Risk and Value Engineering:
Two Stories at the Intersection

Southern California, 15th April 2020
Today’s Presenters

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Statement of Purpose

After attending this presentation you should be able to

1. Describe how risk assessments can inform capital planning.
2. Compare risk assessments and value engineering as tools for project analysis.
3. Understand how risk assessments and value engineering can be employed to make decisions regarding project scope and value
Two Stories at the Intersection

- Capital Plan Risk Assessment
- Risk as a Tool for Value Analysis
Capital Plan Risk Assessment
The Problem

A major public agency wants to assess the risk to the multibillion dollar 10 year capital plan.

This contains over 600 projects, ranging from multi billion dollar mega programs to tiny projects.

These projects are at various stages in their lifecycle across a diverse portfolio of airport, highway, bridge and rail projects.

Oh – one final thing, we are going to present this to the board next month!!
The Traditional Approach

Assessing risk and quantifying the impacts requires a rigorous process of preparation, workshops & modeling. This will take weeks for each individual project.

To meet the deadline hundreds of risk managers will be needed.

Clearly another solution was needed.
The Client’s Needs

1. Engage agency leadership within two weeks.
2. Build on existing data
3. Risk exposure Major Programs, Departments & Agency
4. Provide accurate year by year spending
5. Determine actual spending in 10 year window
**Approach Requirements**

1. Gain confidence in costs of projects and major programs
2. Identify risks to major programs, departments & agency
3. Be manageable within the current resources
4. Be auditable, repeatable, scalable, and compliant
5. Provide results at agency, department & program level
Process Overview: Department Level

- **Core Projects** (TPC: $1M - $100M)
- **Major Programs in Construction**
- **Major Planned Programs**
- **Department Level Risks**

- Model based on previous performance & risk profiles
- Review Current Risk Data
- Assess at Risk Workshop
- Assess at Risk Workshop

Overall Department Level of Exposure
Process Overview: Agency Level

- Aviation Risk Exposure
- Rail Risk Exposure
- Bridges Risk Exposure
- Ports Risk Exposure

Agency Risk Exposure
Process In Detail

1. Understanding Context

Each department’s senior team and the overall agency leadership attended a 1 day workshop
Presentation given on the department and each major program in its capital plan
Key challenges facing department discussed
Process In Detail

2. Identifying Risks

Graffiti method used to identify risks

A facilitated discussion rationalized risks and discussed their impacts

Common risks that impact across the entire department were recorded on a department-wide risk register
Process In Detail

3. Risk Scoring

<table>
<thead>
<tr>
<th>Score</th>
<th>Likelihood</th>
<th>Cost</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>&gt;75%</td>
<td>&gt;$250M</td>
<td>&gt;2yrs</td>
</tr>
<tr>
<td>4</td>
<td>50-75%</td>
<td>$100-250M</td>
<td>1-2yrs</td>
</tr>
<tr>
<td>3</td>
<td>25-50%</td>
<td>$50-100M</td>
<td>6-12mths</td>
</tr>
<tr>
<td>2</td>
<td>10-25%</td>
<td>$10-50M</td>
<td>3-6mths</td>
</tr>
<tr>
<td>1</td>
<td>&lt;10%</td>
<td>&lt;$10M</td>
<td>&lt;3mths</td>
</tr>
</tbody>
</table>

The participants scored the risks individually in a workbook.

This removed cognitive and motivational bias from the scoring.

This methodology also saved a significant amount of time, allowing the workshop to cover more ground.
Process In Detail

4. Risk Analysis

Results were collated and the mode score for likelihood and impact was used.

The mean here is 4 – but only 1 person selected this score.

Using the mode mimics reaching consensus and lessens impact of outliers.

Individual Monte Carlo Analyses run on each program and the department risks.
Process In Detail

5. Risk Control

Outputs presented to department teams to validate results

Mitigations derived for every major risk

Enabled calibration of common department wide risks

Identified agency level risks
Just one more thing...

What impact would these risk assessments have on 10-year spending profile for each major program, department, and the agency as a whole?
Spend in 10-year window

Current Estimate

Spend in 10-year window

- Current Estimate
- Risk Adjusted Estimate

Spend in 10-year window

Risks often resulted in schedule delays which stretched the total spending across more years, outside the spending window. This was especially true for very large, multi-year endeavors.

