ETM

ENGINEERING & TECHNOLOGY MANAGEMENT

ETM 530/630 DECISION MAKING SPRING 2017

Group Project

Selecting the Seismic Investment Option for Multnomah County Bridges on the central Willamette for the next 20 years

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Background

- Portland - A City of Bridges
- Bridges are maintained by:
    - The Oregon Department of Transportation (ODOT)
    - Multnomah County
    - Union Pacific Railroad

Background cont.

- 37% Possibility of the earthquake in the next 50 years [13]
- Major fatalities and injuries
- Major economical loss

Bridges are vulnerable to major e

Actions are required

Scope of the project

Bridges maintained by Multnomah county in central PDX:

- Burnside
- Broadway
- Hawthorne
- Morrison

Burnside Bridge - Background [1]

- Burnside Bridge, over 90 years of Service
- 40,000 vehicles, 2,000 bicycles and pedestrians daily
- 5 vehicle lanes, 2 bike lanes
- Three bus lines
- 300 openings a year
- Crosses Blue/Red Max Lines, 78k weekday riders
- Crosses Union Pacific Railroad mainline
- **Burnside Street: Regional Lifeline Route**

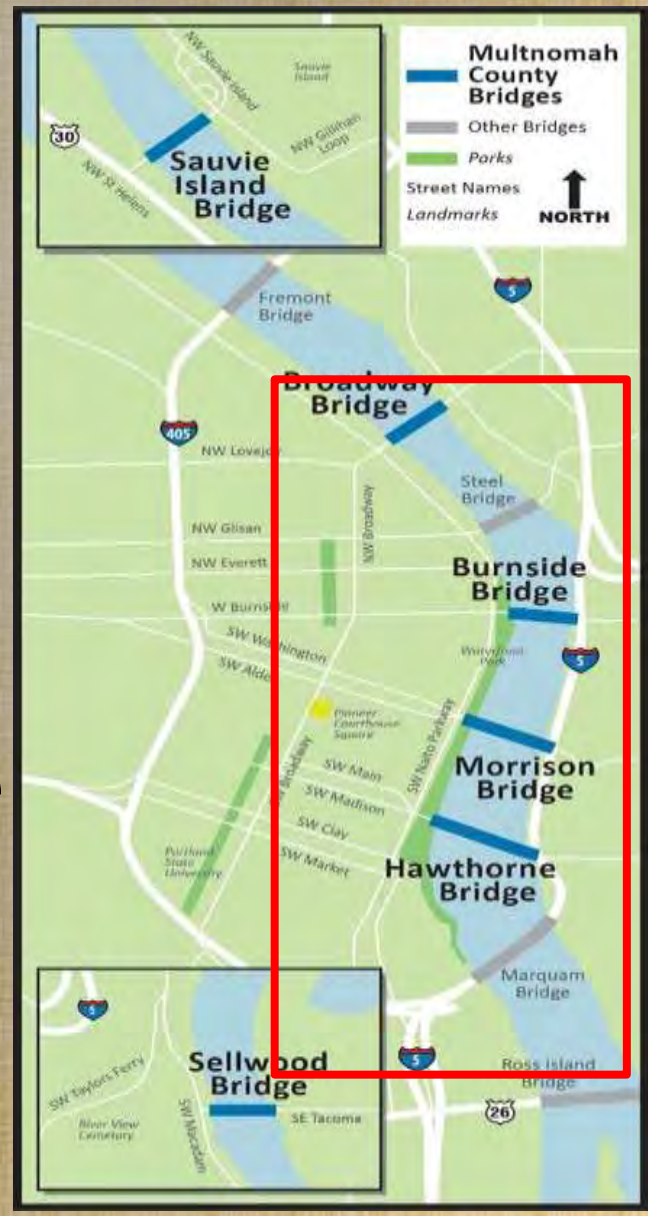
Hawthorne, Morrison, Broadway Bridge's - Background [2] [3] [4]

- Hawthorne Bridge
  - Over 107 years of Service
  - 4 Lanes, 30,000 vehicles, 800 Trimet buses plus 8,000 bicycles and pedestrians daily
- Morrison Bridge
  - Over 59 years of Service
  - 6 Lanes, 50,000 vehicles daily
- Broadway Bridge
  - Over 104 years of Service
  - 4 vehicle lanes, 1 Streetcar lane
  - 50,000 vehicles daily

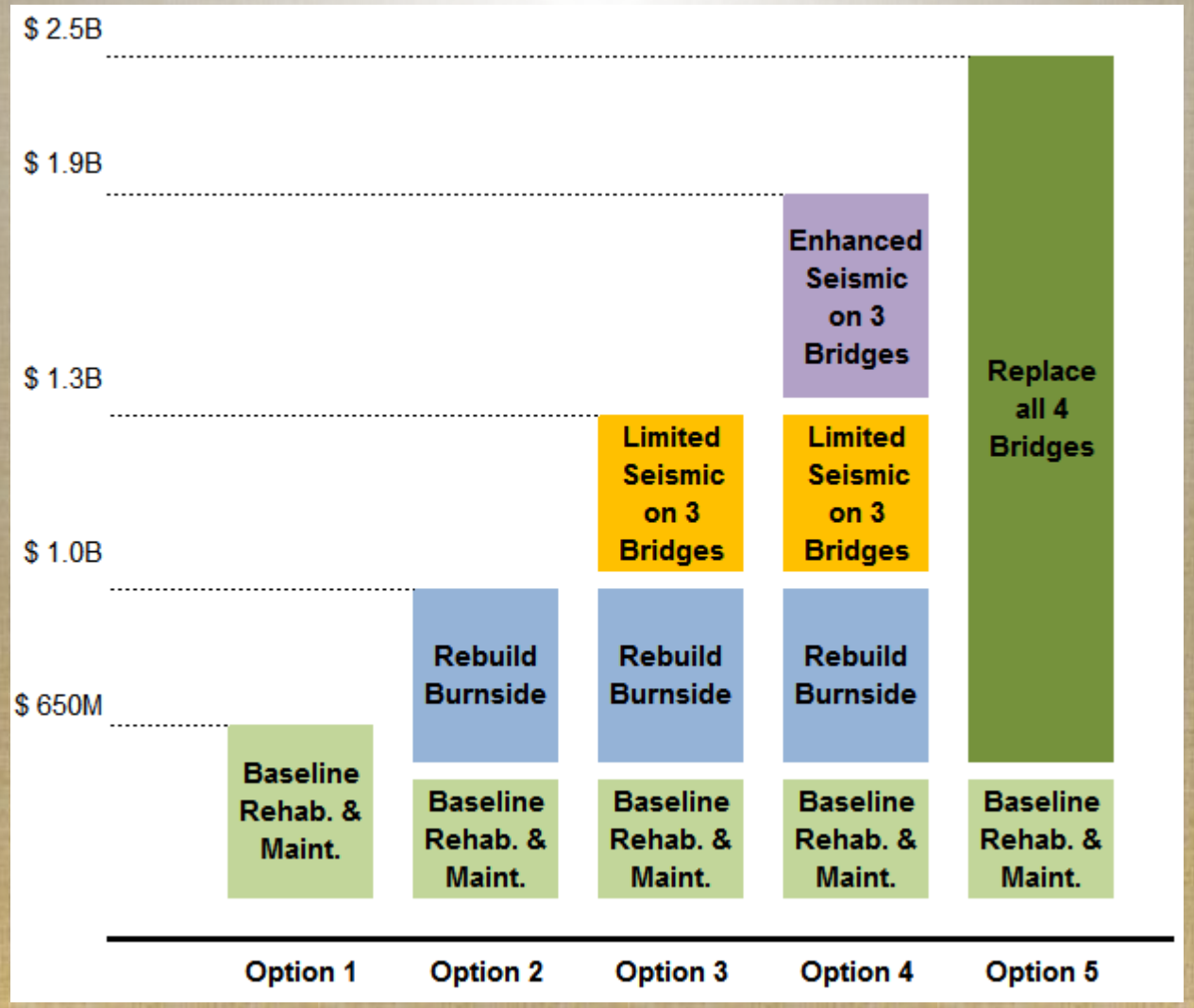
KEY DECISION

Selecting the **Seismic Investment Option** for central PDX Multnomah County bridges on the Willamette for the next 20 years

