
Constructability Schedule & Risks (Balhaf, Yemen US Consulate)

Final Report

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Risk Management

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Revision History

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1.0 Project Overview

1.1 Executive Summary

Company X&M is hired by the US government (USG) to conduct a risks study for the construction project of the new consular 3-story building in Belhaf, Yemen. The project duration is 12months for a budget of thirty million dollars (\$90M) in a foreign country with political unrest and possible change in the two countries relationship.

The design is per US standard and construction will be performed by a US construction company with local subcontractors in some trades. Design completion is scheduled for 3 months with 2 months extension optional and concurrent with contract procurement. The DBB Construction contract award is scheduled for end of FY18 and substantial completion is December 20, 2019.

X&M used Analysis Hierarchy Process (AHP) within Expert Choice Riskion Software to assess Risks associated with project. The overall likelihood, impact, and risk computed and simulated are 198% and 87% are reasonable implying a high risk for this project.

1.2 Project Background

The United State Government to provide a risk analysis to the construction project of the new consulate in the city of Belhaf located on the Yemen Arabian Sea.

In the pre Arab Spring, the political climate in the country is extremely tense because of numerous of protects/riots in the streets, as the majority of the country was demanding a change at the helm and the risk of another civil war looming.

The planning of the project started a couple years prior as the USG is becoming increasingly concerned about the structural condition of the existing building as well as the terrorist attack on a vulnerable compound.

The new consulate was a 3-story building, budgeted for Ninety million dollars (\$90M) and projected to last 12months.

1.3 Planning & Methodology

- In using Expert Choice Riskion, X&M understood that in developing a comprehensive risk register with simulating and computing results, it needed to proceed in methodologically.
- The ability to develop a model in brainstorming to collect and distinguish between the followings: events, objectives, sources, impacts, and consequences.
- Risk Managers in analyzing using statistical tools to measure and synthesize the aforementioned are able to incorporate objective and subjective considerations to inform decision makers utilizing statistical tools.
- The measurement scales are Likelihood (Probability), Impact, and Risk respectively defined by the product of two measures, consequences of objectives and importance of objectives, and event as a product of likelihood and impact.

- The project is a hybrid case thus the analysis of events and risk take are hybrid as well with evaluators in the critical real life roles to prioritize the risks by impact consequently or importance.

2.0 Structuring the Model

2.1 Identify the Objectives



Figure 2.1-1- Hierarchy of Objectives

2.2 Identify the Events

In this consultancy service, the risk managers brainstormed to register events or hazards associated with the construction of the consulate in Balhaf by identifying the objectives that have risk (loss) that matters

Add Insert Below Edit Attributes Select Columns		
<input type="checkbox"/> Enable Multi-select		
Unique ID		Events
[01]		Design Delay
[02]		Procurement Delay
[05]		Change in Government
[10]		Countless of Change orders submitted by contractor
[11]		Damages to newly built Fire systems
[13]		Architectural Concrete Facade unachievable
[14]		Specified Building Automation System is discontinued
[18]		Construction Delay
[19]		Resolicitation
[20]		All technical proposals are disqualified
[21]		Price proposals too Low
[24]		Proposed schemes rejected
[25]		Litigations to resolve REAs
[26]		New gov imposes tariff on exported materials
[27]		Constuction stoppage
[28]		Building cannot receive Accreditation
[29]		More than one bidders protest
[30]		Design Errors

Figure 2.2-1Events

2.3 Identify The Sources

The sources (causes, capability, intent, and threat) of the events that would create loss vis a vis of the objectives of completing the construction of the consulate on time and under budget in order to move consulate workers into a more secure facility.



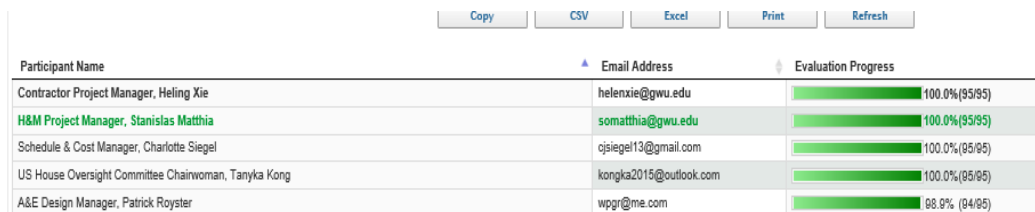
Sources	
	Senior Management disliked proposed schemes
	Government Shutdown
	Human's error and Engineer mistakes
	Dictatorship & Corruption
	Lack of good quality construction materials
	Lack of skilled labor
	Change in policy with new government
	No consensus between TEP members
	Too many requirements
	No Bid came in.
	Bids came in too high
	Scope changes

Figure 2.3-1 Hierarchy of Sources

2.4 Participants And Roles

The risk Managers of X&M understood the importance of choosing evaluators that are experts in various aspects of construction project. From the designer to the end-user. This the followings were invited to enter professional judgements as it relates to the new consulate in Balhaf, Yemen.