Time-space analysis and comparison to previous spending plans indicated that for some facilities, the proposed spending plan was likely too ambitious.

A “smoothing factor” was applied to the 10-year spending curves, based on historic data that suggested what could realistically be spent at a given facility annually.
Spend in 10-year window
Spend in 10-year window
Spend in 10-year window

- Base Case
- Risk Adjusted
- Risk and Smoothed
Conclusions

The Agency with a capital plan measured in billions of dollars was able to review its entire portfolio of projects.

The assessment encouraged peer review and discussion between program directors and senior management.

This was accomplished in 6-weeks with most of the effort provided by just three risk engineers.
Risk as a Tool for Value Analysis
Risk as a Tool for Value Analysis

A federal agency must stabilize the seawall around an island in NYC harbor

Portions of the wall are in urgent need of repair; some portions are historic

The agency does not have the budget to make all repairs.

- Which areas should get priority?
- Which areas should be “de-scoped”?
- Which repairs offer the best value?
The Mission

Hold a “Design Development / Value Analysis” Workshop.
Prioritize areas for inclusion in scope; “de-scope” all other areas.
Employ the principles of Value Analysis (VA) and the agency’s “Choosing by Alternatives” (CBA) methodology for key seawall areas where there were multiple rehabilitation alternatives.

Oh – one final thing, we need to accomplish all of this in a 1-day workshop
Multiple Seawall Types and Site Issues
Multiple Seawall Types and Site Issues
**Approach:** Choosing by Risk and Advantage

1. **Function Analysis**
   - Done previously – just review

2. **Review Alternatives**
   - Creativity
   - Evaluation
   - Development

3. **Assess Risk**
   - Probability
   - Impact
   - Ranking

4. **Evaluate**
   - Choose based on risk and advantages
# Function Analysis

<table>
<thead>
<tr>
<th>Verb</th>
<th>Noun</th>
<th>Basic / Secondary / Higher Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilize</td>
<td>Seawall</td>
<td>Basic</td>
</tr>
<tr>
<td>Facilitate</td>
<td>Constructability</td>
<td>Secondary</td>
</tr>
<tr>
<td>Avoid</td>
<td>Construction Shutdown</td>
<td>Secondary</td>
</tr>
<tr>
<td>Maintain</td>
<td>Operations</td>
<td>Secondary</td>
</tr>
<tr>
<td>Minimize</td>
<td>Permitting</td>
<td>Secondary</td>
</tr>
<tr>
<td>Minimize</td>
<td>Environmental Risks</td>
<td>Secondary</td>
</tr>
<tr>
<td>Minimize</td>
<td>Cultural Resource Impact</td>
<td>Secondary</td>
</tr>
<tr>
<td>Maximize</td>
<td>Flexibility for Future Work</td>
<td>Secondary</td>
</tr>
<tr>
<td>Protect</td>
<td>Visitors</td>
<td>Higher Order</td>
</tr>
<tr>
<td>Maintain</td>
<td>Visitor Accessibility (ADA)</td>
<td>Higher Order</td>
</tr>
<tr>
<td>Control</td>
<td>Public Movement</td>
<td>Higher Order</td>
</tr>
<tr>
<td>Maximize</td>
<td>Queuing Area</td>
<td>Secondary</td>
</tr>
</tbody>
</table>
Creativity, Evaluation and Development

1. Review seawall type.
2. Review underwater inspection photos.
3. What is current factor of safety?
4. Consider repair components and options.
5. What would repair design look like, and how much would it cost?
### Area 3: Island North Seawall (Type II-B)

#### TYPE II SEAWALL

| Description | Type II Seawall consists of 2 sections of concrete gravity wall (upper and lower sections) placed on a concrete bag/levelling course foundation in front of the timber cribbing. Lower sections are connected by keyed joints (chain grooves) filled with concrete bags. The granite fascia blocks are connected to the wall by iron wedges and ties (through Lewis holes, Sta. 0+00 to 7+45) or iron ties only (17+35 to 23+57). A 385-ft-long timber fender system is located along the north side of the ferry slip. |

| Material | Pre-cast and Cast-in-Place Concrete Gravity Wall w/ Granite Block Fascia |
| Dimensions | 2 sections  
- Lower: 10 ft wide x 17 ft high x 8 ft thick (max)  
- 10 ft wide x 11 ft high x 5 ft thick (max, including fascia) |
| Anchorage | None |
| Cribbing Setback | 12 ft to 50 ft |
| Year Constructed | 1914 - 1921 |
| Length | 1,367 ft |
| Toe Walls | 27 ft – 234+8 to 23+75 (2012) |
Area 3: Island North Seawall (Type II-B)
Area 3: Island North Seawall (Type II-B)
Area 3: Gravity Wall Diver Observations

