ...

- Driver workload
- Information placement
- Ramp spacing
- Atypical features
- Confinement

- Roadside
- Geometry/alignment
- Cross section
- Speed
- Sight distance
- VRU treatments
Collision vector risk profiles

- The ranges/distributions used for:
  - Impact
  - Likelihood

For each collision vector

- Based on toolset developed over multiple projects & from research literature
## Risk Profiles Used

### Probabilistic Risk Analysis of Alternatives

<table>
<thead>
<tr>
<th>Risk element</th>
<th>Impact</th>
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<tbody>
<tr>
<td>Driver workload</td>
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<tr>
<td>Information placement</td>
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<tr>
<td>Interchange/Ramp spacing</td>
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<tr>
<td>Atypical features</td>
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<tr>
<td>Confinement</td>
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<tr>
<td>Roadside</td>
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<tr>
<td>Geometry/Alignment/Consistency</td>
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<tr>
<td>Roadway cross section</td>
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<tr>
<td>Speed</td>
<td></td>
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<tr>
<td>Sight distance deficiency</td>
<td></td>
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<tr>
<td>Vulnerable road users</td>
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<td>Sabre DOES NOT USE</td>
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<tr>
<td>Sabre DOES NOT USE</td>
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### Risk element |

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### Deterministic outputs

<table>
<thead>
<tr>
<th>Alternative &gt;&gt;&gt;</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk element</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver workload</td>
<td>0.15</td>
<td>0.30</td>
<td>0.15</td>
<td>0.30</td>
<td>0.39</td>
</tr>
<tr>
<td>Information placement</td>
<td>0.06</td>
<td>0.12</td>
<td>0.10</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Interchange/Ramp spacing</td>
<td>0.25</td>
<td>0.42</td>
<td>0.36</td>
<td>0.33</td>
<td>0.36</td>
</tr>
<tr>
<td>Atypical features</td>
<td>0.06</td>
<td>0.15</td>
<td>0.03</td>
<td>0.13</td>
<td>0.20</td>
</tr>
<tr>
<td>Confinement</td>
<td>0.20</td>
<td>0.30</td>
<td>0.18</td>
<td>0.27</td>
<td>0.36</td>
</tr>
<tr>
<td>Roadside</td>
<td>0.24</td>
<td>0.35</td>
<td>0.24</td>
<td>0.35</td>
<td>0.45</td>
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<tr>
<td>Geometry/Alignment/Consistency</td>
<td>0.12</td>
<td>0.10</td>
<td>0.15</td>
<td>0.13</td>
<td>0.18</td>
</tr>
<tr>
<td>Roadway cross section</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.15</td>
</tr>
<tr>
<td>Speed</td>
<td>0.11</td>
<td>0.16</td>
<td>0.11</td>
<td>0.16</td>
<td>0.25</td>
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<tr>
<td>Sight distance available</td>
<td>0.10</td>
<td>0.20</td>
<td>0.12</td>
<td>0.23</td>
<td>0.30</td>
</tr>
<tr>
<td>Vulnerable road users</td>
<td>0.18</td>
<td>0.07</td>
<td>0.21</td>
<td>0.18</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Average risk index:</strong></td>
<td>0.14</td>
<td>0.20</td>
<td>0.16</td>
<td>0.21</td>
<td>0.27</td>
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<tr>
<td><strong>Performance Scale Score:</strong></td>
<td>6</td>
<td>8.00</td>
<td>7.00</td>
<td>9.00</td>
<td>10.00</td>
</tr>
</tbody>
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## Value opportunities

<table>
<thead>
<tr>
<th>Design Alternative</th>
<th>Value Improvement Opportunities (Risk Index &gt;0.30)</th>
<th>Relevant Risk Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>None</td>
<td>NA</td>
</tr>
<tr>
<td>C</td>
<td>Interchange ramp spacing</td>
<td>0.36</td>
</tr>
<tr>
<td>B</td>
<td>Driver workload</td>
<td>Interchange ramp spacing</td>
</tr>
<tr>
<td>D</td>
<td>Driver workload</td>
<td>Interchange ramp spacing</td>
</tr>
<tr>
<td>E</td>
<td>Driver workload</td>
<td>Interchange ramp spacing</td>
</tr>
</tbody>
</table>
Focus of value opportunities

- Derived from detailed collision vector commentary
Probabilistic model

- **Uses:**
  - Collision vector format
  - Min/Max ranges from deterministic model
  - Most likely values from deterministic model
  - Suitable statistical distribution(s)

- Monte Carlo simulation used
RI distribution: A

Distribution for Average Risk Index: / 1A/B46

Mean = 0.205692

5%  90%  5%
.1769  .2384

Mean = 0.205692
RI distribution: Alt B

Distribution for Average Risk Index: / 1B/C46

Mean = 0.2306347

5%  90%  5%

0.1983  0.2647
RI distribution: Alt C

Distribution for Average Risk Index: / 2A/D46

Mean=0.2124413
RI distribution: Alt D

Distribution for Average Risk Index: / 2B/E46

Mean = 0.2314018
RI distribution: Alt E

Distribution for Average Risk Index: F46

Mean = 0.2516977

5%  90%  5%
0.2197  0.2847  0.2847
Benefits & Stakeholder Perceptions
Benefits

- Explicit evaluation provides defensibility
- Provides a measure of uncertainty
- Enhances potential for better decisions
- Explains decision-making rationale
- Provides basis for risk management plan
Factors affecting perception:

- Degree of personal control
- Potential for catastrophic consequences
- Whether consequences are “dreaded”
- Distribution of costs & benefits
- Degree to which risk is voluntary
Concluding thoughts
Concluding thoughts

- Risk assessment & management: a complex world
- Well established in many areas:
  - Financial, health & safety, insurance etc.
- Opportunities exist in value engineering:
  - A need to recognize uncertainty
  - A need to communicate it effectively
Thanks ...

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PDF of presentation available at

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