- 1- US Congress Foreign Relation Oversight Committee Chairwoman, Tanyka Kong
- 2- X&M Project Manager, Stan Matthia
- 3- Schedule & Cost Control Manager, Charlotte Siegle
- 4- A&E Design Manager, Patrick Royster
- 5- Contractor Project Manager, Heling Xie



Participant Name	Email Address	Evaluation Progress
Contractor Project Manager, Heling Xie	helenxie@gwu.edu	100.0% (95/95)
H&M Project Manager, Stanislas Matthia	somathia@gwu.edu	100.0% (95/95)
Schedule & Cost Manager, Charlotte Siegle	csiegle13@gmail.com	100.0% (95/95)
US House Oversight Committee Chairwoman, Tanyka Kong	kongka2015@outlook.com	100.0% (95/95)
A&E Design Manager, Patrick Royster	wpgr@me.com	98.9% (94/95)

Figure 2.4-1 Participants & Roles

2.5 Mapping Events & Sources

After developing events and sources, the risk managers sought out to link each source to one or more specific loss. The figure below is a vulnerability grid which describes how each source is link to each event.

Events	Sources												
	Senior Management disliked propo...	Government Shutdown	Human's error and Err...	Dictatorship & Corrupt...	Lack of good quality co...	Lack of skilled labor	Change in policy with...	No consensus between...	Too many requirements	No Bid came in.	Bids came in too high	Scope changes	
<input type="checkbox"/> Design Delay	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Procurement Delay	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Change in Government	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Countless of Change ord	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Damages to newly built F	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Architectural Concrete Fe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Specified Building Autom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Construction Delay	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/> Resolicitation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> All technical proposals ar	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Price proposals too Low	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Proposed schemes reject	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Litigations to resolve RE/	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> New gov imposes tariff or	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Construction stoppage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Building cannot receive A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> More than one bidders pr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Design Errors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 2.5-1 Mapping Sources to Events

Using Bow-Tie Diagram below describes visually how source contributes to event loss in Bio-diagram. As well as showing for example how Procurement delay has several causes and objectives. Listing below are Bow-Tie Diagrams for the top 3 Event Risks while considering Causes and Objectives at the same time:

1. Procurement Delay: 42.63%

Event Risk = Likelihood of causes 91.40% * Likelihood of objectives 46.64% = 42.63%

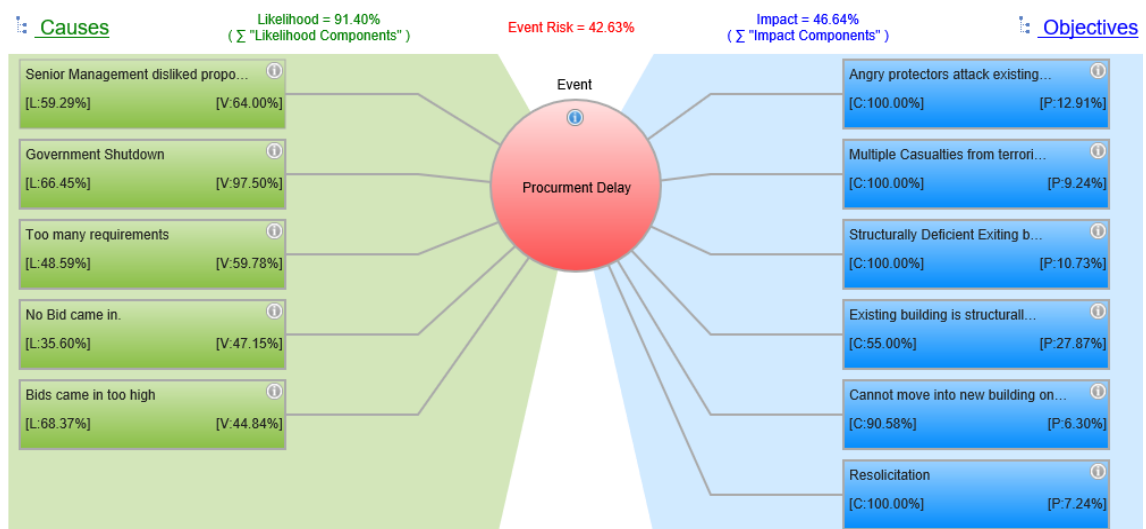


Figure 2.5-2 Bow-Tie Diagram for Procurement Delay

2. Design Delay: 17.07%

Event Risk = Likelihood of causes 52.90% * Likelihood of objectives 32.27% = 17.07%