These voids are most severe from Sta. 19+00 to Sta. 21+85. At Sta. 20+52, erosion between two adjacent lower gravity wall blocks is approximately 8 ft high by 7 ft wide and the gap between the blocks is 15.5 in. wide. During the inspection, the void within this gap was measured to be approximately 9 ft deep and a soft refusal was encountered with a ruler, indicating exposure of loose fill material at the back of the void (Photo 2-16).
Area 3: Gravity Wall Evaluation Summary

Gravity Wall Typical Stability Checks

1. Gravity Wall Stability Checks
   - **Sliding**
     
     \[
     (F.S.)_{sliding} = \frac{\text{sliding resistance force}}{\text{sliding force}}
     \]
   - **Overturning**
     
     \[
     (F.S.)_{overturning} = \frac{\text{total resisting moment about toe}}{\text{total overturning moment about toe}}
     \]
   - **Soil’s Ultimate Bearing Capacity Failure**
     
     \[
     (F.S.)_{bearing\ capacity\ failure} = \frac{\text{soil’s ultimate bearing capacity}}{\text{actual maximum contact (base) pressure}}
     \]

Gravity Walls Evaluation Summary - Island North Wall, and East Wall South of the Slip

### Existing Condition: Factors of Safety against Overturning and Sliding of Bottom Precast Concrete Wall without Concrete Slab Remediation

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOS against Sliding</td>
<td>FOS against Overturning</td>
<td>FOS against Sliding</td>
</tr>
<tr>
<td>Area 7 - East of the Island, South of Ferry Slip</td>
<td>1.22</td>
<td>0.98</td>
<td>1.22</td>
</tr>
<tr>
<td>Area 5 - North of the Island</td>
<td>1.27</td>
<td>0.94</td>
<td>1.27</td>
</tr>
</tbody>
</table>

**Note:**
1. For the 100 year wave load case, no surcharge was taken on the back of the existing gravity wall.
2. Since the wave height for 100 year storm is greater than the height of the existing gravity wall, soil on the back of the existing gravity wall is considered to be completely submerged.

### Existing Condition with Design Surcharge: Factors of Safety against Overturning and Sliding of Bottom Precast Concrete Wall without Concrete Slab Remediation

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<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>FOS against Sliding</td>
<td>FOS against Overturning</td>
<td>FOS against Sliding</td>
</tr>
<tr>
<td>Area 7 - East of the Island, South of Ferry Slip (100 psf Surcharge)</td>
<td>1.04</td>
<td>0.98</td>
<td>1.15</td>
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<tr>
<td>Area 5 - North of the Island (50 psf Surcharge)</td>
<td>0.95</td>
<td>0.84</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**Note:**
1. For the 100 year wave load case, no surcharge was taken on the back of the existing gravity wall.
2. Since the wave height for 100 year storm is greater than the height of the existing gravity wall, soil on the back of the existing gravity wall is considered to be completely submerged.

Factors of Safety against Overturning and Sliding of Bottom Precast Concrete Wall with Concrete Slab Remediation

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>FOS against Sliding</td>
<td>FOS against Overturning</td>
<td>FOS against Sliding</td>
</tr>
<tr>
<td>Area 7 - East of the Island, South of Ferry Slip</td>
<td>1.26</td>
<td>1.27</td>
<td>1.26</td>
</tr>
<tr>
<td>Area 5 - North of the Island</td>
<td>1.08</td>
<td>1.64</td>
<td>1.08</td>
</tr>
</tbody>
</table>

**Note:** Results are for a concrete slab 6.5 ft wide and 6.5 ft deep, with soil backfill above.
Area 3: Island North Seawall (Type II-B)

RECOMMENDED REPAIR COMPONENTS: Estimated Cost = $6.4m

1. Gravity Wall Strengthening
2. New Waterside Toe Wall Encasement
3. Retrieve Observed Fascia Blocks from Mudline
4. Gravity Wall Concrete and Granite Fascia Repairs
5. Landside Settlement Repairs (Pending observations after Kiewit work)
Area 3: Gravity Wall Strengthening
Assess Risk

**Probability**
- Based on safety factor & risk of failure
- Recommended by the consultant

**Impact**
- Based on consequences to site and operations
- Recommended by the agency
## Ranging Risk

Use a 5-point scale based on probability x impact

<table>
<thead>
<tr>
<th>Probability</th>
<th>VH</th>
<th>H</th>
<th>M</th>
<th>L</th>
<th>VL</th>
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<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td>Very High</td>
<td>Very High</td>
</tr>
<tr>
<td>Med</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td>Very High</td>
<td>Very High</td>
</tr>
<tr>
<td>High</td>
<td>Very Low</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Very High</td>
<td>Very Low</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Impact</th>
<th>VL</th>
<th>L</th>
<th>M</th>
<th>H</th>
<th>VH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Very Low</td>
<td>Low</td>
<td>Low</td>
<td>Med</td>
<td></td>
</tr>
</tbody>
</table>

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**Note:** Use a 5-point scale based on probability x impact.
Evaluate Choose based on risk and advantages

Risk Factors Used to Determine Priority:
Probability x Impact = Total Risk Score

Descoping
- Slip North Wall
- Sta 0+00 - Sta 7+37

Area 1
Evaluate Choose based on risk and advantages

<table>
<thead>
<tr>
<th>Risk Factors Used to Determine Priority:</th>
<th>Descoping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability x Impact = Total Risk Score</td>
<td>Slip North Wall Sta 0+00 - Sta 7+37</td>
</tr>
<tr>
<td>Relative Probability of Seawall Failure (based on safety factor)</td>
<td>Area 1</td>
</tr>
<tr>
<td>Very Low, Low, Medium, High, Very High</td>
<td>VH</td>
</tr>
<tr>
<td>Impacts (to public, to buildings, to operations)</td>
<td>VH</td>
</tr>
<tr>
<td>Very Low, Low, Medium, High, Very High</td>
<td></td>
</tr>
<tr>
<td>Total Risk Score (Probability x Impact) based on heat map</td>
<td>VH</td>
</tr>
<tr>
<td>Cost (in millions)</td>
<td>$17.930</td>
</tr>
</tbody>
</table>

CMAA Southern California Chapter
Advancing Professional Construction and Program Management Worldwide
Evaluate Choose based on risk and advantages

<table>
<thead>
<tr>
<th>Risk Factors Used to Determine Priority</th>
<th>Descoping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability x Impact = Total Risk Score</td>
<td>Slip North Wall Sta 9+00 - Sta 7+37</td>
</tr>
<tr>
<td>Relative Probability of Seawall Failure (based on safety factor) Very Low, Low, Medium, High, Very High</td>
<td></td>
</tr>
<tr>
<td>Impacts (to public, to buildings, to operations) Very Low, Low, Medium, High, Very High</td>
<td></td>
</tr>
<tr>
<td>Total Risk Score (Probability x Impact) based on heat map</td>
<td>VH</td>
</tr>
<tr>
<td>Cost (in millions)</td>
<td>$17.030</td>
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<tr>
<td>Cost by priority areas:</td>
<td></td>
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<tr>
<td>$27.230</td>
<td>$9.386</td>
</tr>
<tr>
<td>Total cost of entire repair program:</td>
<td>$50M</td>
</tr>
<tr>
<td>Agency budget available:</td>
<td>$28M</td>
</tr>
<tr>
<td>Cost of top priority repairs:</td>
<td>$27M</td>
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</table>
Evaluate Choose based on risk and advantages
Conclusions

The agency was able to de-scope a repair program to meet a limited project budget,

With confidence that the plan is defensible, as it is based on safety factor and risk, and

Chooses wisely from among many design alternatives to achieve the best value
Conclusions

The consultant was able to present the full gamut of repair options available,

Building upon their previous inspection and design work while engaging the insights of knowledgeable agency personnel,

Resulting in an objective approach that meets the agency’s VE requirements while steering a viable, defensible path through de-scoping.
Conclusions

The assessment encouraged peer review and discussion between agency and consultant personnel,

Established the basis for programmatic spending at the facility for years to come

Created a new approach to value analysis that the agency plans to implement on other projects
QUESTIONS?
Today’s Presenters

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