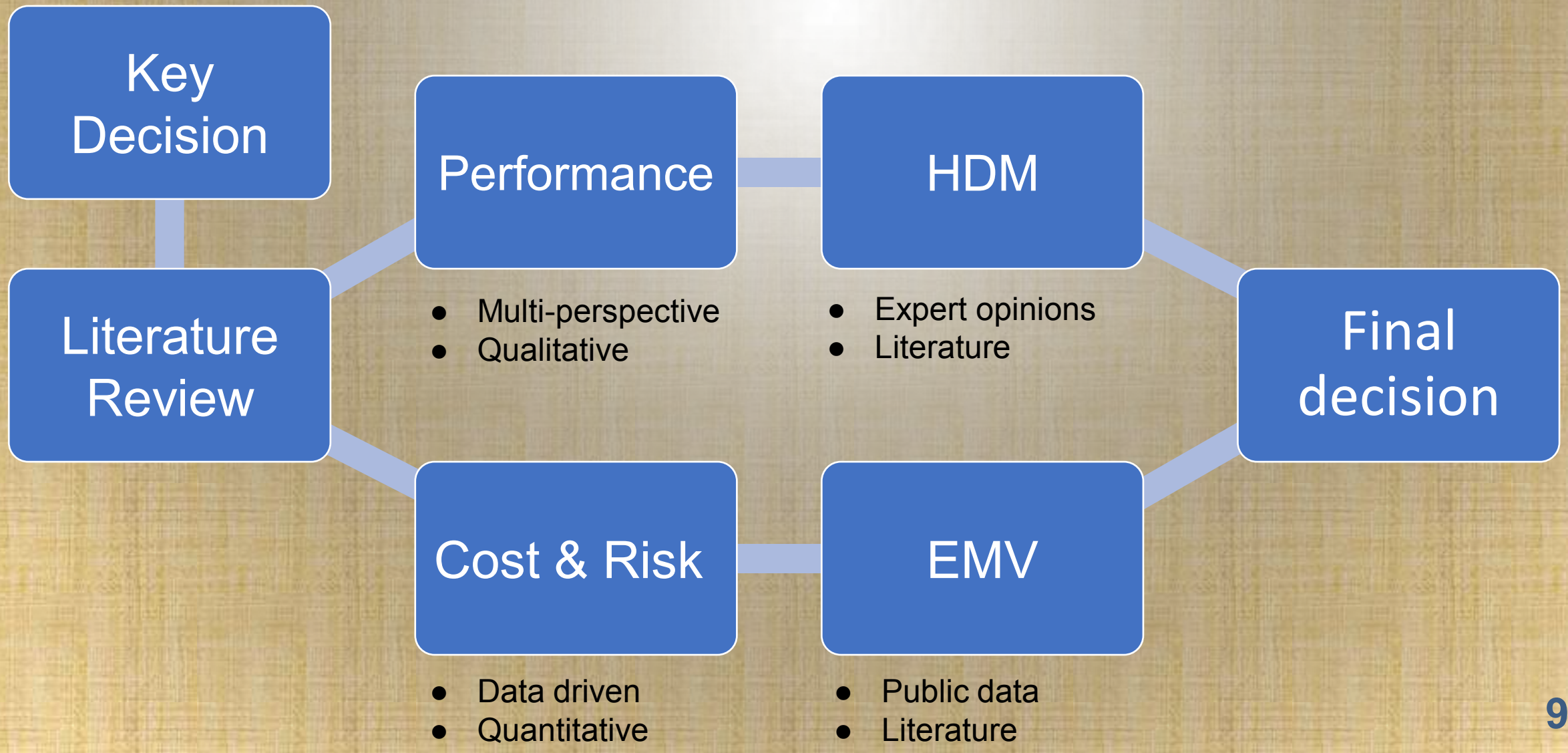
What are the options??



Key Decision Options



Methodology



Methodology

Performance Attributes

Literature review

Creation of first HDM

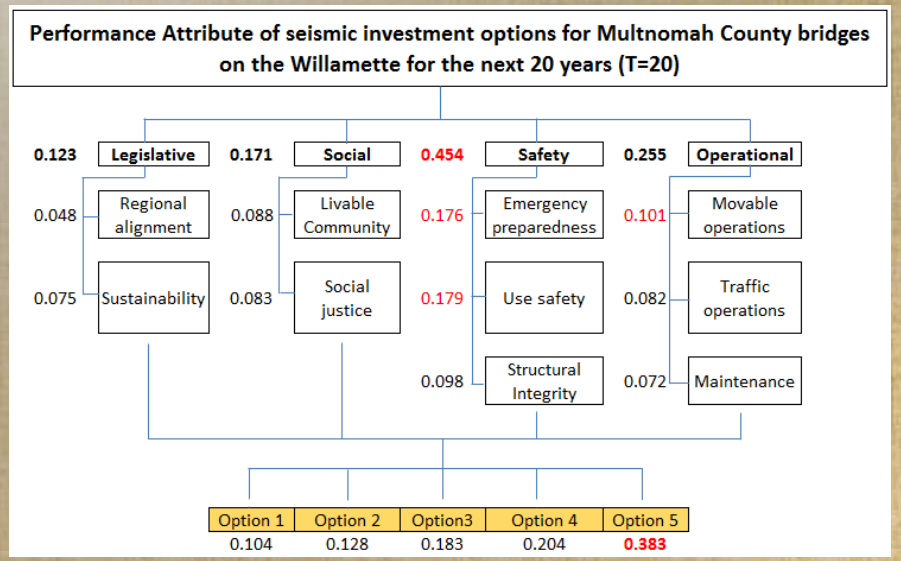
Meeting with experts

New Performance Attributes

New HDM

Expert opinion

Final HDM



Methodology

Cost & Risk Factors

Literature review

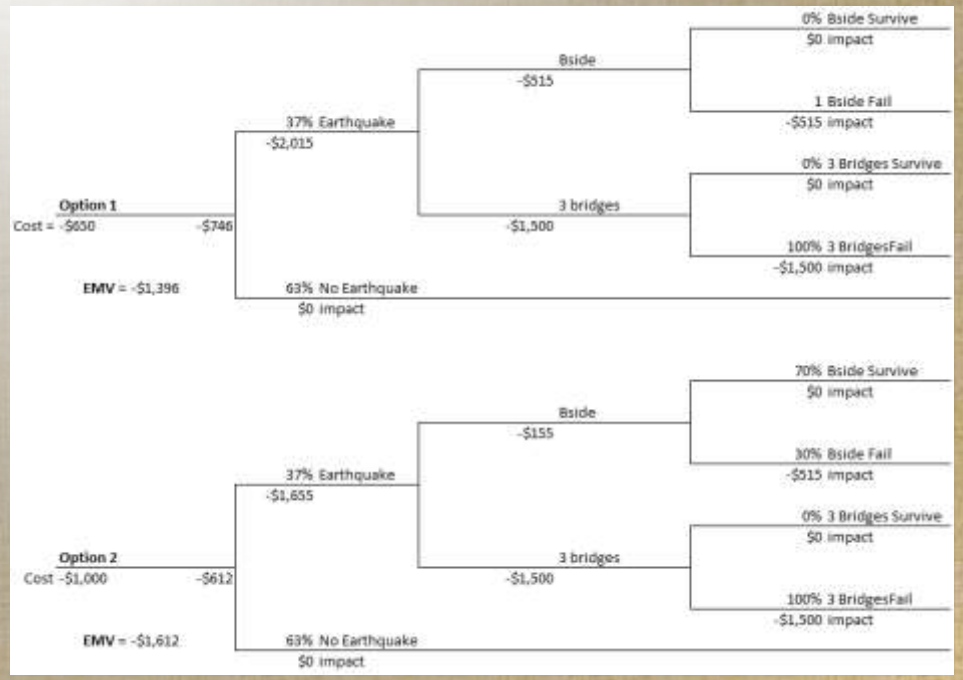
Utilization of EMV

Numerical Analysis

Public data

Meeting with experts

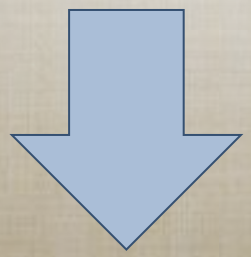
EMV for different options



Methodology

Multnomah County Project Prioritization:

$$\text{Importance Factor} = \text{Occurrence Probability} \times \frac{\text{Cost Consequence of Inaction}}{\text{Direct Cost}} \times \text{Performance Attribute}$$



Seismic Investment:

$$\text{Decision Points} = \frac{\text{Cost Consequence of Inaction}}{\text{EMV}} \times \text{Performance Attribute}$$

Methodology

$$\text{Importance Factor} = \text{Occurrence Probability} \times \frac{\text{Cost Consequence of Inaction}}{\text{Direct Cost}} \times \text{Performance Attribute}$$

Multnomah County Report

HDM

$$\text{Decision Points} = \frac{\text{Cost Consequence of Inaction}}{\text{EMV}} \times \text{Performance Attribute}$$

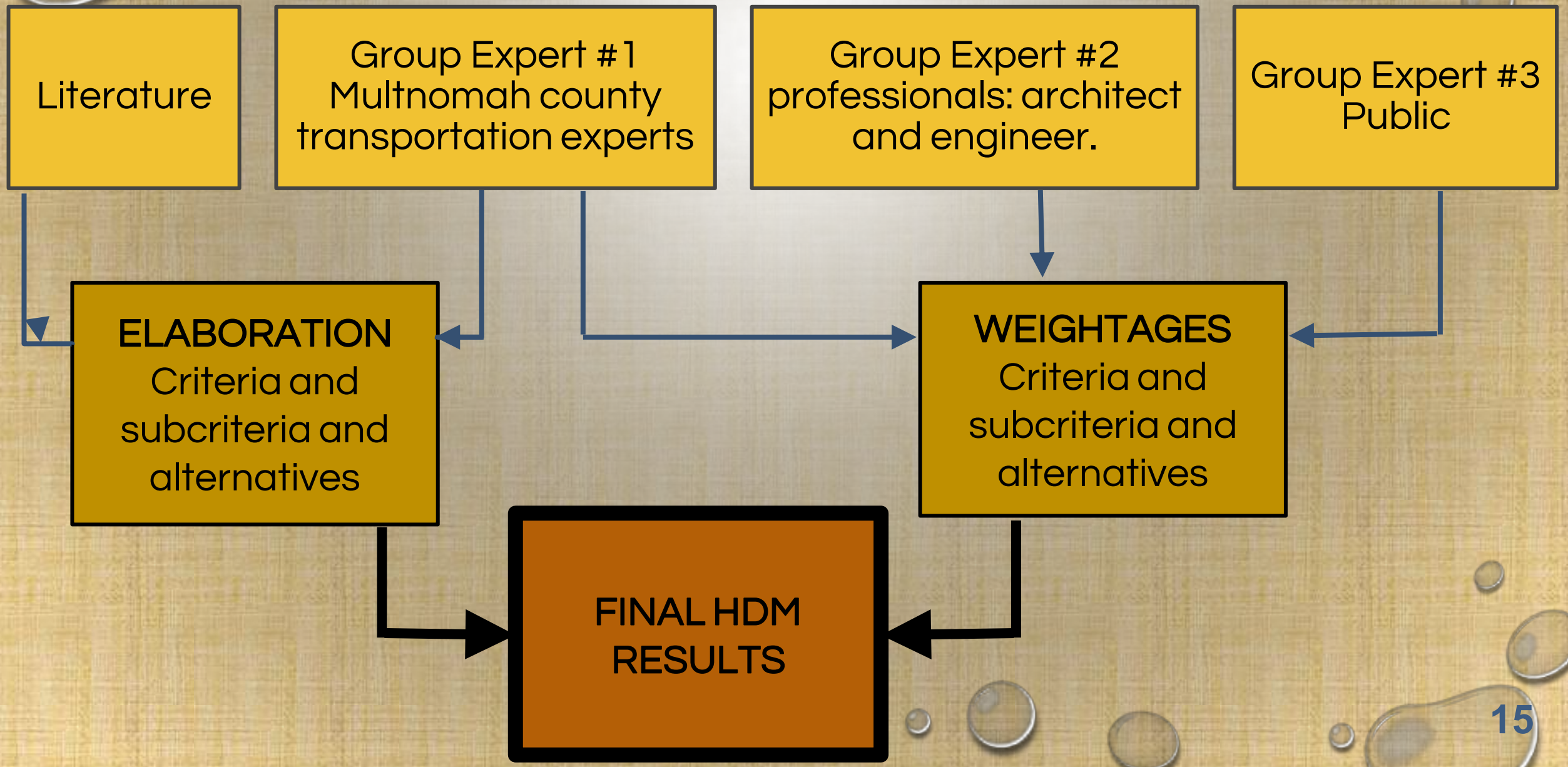
Occurrence Probability

LITERATURE REVIEW

- Articles - Oregon cascadia subduction zone and its impact on Portland
- Characteristics of Multnomah county bridges - PBOT, ODOT and Multnomah County-Transportation, Bridge Departments
- Scholarly articles regarding Bridges, Earthquakes
- Scholarly articles regarding decision making methodologies (mainly HDM and EMV)
- Cost analysis - Capital Improvement Plan (CIP) reports of Multnomah County

PBOT, ODOT and Multnomah county Transportation and Bridge Department Reports

SOURCES OF DATA



Sources of Data for HDM

Multco Bridge Engineer

Public

Engineer

Architect

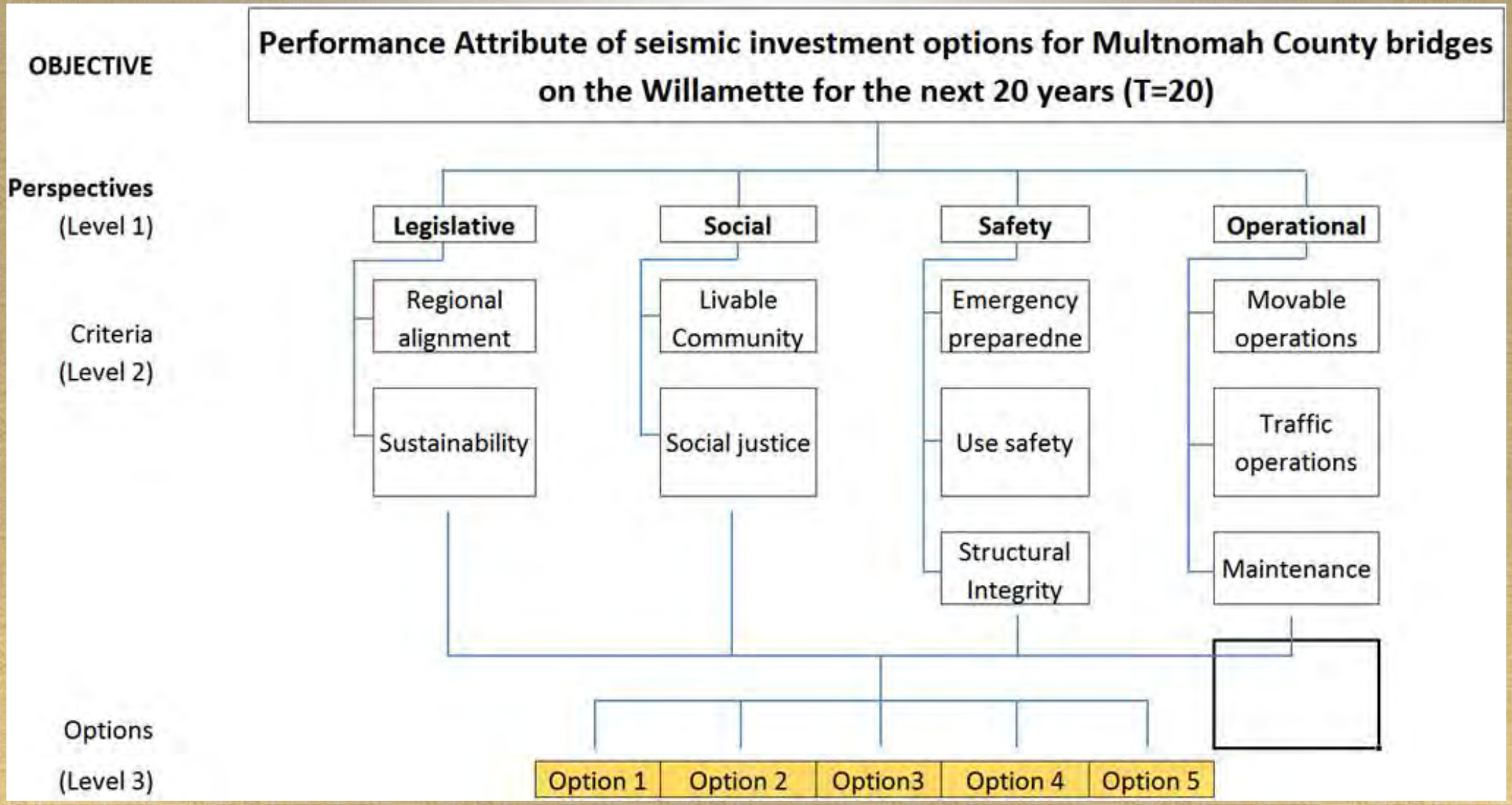
EXPERT PANEL (HDM)

EXPERTS	DESIGNATION
EXPERT 1	PUBLIC
EXPERT 2	ENGINEER
EXPERT 3	PUBLIC
EXPERT 4	ARCHITECT
EXPERT 5	PUBLIC
EXPERT 6	MULTCO ENGINEER
EXPERT 7	PUBLIC
EXPERT 8	PUBLIC

Different Backgrounds

Different Perspectives

HDM


OBJECTIVE
Performance Attribute of seismic investment options for Multnomah County bridges on the Willamette for the next 20 years (T=20)
Perspectives (Level 1)
Legislative
Social
Safety
Operational
Criteria (Level 2)
Regional alignment
Sustainability
Livable Community
Social justice
Emergency preparedne
Use safety
Structural Integrity
Movable operations
Traffic operations
Maintenance
Options (Level 3)
Option 1
Option 2
Option3
Option 4
Option 5

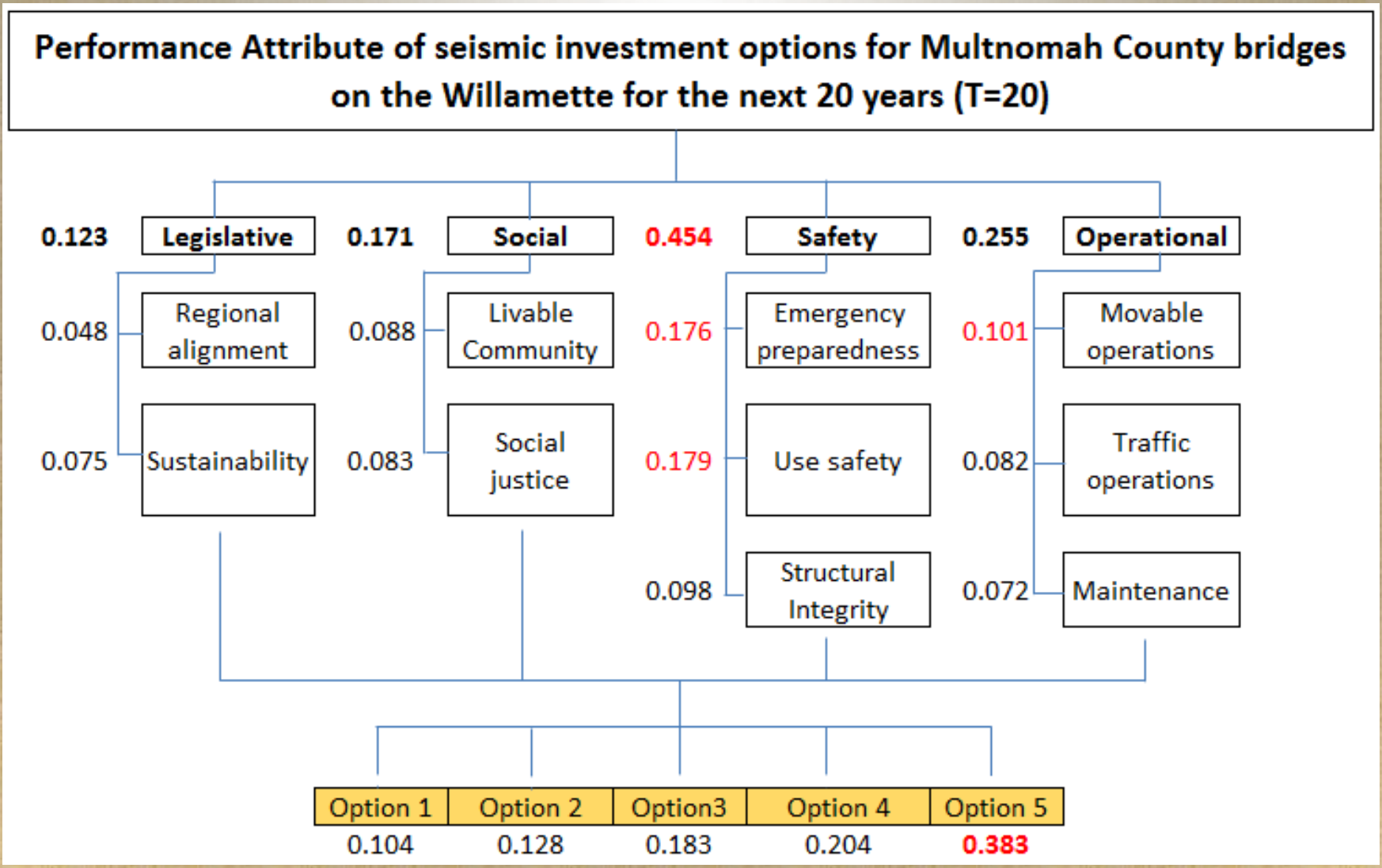
HDM Level Details

Perspective	Criteria	Explanation
Legislative	**Regional alignment**	How well the projects align with adjacent Partner Agency CIP projects and regional plans, including emergency preparedness plans
	Sustainability	Long-term economic and environmental well-being of the community including preservation of the historic and iconic nature bridges.
Social	**Livable community**	How the improvement promotes a multi-modal community including the use of bicycles, transit, pedestrians (ADA compatibility) to encourage a more livable and healthy community.
	Social justice	How the projects serve traditionally underserved (minority, low income, limited English proficiency, youth, elderly, disabled) communities.

HDM Level Details

Perspective	**Criteria**	**Explanation**
Safety	**Emergency preparedness**	The bridges' ability to resist seismic, flood and other emergency events.
	User safety	Multi-modal (including river traffic) safety on the facilities and approaches during normal use.
	Preserving structural integrity	The structural condition of the bridges (using national bridge rating standards), including paint system ability to preserve the structural condition of the bridges.

HDM Summary Results



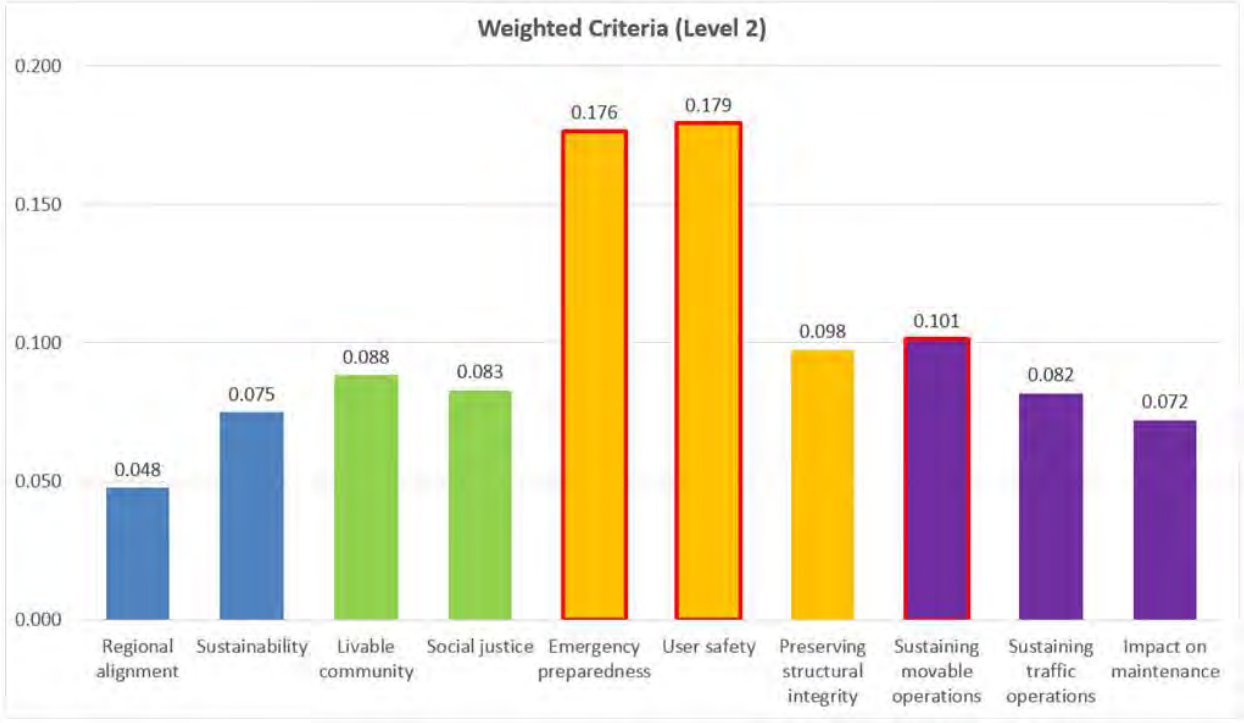
Results for Performance Attribute

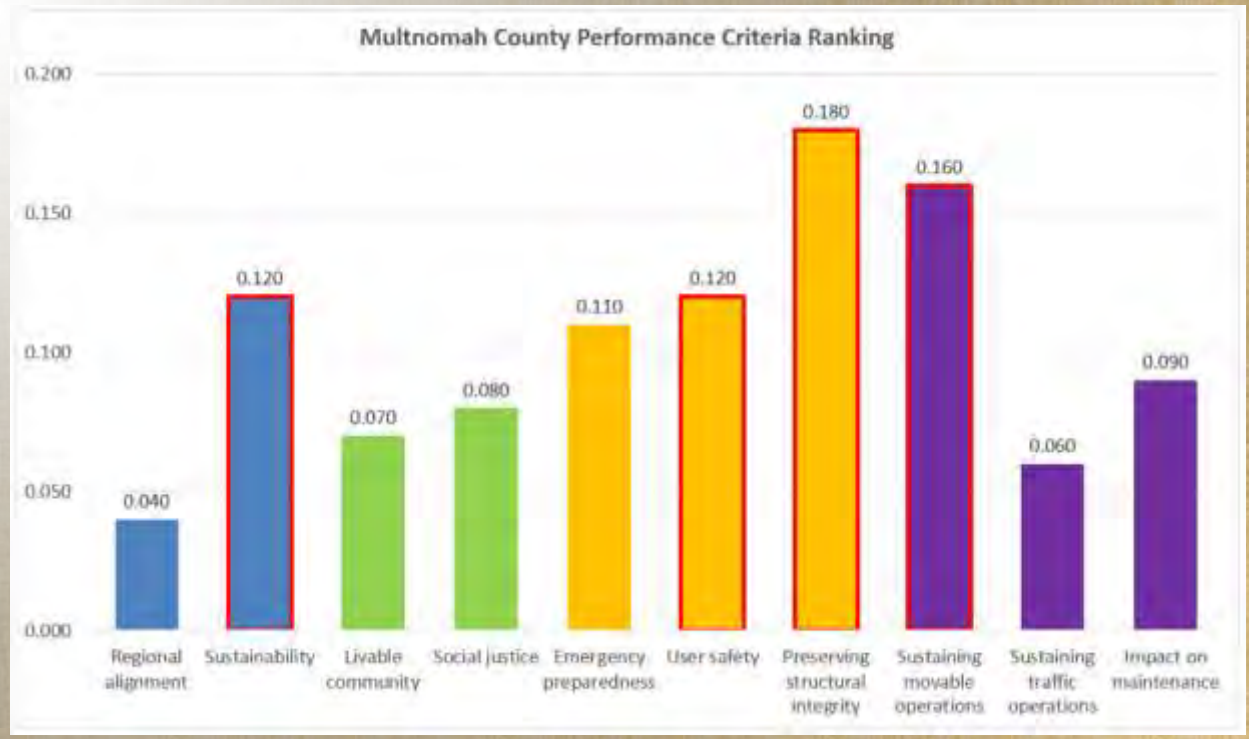
Safety first!

Results for Performance Attribute

1. Emergency preparedness
1. User Safety
1. Sustaining movable operations

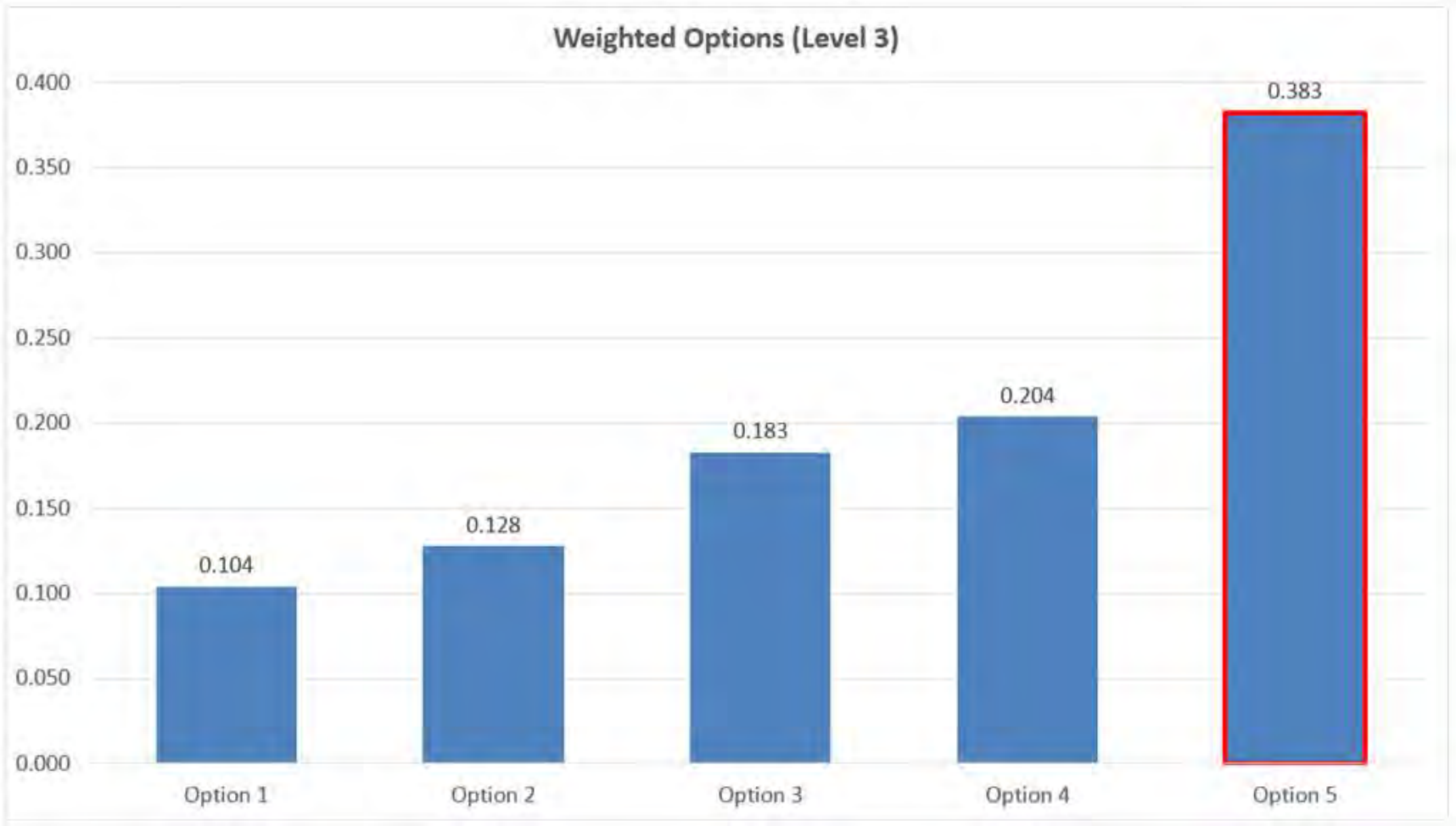
Comparison with Multnomah County





- User safety and sustaining movable operations are in top 3 priority in both cases.
- Difference in emergency preparedness vs. sustainability and preserving structural integrity.

Results for Performance Attribute



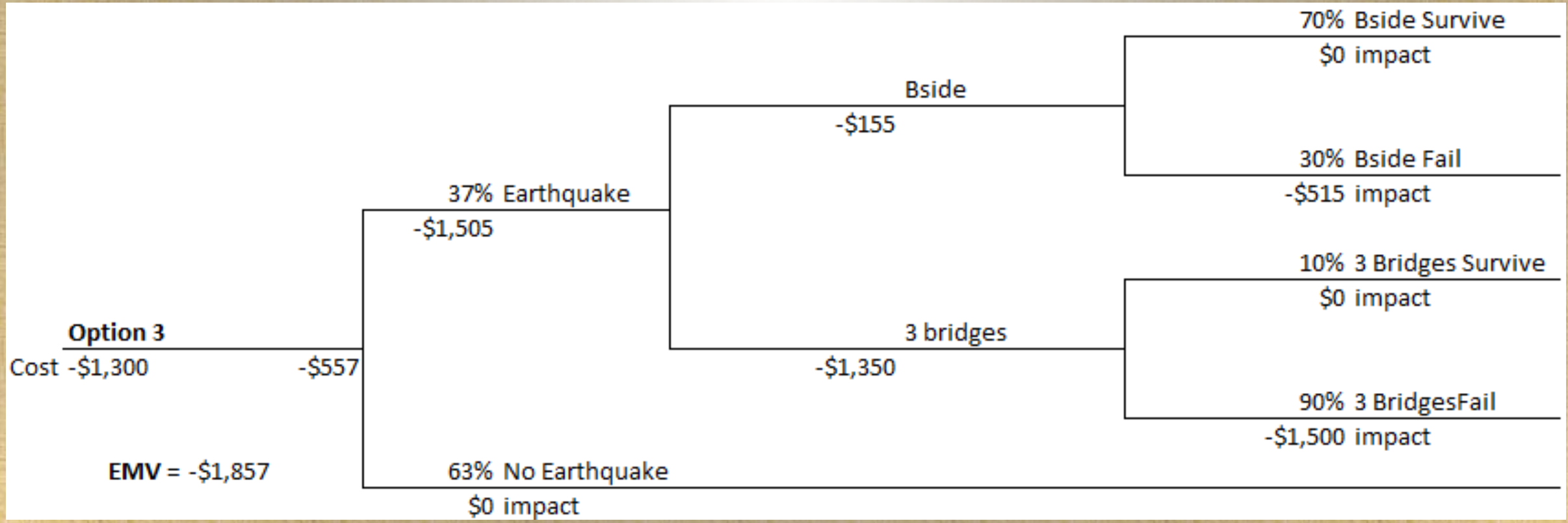
1. Option 5
1. Option 4
1. Option 3
1. Option 2
1. Option 1

Results for Performance Attribute

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.39	4	0.096	**15.36**
Between Conditions:	0	7	0	
Residual:	0.18	28	0.006	
Total:	**0.56**	**39**		
Critical F-value with degrees of freedom 4 & 28 at 0.01 level:				**4.07**
Critical F-value with degrees of freedom 4 & 28 at 0.025 level:				**3.29**
Critical F-value with degrees of freedom 4 & 28 at 0.05 level:				**2.71**
Critical F-value with degrees of freedom 4 & 28 at 0.1 level:				**2.16**

Results are way over 99% confidence level

EMV Sample



all costs in millions

Final Results

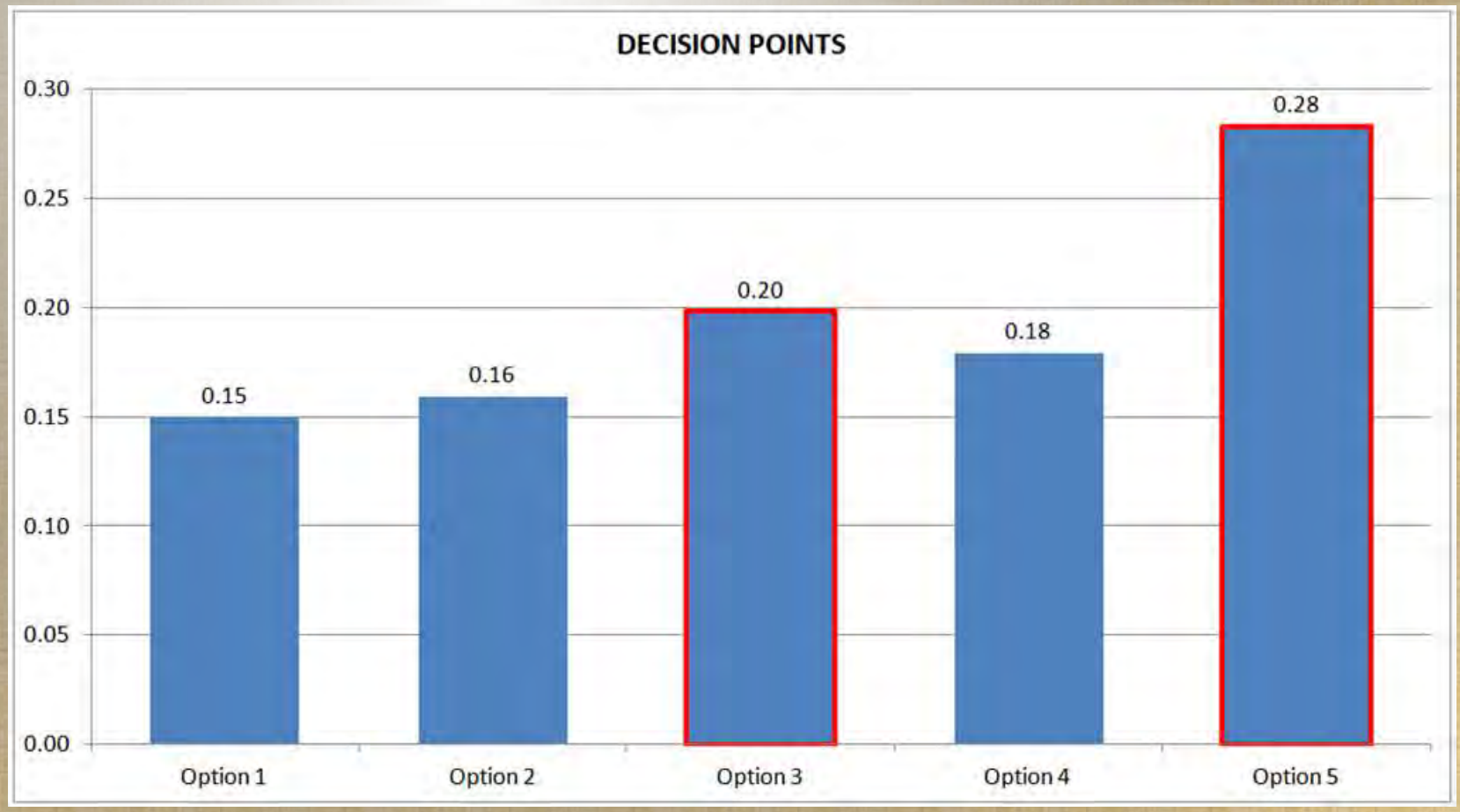
	Earthquake Occurrence Probability	Cost of Inaction (millions)	Catastrophic Failure Probability - 3 brdgs	Catastrophic Failure Probability - Burnside	Cost of implementing the project (millions)	EMV (millions)	Performance Attribute (HDM Result)	DECISION POINTS
Option 1	37%	$2,015	100%	100%	$650	$1,396	0.104	**0.15**
Option 2	37%	$2,015	100%	30%	$1,000	$1,612	0.128	**0.16**
Option 3	37%	$2,015	90%	30%	$1,300	$1,857	0.183	**0.20**
Option 4	37%	$2,015	60%	30%	$1,900	$2,290	0.204	**0.18**
Option 5	37%	$2,015	30%	30%	$2,500	$2,724	0.383	**0.28**

$$\frac{\text{Cost Consequence of Inaction}}{\text{EMV}} \times \text{Performance Attribute} = \text{Decision Points}$$

Final Results

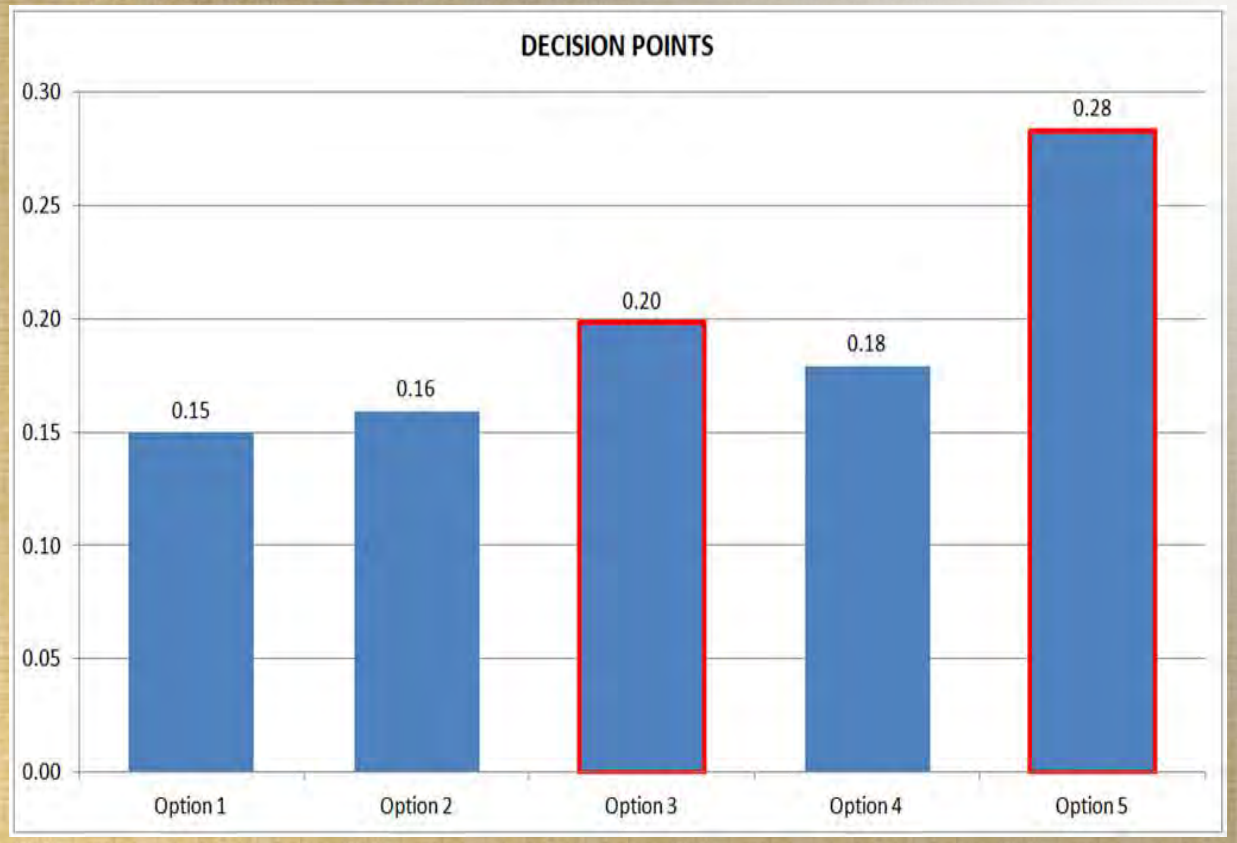
Option 5 is the best choice but it is the most expensive.

Setting Option 5 aside due to cost, Option 3 is the best decision!

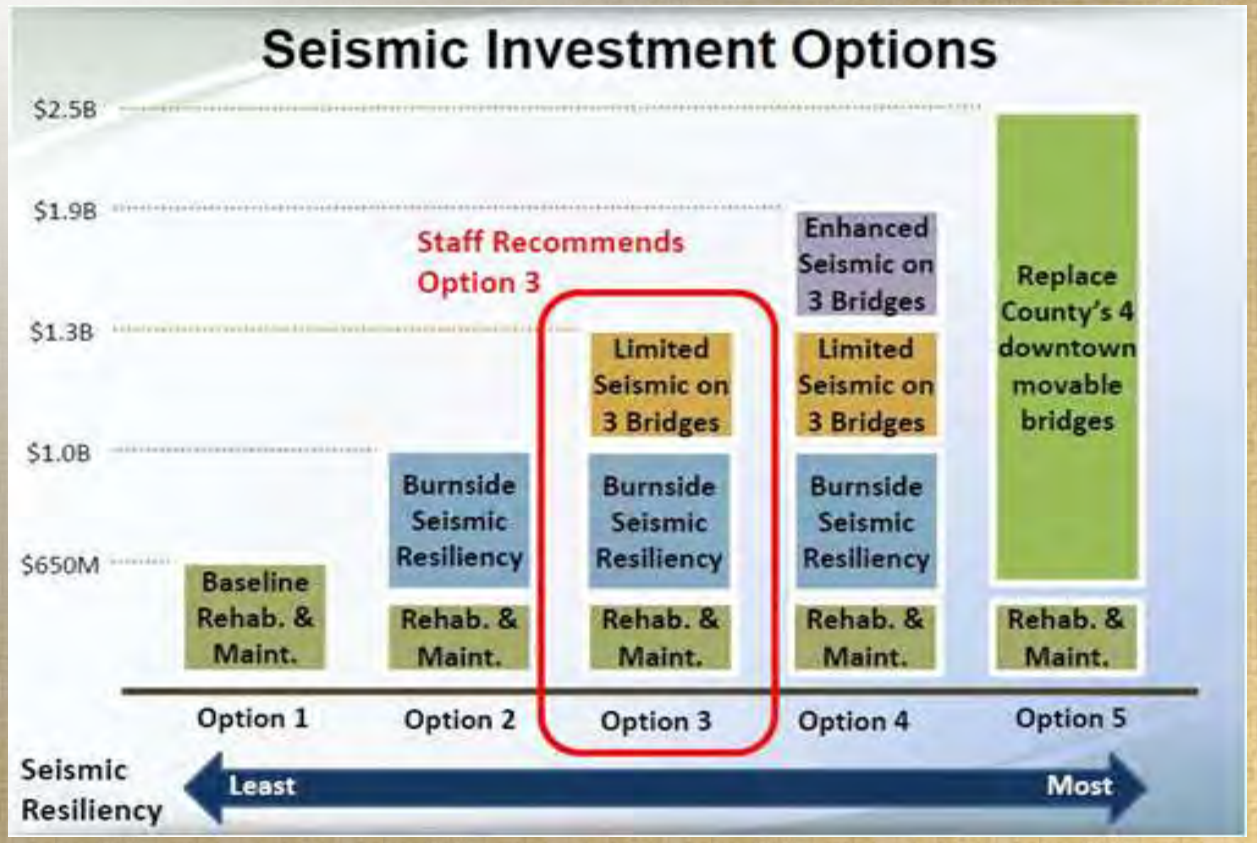


Final Results

Team 8:



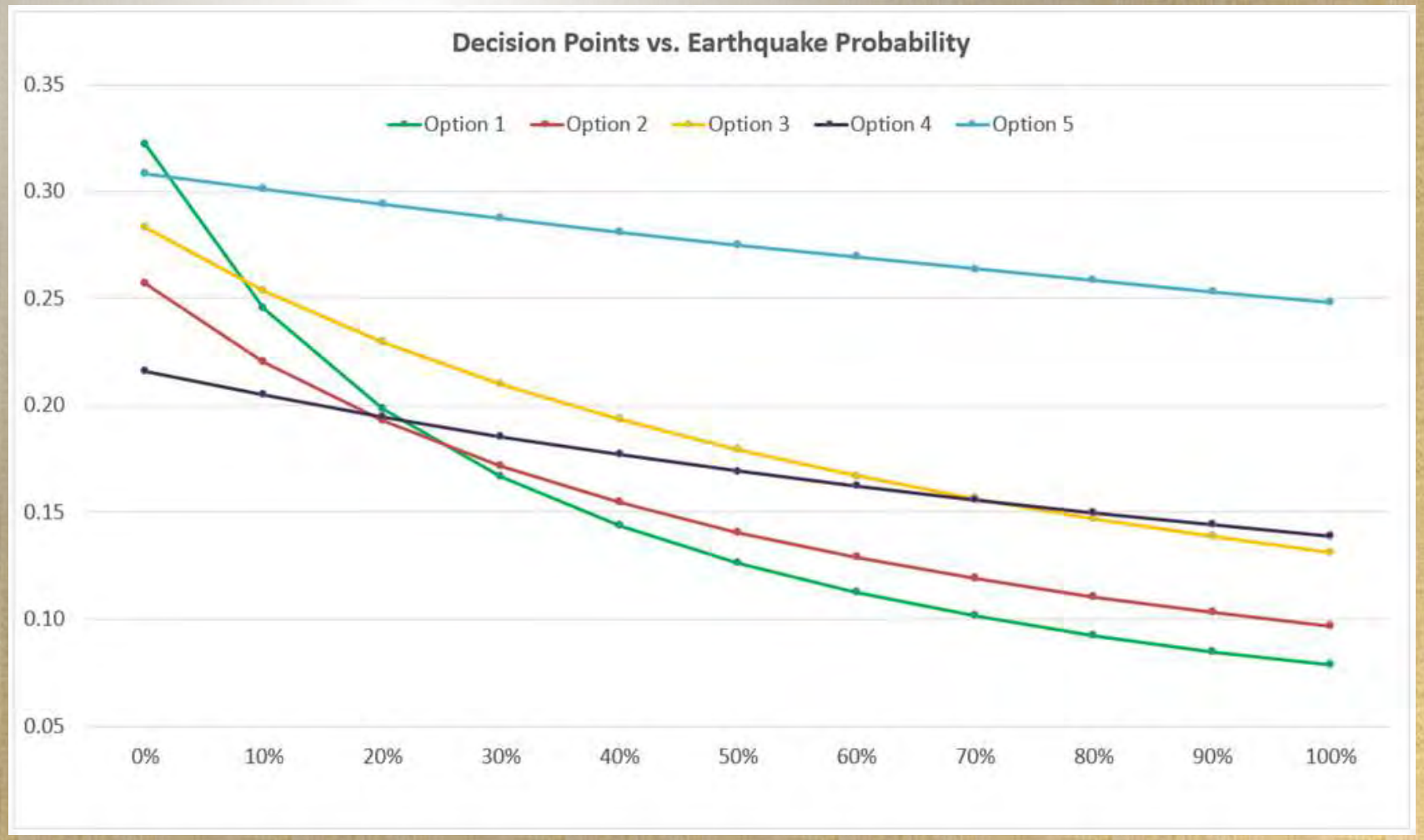
Multnomah County:



Final Results

Calculation is dependent on earthquake probability. Decision ranking changes with seismic hazard (estimated at 37%).

Setting Option 5 aside (too expensive) Option 3 is top choice for 10%-70% seismic hazard.



FUTURE RESEARCH

- Standardization
- Decision making for next steps
- Cost of inaction would probably be greater than just rebuilding the bridges. Other losses could be added like business loss, river cleaning etc.
- More experts can be added from transportation, legal, sustainability backgrounds.

REFERENCES

[1] “Burnside bridge characteristics”, https://multco.us/bridges/burnside-bridge
[2] “Hawthorne bridge characteristics”, https://multco.us/bridges/hawthorne-bridge
[3] “Broadway bridge characteristics”, https://multco.us/bridges/broadway-bridge
[4] “Morrison bridge characteristics”, https://multco.us/bridges/morrison-bridge
[5] “Historical significance”, https://www.oregon.gov/oprd/HCD/SHPO/docs/Environmental%20Compliance/MitigationPage/WillametteBridges_MPD.pdf
[6] “Multnomah County's 20-year bridge plan emphasizes earthquake endurance”, http://www.oregonlive.com/portland/index.ssf/2015/02/multnomah_countys_20-year_brid.html
[7] “Portland bridges likely to fail in major earthquake”, http://djcoregon.com/news/2011/09/21/portland-bridges-likely-to-fail-in-major-earthquake

[8] “THE REALLY BIG ONE: An earthquake will destroy a sizable portion of the coastal Northwest. The question is when.”, http://www.newyorker.com/magazine/2015/07/20/the-really-big-one

[9] “Seismic Vulnerabilities of Multnomah County’s Willamette River Bridges”,

https://www.portlandoregon.gov/pbem/article/575931

REFERENCES

[10] “Multnomah County's 20-year bridge plan emphasizes earthquake endurance”, http://www.oregonlive.com/portland/index.ssf/2015/02/multnomah_countys_20-year_brid.html

[11] “20-year Technical Deficiencies Assessment for Multnomah County’s Iconic Movable Bridges: ODOT Bridge Design Conference”, May 11, 2015, Multnomah County

[12] “Multnomah County Willamette River Bridges Capital Improvement Plan: Final Project Prioritization Report”, May 21, 2015, Multnomah County

[13] “Multnomah County Willamette River Bridges Capital Improvement Plan (2015-2034)”

[14] “Crossing the divide: City of Portland Bridge Inventory”, 2015, PBOT

[15] Stéphane Mazzotti and John Adams, “Variability of Near-Term Probability for the Next Great Earthquake on the Cascadia Subduction Zone”, Bulletin of the Seismological Society of America October 2004 vol. 94 no. 5 1954-1959

[16] Ram Kulkarni, Ivan Wong, Judith Zachariasen, Chris Goldfinger, and Martin Lawrence, “Statistical Analyses of Great Earthquake Recurrence along the Cascadia Subduction Zone”, Bulletin of the Seismological Society of America December 2013 vol. 103 no. 6 3205-3221

[17]J. R. Meredith and S. J. Mantel, “Project Management: A Managerial Approach”, 9th ed. Hoboken, NJ: Wiley, 2012

[18] T. U. Daim and D. F. Kocaoglu, Eds., “Hierarchical decision modeling: essays in Honor of Dundar F. Kocaoglu”, Cham: Springer, 2016

Let’s Discuss…

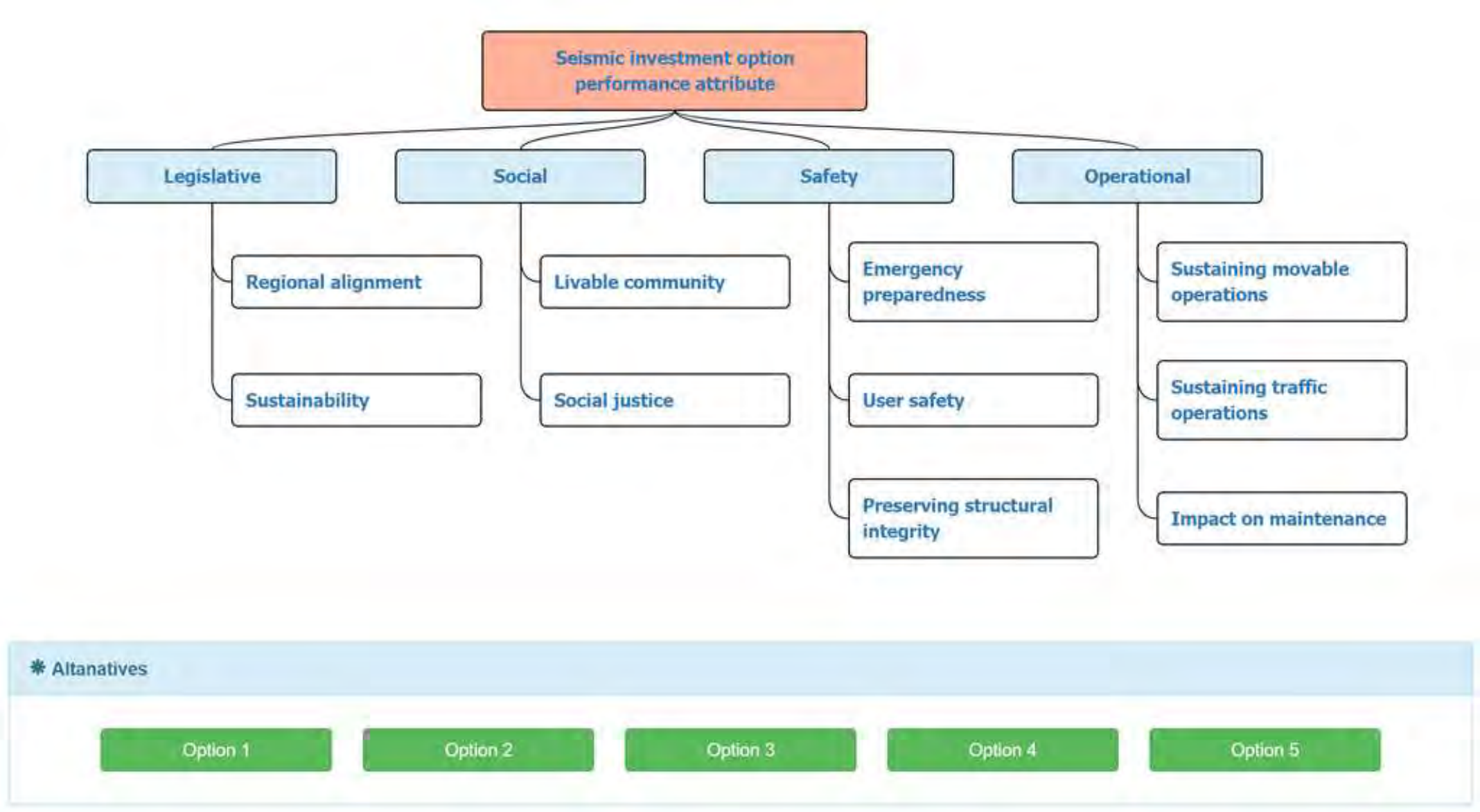
Anything missing???

- Cost
- //Mention why cost was not considered before in HDM as a criteria

NOT COMPARABLE

GO/NO GO

HDM Design


Seismic investment option performance attribute
Legislative
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Livable community
Social justice
Emergency preparedness
User safety
Preserving structural integrity
Sustaining movable operations
Sustaining traffic operations
Impact on maintenance
Altanatives
Option 1
Option 2
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Option 4
Option 5