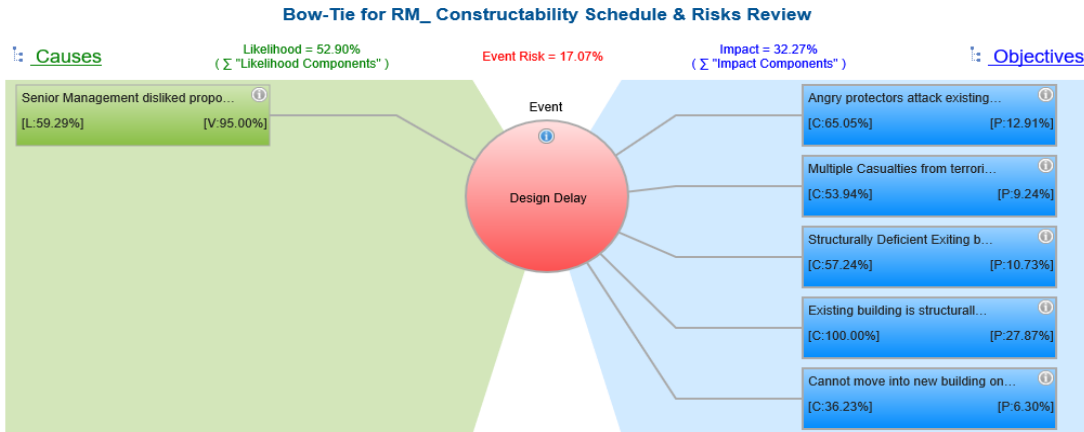


Figure 2.5-3 Bow-Tie Diagram for Design Delay

3. Countless of Change orders submitted by contractor: 15.19%

Event Risk = Likelihood of causes 91.60% * Likelihood of objectives 16.58% = 15.19%

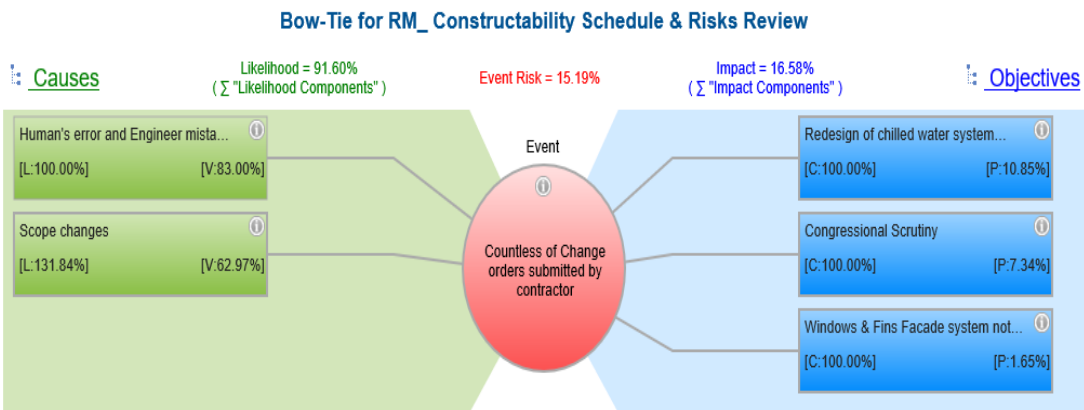


Figure 2.5-4 Bow-Tie Diagram for Countless of Change orders submitted by contractor

3.0 Measurement Methods

Using Pairwise Comparison for evaluation method to derive importance and establish prioritization, X&M risk managers ensured that participants compare how likely (probability) one source occurs with respect to another one for each event relative to the objective. Participant must compare each element to one another using quantifiable value determining importance. At the end, a table prioritizing the objective with respect to a specific one will show the importance with an Inconsistency Ratio. Like the Inconsistency Ratio for Security and Safety 0.18. There are other measure methods like

pairwise comparison with a given a likelihood of one known element that was measured and aids to determine the other probabilities.



Figure 2.5-1 Priority of Objectives Sample using pairwise Sample

There are other measure methods like pairwise comparison with a given a likelihood of one known element that was measured and aids to determine the other probabilities.

Measure Event Likelihoods	Measurement Type Default: Rating Scale	Measurement Scale or Given Likelihood	Action	# of Probabilities	Judgments in Cluster	Default: All pairs (maximum accuracy)	Default: All pairs	Default: Verbal
Sources								
Senior Management disliked proposed schedule	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	3	3			
Government Shutdown	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	1	1			
Human's error and Engineer mistakes	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	2	2			
Dictatorship & Corruption	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	2	2			
Lack of good quality construction materials	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	3	3			
Lack of skilled labor	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	3	3			
Change in policy with new government	Rating Scale ▾	Default Likelihood Scale ▾	Copy Edit ↗	3	3			
No consensus between TEP members	Pairwise Com ▾		Copy ↗	3	3*(3-1)/2 = 3	All pairs (maximum accuracy) ▾	All pairs ▾	Graphics ▾
Too many requirements	Pairwise Com ▾		Copy ↗	2	2*(2-1)/2 = 1	All pairs (maximum accuracy) ▾	All pairs ▾	Graphics ▾
No Bid came in.	Pairwise Com ▾		Copy ↗	2	2*(2-1)/2 = 1	All pairs (maximum accuracy) ▾	All pairs ▾	Graphics ▾
Bids came in too high	Pairwise Com ▾		Copy ↗	3	3*(3-1)/2 = 3	All pairs (maximum accuracy) ▾	All pairs ▾	Graphics ▾
Scope changes	Pairwise Com ▾		Copy ↗	2	2*(2-1)/2 = 1	All pairs (maximum accuracy) ▾	All pairs ▾	Graphics ▾
NO SOURCES								
Damages to newly built Fire systems	Rating Scale ▾	WIDE LIKELIHOOD RATING SCALE ▾	Copy Edit ↗	1	1			
Specified Building Automation System is discarded	Rating Scale ▾	WIDE LIKELIHOOD RATING SCALE ▾	Copy Edit ↗	1	1			
Design Errors	Rating Scale ▾	WIDE LIKELIHOOD RATING SCALE ▾	Copy Edit ↗	1	1			
				Total 29				
Project status: Available and								

Figure 2.5-2 other measure methods

4.0 Synthesis & Analysis

At the end of the evaluations, X&M consolidates the data to assess impact & likelihood. The results clearly indicate the priorities of the US government which are Security & Safety at 32.88% followed by the risk of Existing Facility Collapsing at 27.87%, then Avoiding Design Errors and Omissions at 13.82% and finally Solicitation at 7.24% as respective objectives.

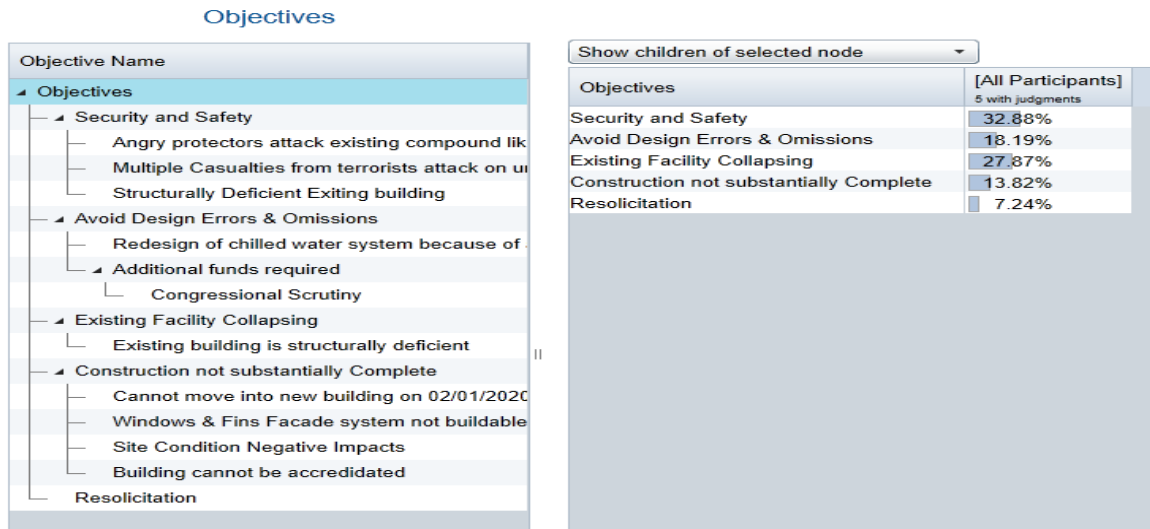


Figure 2.5-1 Synthesis - Priority of Objectives

4.1 IMPACTS OF EVENTS (OVERALL RESULTS) – Objectives Chart

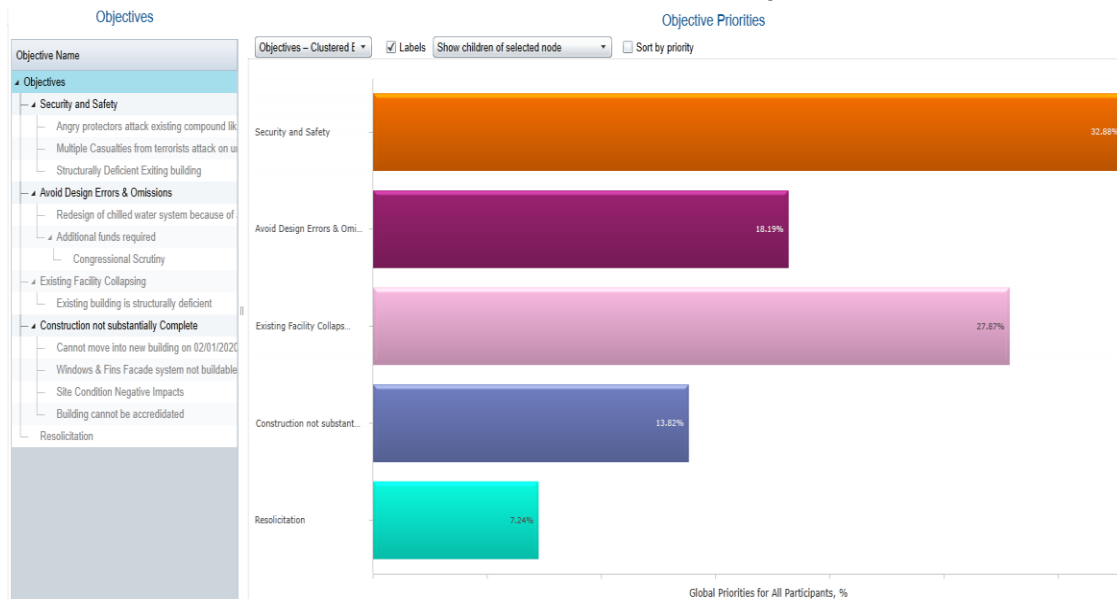


Figure 4.1-1 4.1 IMPACTS OF EVENTS - Objectives Chart

4.2 IMPACTS OF EVENTS (OVERALL RESULTS) –Events Chart

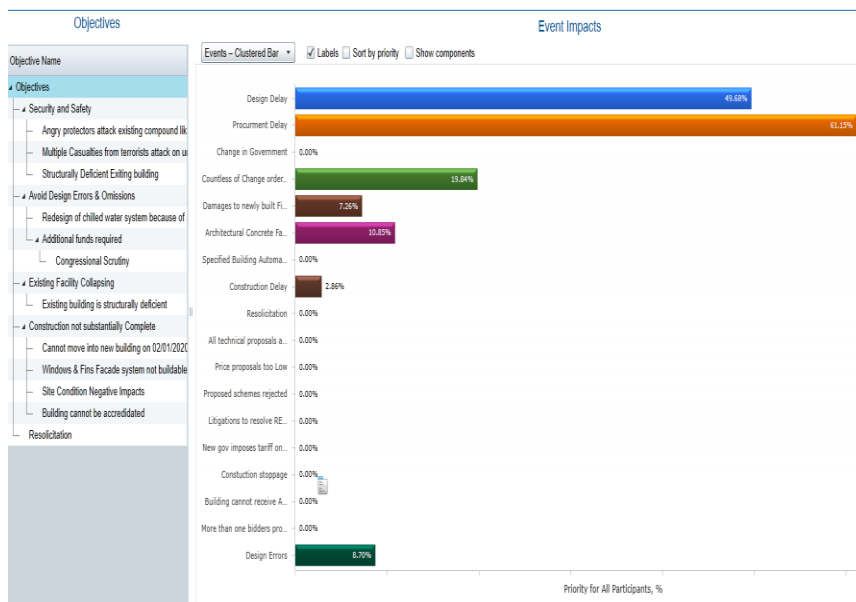


Figure 4.2-1 IMPACTS OF EVENTS - Events Chart

5.0 Risk

Risk is obtained by multiplying the likelihood of events with the impact of events.

5.1 Computed Risk: Overall Likelihoods, Impacts and Risks

Computed Total Risk is 198.75%

No. ▲	Event	Likelihood Computed	All Participants Impact Computed	Risk Computed
[01]	Design Delay	56.32%	49.68%	27.98%
[02]	Procurement Delay	179.22%	61.15%	109.60%
[05]	Change in Government	63.55%	0.00%	0.00%
[10]	Countless of Change orders submitted by contractor	166.02%	19.84%	32.93%
[11]	Damages to newly built Fire systems	29.07%	7.26%	2.11%
[13]	Architectural Concrete Facade unchievable	122.46%	10.85%	13.29%
[14]	Specified Building Automation System is discontinued	29.05%	0.00%	0.00%
[18]	Construction Delay	245.45%	2.86%	7.02%
[19]	Resolicitation	57.73%	0.00%	0.00%
[20]	All technical proposals are disqualified	22.16%	0.00%	0.00%
[21]	Price proposals too Low	10.49%	0.00%	0.00%
[24]	Proposed schemes rejected	39.72%	0.00%	0.00%
[25]	Litigations to resolve REAs	65.80%	0.00%	0.00%
[26]	New gov imposes tariff on exported materials	140.39%	0.00%	0.00%
[27]	Constuction stoppage	84.67%	0.00%	0.00%
[28]	Building cannot receive Accreditation	37.91%	0.00%	0.00%
[29]	More than one bidders protest	16.06%	0.00%	0.00%
[30]	Design Errors	66.82%	8.70%	5.82%
				Computed
				Total Risk 198.75%

Figure 5.1-1 Computed Total Risk

5.2 Computed Risk with Money Value

Cost implication in Computed mode. Obviously, whether the results are computed or simulated the impacts are exponentially considerable; thus, mitigations (controls) must be implemented to reduce the impacts.

Overall Likelihoods, Impacts, and Risks for RM_ Constructability Schedule & Risks Review

No. ▲	Event		All Participants		
			Likelihood Computed	Impact, \$ Computed	Risk, \$ Computed
[01]	Design Delay	≡	56.32%	44,707,867	25,180,656
[02]	Procurement Delay	≡	179.22%	55,039,127	98,638,918
[05]	Change in Government	≡	63.55%	0	0
[10]	Countless of Change orders submitted by contractor	≡	166.02%	17,852,960	29,640,042
[11]	Damages to newly built Fire systems	≡	29.07%	6,532,886	1,898,979
[13]	Architectural Concrete Facade unachievable	≡	122.46%	9,768,017	11,962,184
[14]	Specified Building Automation System is discontinued	≡	29.05%	0	0
[18]	Construction Delay	≡	245.45%	2,572,985	6,315,451
[19]	Resolicitation	≡	57.73%	0	0
[20]	All technical proposals are disqualified	≡	22.16%	0	0
[21]	Price proposals too Low	≡	10.49%	0	0
[24]	Proposed schemes rejected	≡	39.72%	0	0
[25]	Litigations to resolve REAs	≡	65.80%	0	0
[26]	New gov imposes tariff on exported materials	≡	140.39%	0	0
[27]	Construction stoppage	≡	84.67%	0	0
[28]	Building cannot receive Accreditation	≡	37.91%	0	0
[29]	More than one bidders protest	≡	16.06%	0	0
[30]	Design Errors	≡	66.82%	7,833,386	5,234,269
Computed					Total Risk \$178,870,501

Figure 5.2-1 Computed Total Risk (with Money Value)

5.3 Simulated Risk: Overall Likelihoods, Impacts and Risks

The results shown below indicate a high risk potential for the project from procurement to construction execution in Balhaf, Yemen. In computed analysis, the likelihood of design, procurement, and construction delays are extremely high (between 50%-245%) and the impacts and risks are all less than 50% each with the overall computed total risk at 198.75% vs. 87.3% for simulated total risk.

Overall Likelihoods, Impacts, and Risks for RM_ Constructability Schedule & Risks Review

No. ▲	Event		All Participants		
			Likelihood Simulated	Impact Simulated	Risk Simulated
[01]	Design Delay	≡	52.90%	32.27%	17.07%
[02]	Procurement Delay	≡	91.40%	46.64%	42.63%
[05]	Change in Government	≡	53.40%	0.00%	0.00%
[10]	Countless of Change orders submitted by contractor	≡	91.60%	16.58%	15.19%
[11]	Damages to newly built Fire systems	≡	28.80%	3.61%	1.04%
[13]	Architectural Concrete Facade unachievable	≡	78.30%	7.45%	5.83%
[14]	Specified Building Automation System is discontinued	≡	31.20%	0.00%	0.00%
[18]	Construction Delay	≡	99.20%	2.12%	2.10%
[19]	Resolicitation	≡	48.10%	0.00%	0.00%
[20]	All technical proposals are disqualified	≡	21.90%	0.00%	0.00%
[21]	Price proposals too Low	≡	11.00%	0.00%	0.00%
[24]	Proposed schemes rejected	≡	36.50%	0.00%	0.00%
[25]	Litigations to resolve REAs	≡	65.80%	0.00%	0.00%
[26]	New gov imposes tariff on exported materials	≡	90.00%	0.00%	0.00%
[27]	Construction stoppage	≡	64.80%	0.00%	0.00%
[28]	Building cannot receive Accreditation	≡	29.40%	0.00%	0.00%
[29]	More than one bidders protest	≡	15.10%	0.00%	0.00%
[30]	Design Errors	≡	67.10%	5.14%	3.45%
Simulated					Total Risk 87.3%

Figure 5.3-1 Simulated Risk

5.4 Simulated Risk with Money Value

Cost implication in simulated mode.

Overall Likelihoods, Impacts, and Risks for RM_ Constructability Schedule & Risks Review

No. ▲	Event	Likelihood Simulated	All Participants Impact, \$ Simulated	Risk, \$ Simulated
[01]	Design Delay	52.90%	29,040,855	15,362,612
[02]	Procurement Delay	51.40%	41,974,243	38,364,458
[05]	Change in Government	53.40%	0	0
[10]	Countless of Change orders submitted by contractor	51.60%	14,920,258	13,666,956
[11]	Damages to newly built Fire systems	28.80%	3,245,583	934,728
[13]	Architectural Concrete Facade unchievable	78.30%	6,700,616	5,246,582
[14]	Specified Building Automation System is discontinued	31.20%	0	0
[18]	Construction Delay	99.20%	1,906,386	1,891,135
[19]	Resolicitation	48.10%	0	0
[20]	All technical proposals are disqualified	21.90%	0	0
[21]	Price proposals too Low	11.00%	0	0
[24]	Proposed schemes rejected	36.50%	0	0
[25]	Litigations to resolve REAs	65.80%	0	0
[26]	New gov imposes tariff on exported materials	90.00%	0	0
[27]	Construction stoppage	64.80%	0	0
[28]	Building cannot receive Accreditation	29.40%	0	0
[29]	More than one bidders protest	15.10%	0	0
[30]	Design Errors	67.10%	4,622,241	3,101,524
Total Risk				\$78,567,998

Figure 5.4-1 Simulated Risk with Money Value

5.5 Risk Map

Risk Location in the Map - Showing great graphical representation of the overall risk the construction of US Consulate in Balhaf, Yemen is undertaken.

Top 3 Event

1. Procurement Delay: 42.63%, Red zone
2. Design Delay: 17.07%, Between Red and Yellow
3. Countless of Change orders submitted by contractor: 15.19%, Ditto

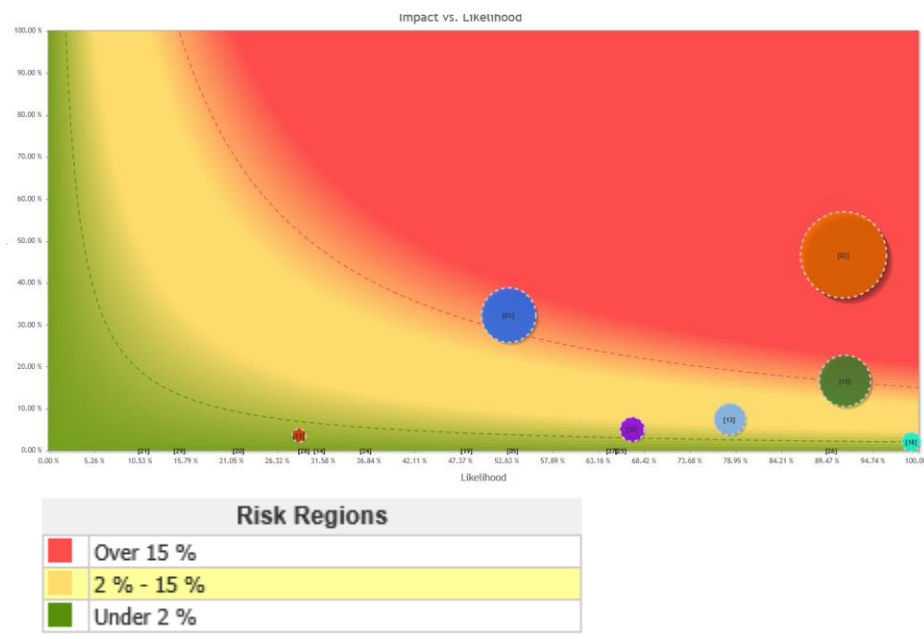


Figure 5.5-1 Risk Map

5.6 Loss Exceedance Curve for All Participants - Percent lost

The Loss Exceedance was generated to show the Average loss: 87.3%. There is 5% chance to lose 100% value of the project.

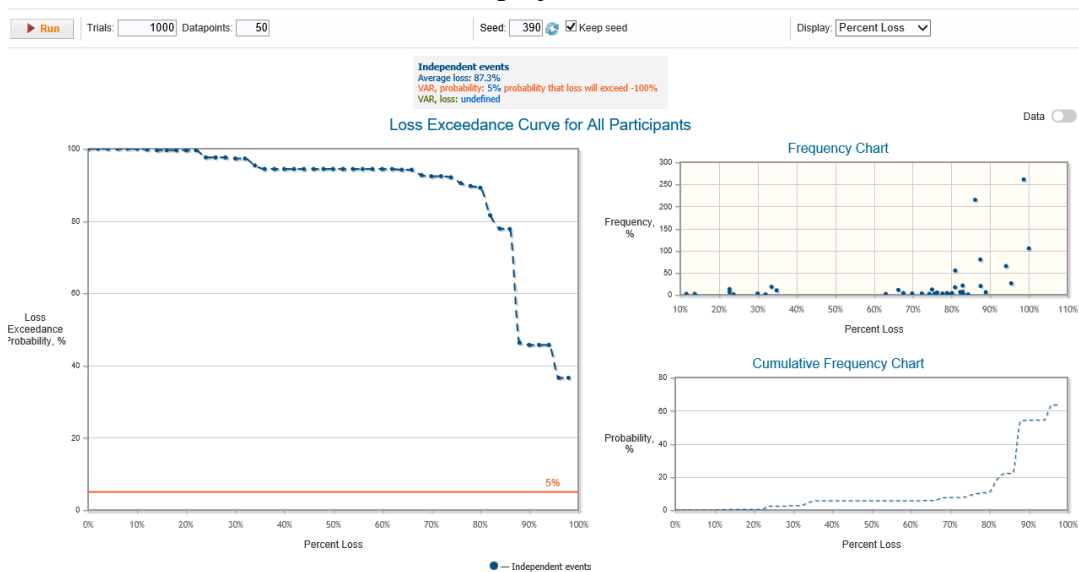


Figure 5.6-1 Loss Exceedance Curve

5.7 Risk of each event - from source

The highest risks of events come from the sources of “Senior management disliked proposed schemes” and “Government Shutdown”, which is 45.02% and 46.28% respectively. While the lowest risk of events come from the source of “Dictatorship & Corruption”, which is 7.79%.

Likelihoods, Impacts, and Risks from Cause Senior Management disliked proposed schemes for RM_Constru

No. ▲	Event	Likelihood Simulated	All Participants Impact Simulated	Risk Simulated
[01]	Design Delay	56.70%	38.18%	21.65%
[02]	Procurement Delay	37.50%	42.27%	15.85%
[24]	Proposed schemes rejected	41.00%	0.00%	0.00%
				Simulated
				Total Risk 45.02%

Likelihoods, Impacts, and Risks from Cause Government Shutdown for RM_Constructability Sch

No. ▲	Event	Likelihood Simulated	All Participants Impact Simulated	Risk Simulated
[02]	Procurement Delay	64.20%	60.42%	38.79%
				Simulated
				Total Risk 46.28%

Likelihoods, Impacts, and Risks from Cause Dictatorship & Corruption for RM_Constructability S

No. ▲	Event	Likelihood Simulated	All Participants Impact Simulated	Risk Simulated
[05]	Change in Government	39.30%	0.00%	0.00%
[26]	New gov imposes tariff on exported materials	67.50%	0.00%	0.00%
				Simulated
				Total Risk 7.79%

Figure 5.7-1 Risk of each event - from source

5.8 Risk of each event - from objective

The highest risk of events come from objective “Security and Safety”, which is 30.64%. While the lowest risk of events come from objective “Re-solicitation”, which is 6.86%.

Likelihoods, Impacts and Risks to Objective Resolicitation for RM_ Constructability Schedu

No. ▲	Event		All Participants		
			Likelihood Simulated	Impact Simulated	Risk Simulated
[02]	Procurement Delay	≡	91.40%	5.21%	4.76%
[18]	Construction Delay	≡	99.20%	2.12%	2.10%
					Simulated
					Total Risk 6.86%

Likelihoods, Impacts and Risks to Objective Security and Safety for RM_ Constructability Sch

No. ