Risk Based Design
Something seems to be working

TMR is committed to a vision of **zero road deaths** and serious injuries

**Figure 1: Fatalities per 100,000 population, Queensland, 1952 to 2015**

- 1954: 35
- 1955: 30
- 1956: 25
- 1957: 20
- 1958: 15
- 1959: 10
- 1960: 5
- 1961: 0

- Seatbelts compulsory
- Campaign 650
- Campaign 300
- 0.05% RBTs
- Speed cameras
- 50km/h urban streets
- 2017 - 248
Risk Analysis – Asking the right questions

**Table 1 - Risk Assessment Hierarchy**

<table>
<thead>
<tr>
<th>RISK ASSESSMENT HIERARCHY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ELIMINATE</td>
<td>Eliminate the process, material or substance completely</td>
</tr>
<tr>
<td>SUBSTITUTE</td>
<td>Replace the process, material or substance with a safer one</td>
</tr>
<tr>
<td>ISOLATE</td>
<td>Isolate the person(s) from the process, material or substance</td>
</tr>
<tr>
<td>ENGINEER</td>
<td>Design or re-design the process, material or substance</td>
</tr>
<tr>
<td>ADMINISTRATE</td>
<td>Limit exposure to the risk by job rotation, procedure and training</td>
</tr>
<tr>
<td>PPE</td>
<td>Use protective equipment</td>
</tr>
</tbody>
</table>

**Strategy:** Can we eliminate or substitute a river?

**Table 2 - Risk Assessment Calculator**

<table>
<thead>
<tr>
<th>RISK ASSESSMENT CALCULATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the hazards or risks of the work. Access the likelihood and consequences from the hazards or risk. Control the hazards or risks using control options</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>L</td>
</tr>
</tbody>
</table>

**Quantify severity of the risk:** What is a *likely* outcome?
Risk Management – Finding a workable solution

### Table 3 - Risk Assessment Matrix

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Insignificant (No injury - 0-low $ loss)</th>
<th>Minor (First Aid injury - medium $ loss)</th>
<th>Moderate (Medical Treatment - medium - high $ loss)</th>
<th>Major (Serious Injuries - major $ loss)</th>
<th>Catastrophic (Death - huge $ loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>H</td>
<td>H</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Likely</td>
<td>L</td>
<td>H</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Possible</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Unlikely</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>E</td>
</tr>
<tr>
<td>Rare</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Where risk assessment is rated as ‘Extreme’ the characteristics and values should be revisited to generate a design that does not have a ‘High’ risk rating.

Where risk assessment is ‘High’ mitigation measures should be introduced which could include removal of a hazard or providing protection.

Where risk is rated as ‘Medium’ no immediate action is necessary but the road should continue to be monitored with a view to confirm safe performance.

Where risk is rated as ‘Low’ no further action is necessary.
Case Study

- Widen single lane bridge and approaches
- Guardrail frequently damaged by flooding debris

Do we need Guardrail?
Case Study

Parameters:
Widen Approaches & Bridge
Lanes: 2 x 3.5
Shoulders: 2 x 0.5
Grade: 4.8% (Max)
Curves: R1600 & R1000
$V_{85} = 70$ km/h
AADT: 86 (Projected)
### Parameters:

- $V_{85} = 100$ km/h
- AADT: 86 (Projected)
- Hazzard: Condamine River.

Needs a traffic volume over 400 VPD to reach a BCR of 1.5
### Project Parameters

**General:**
- Vehicle Swath Width (m): 3.6
- Discount Rate (%): 6
- Growth Rate (%): 2
- Project Life (years): 20
- Coefficient of Friction: 0.4
- Encroachment Rate (enc/km/year/veh/day): 0.0003

**Crash Costs:**
- Profile Name: 2016 WTP
- Property Costs: $9,775
- Minor Injury Costs: $40,930
- Moderate Injury Costs: $125,395
- Hospitalisation Costs: $633,244
- Fatal Costs: $9,077,270

**Capacity:**
- 50 km/h: 2400
- 60 km/h: 2390
- 70 km/h: 2370
- 80 km/h: 2330

**Benefit Cost Analysis**

<table>
<thead>
<tr>
<th>Road: Lemontree Rd Bridge</th>
<th>Install</th>
<th>Maint</th>
<th>Repair</th>
<th>Mult</th>
<th>Impacts/Y</th>
<th>Crash Cost</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard: No Guardrail 70 km/h</td>
<td>$1</td>
<td>$1</td>
<td>$10</td>
<td>1.0</td>
<td>0.00111</td>
<td>$4144</td>
<td>4.6</td>
</tr>
<tr>
<td>Treatment: Hazard Markers</td>
<td>$1000</td>
<td>$1</td>
<td>$250</td>
<td>1.0</td>
<td>0.0024</td>
<td>$4</td>
<td>4.6</td>
</tr>
<tr>
<td>Hazard: Condamine River</td>
<td>$12,000</td>
<td>$250</td>
<td>$6,000</td>
<td>1.0</td>
<td>0.0118</td>
<td>$51,600</td>
<td>0.1</td>
</tr>
<tr>
<td>Treatment: y-Guardrail</td>
<td>$6,000</td>
<td>$250</td>
<td>$6,000</td>
<td>1.0</td>
<td>0.0026</td>
<td>$21,600</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Item Details

<table>
<thead>
<tr>
<th>Section</th>
<th>Start</th>
<th>End</th>
<th>Type</th>
<th>Lanes</th>
<th>Median</th>
<th>Section</th>
<th>Grade</th>
<th>Speed (MPH)</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemontree Rd Bridge</td>
<td>0.000</td>
<td>0.240</td>
<td>Undivided</td>
<td>2 x 3.5m</td>
<td>Pen 0.0m</td>
<td>Straight</td>
<td>-5%</td>
<td>70</td>
<td>86</td>
</tr>
</tbody>
</table>

**Roadside Object**

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Position</th>
<th>Offset</th>
<th>Width</th>
<th>Length</th>
<th>Composition</th>
<th>S</th>
<th>C</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.100</td>
<td>Left</td>
<td>5.00</td>
<td>45.00</td>
<td>Intersection Slope, Vertical Slope, Height 4.0, Depth 2.0</td>
<td>7.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>0.100</td>
<td>Left</td>
<td>0.70</td>
<td>0.50</td>
<td>Fixed Objects, Breakaway Support, Velocity change 1.5 m/s</td>
<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>0.120</td>
<td>Left</td>
<td>0.00</td>
<td>15.00</td>
<td>Intersection Slope, Vertical Slope, Height 4.0, Depth 1.0</td>
<td>6.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>0.120</td>
<td>Left</td>
<td>0.50</td>
<td>0.10</td>
<td>Longitudinal Barrier, W-Beam (Weak Post)</td>
<td>0.00</td>
<td>0.00</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>0.120</td>
<td>Left</td>
<td>0.50</td>
<td>0.10</td>
<td>Barrier Terminal, CAT, ET2000, etc., N/A</td>
<td>2.40</td>
<td>2.40</td>
<td>2.50</td>
<td></td>
</tr>
</tbody>
</table>

**Parameters:**
- \( V_{85} = 70 \text{ km/h} \)
- AADT: 86 (Projected)
- Hazzard: Condamine River

Needs a traffic volume over 1300 VPD to reach a BCR of 1.5
Using Lower Order Road Guidelines

Table 19 - Hazard Evaluation Score Card

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Geometry</td>
<td>0</td>
</tr>
<tr>
<td>Accident Evidence</td>
<td>0</td>
</tr>
<tr>
<td>Vertical Geometry</td>
<td>1</td>
</tr>
<tr>
<td>Treatment Impact</td>
<td>-1</td>
</tr>
<tr>
<td>% of Heavy Vehicle</td>
<td>2</td>
</tr>
<tr>
<td>Available Formation Width</td>
<td>1</td>
</tr>
<tr>
<td>Sight Distance Available</td>
<td>0</td>
</tr>
<tr>
<td>Roadside Environmental</td>
<td>1</td>
</tr>
<tr>
<td>Speed Environment</td>
<td>1</td>
</tr>
<tr>
<td>AADT</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 20 – Score Legend

<table>
<thead>
<tr>
<th>Score</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>Guardrail, realignment, widening, clearing, signage, reduce regulatory speed</td>
</tr>
<tr>
<td>7-10</td>
<td>Temporary measures appropriate until a permanent treatment can be implemented. Needs to be prioritised, compared to other projects. The hazard should be closely monitored.</td>
</tr>
<tr>
<td>&lt; 7</td>
<td>Funds may be better utilised elsewhere. Less expensive treatments may be adequate (e.g. Signs)</td>
</tr>
<tr>
<td></td>
<td>Berms, Warning signage, increase guide posts, lower advisory speed</td>
</tr>
</tbody>
</table>

Don’t do nothing – there is still a risk that needs managing!
Available treatments – which is best?

- **Crash reduction effectiveness**
  - 35% - New barrier
  - 32% - Change rigid barrier to less rigid type
  - 79% - Flexible barrier (rural freeway)
  - 86% - Flexible barrier (urban freeway)
  - 70% - Flexible median barriers (undivided rural highways)

- **Cost Rating**
  - $ $

- **Treatment life**
  - ★★★★★

- **Crash reduction effectiveness**
  - 40% - Speed advisory signs
  - 25% - Curve warning signs
  - 30% - Bridge warning signs
  - 15% - Guidance signs
  - 20% - Variable message signs
  - 35% - Vehicle activated signs

- **Cost Rating**
  - $

- **Treatment life**
  - ★★★★★

**Austroads Road Safety Engineering Toolkit**

http://engtoolkit.com.au
Case Study

Measures:
- Hazard Markers
- Centre Line
- Guide Posts
- Advisory Speed
- Delineators
- 1:6 Batters
Legal requirements

Brodie v Singleton Shire Council
(2001) 206 CLR 512

Misfeasance ≈ Negligence
Nonfeasance ≈ Inaction

Implications for Road Design, Construction & Maintenance:
1. Recognised that funding is limited
2. Standards are able to be adapted to suit road classification
3. Duty of care extends to reasonable steps and reasonable timeframes
EDD & Lower Order Roads Guidelines

Don’t abuse it ...

Use it!
Thank You  rod.moss@hig.com.au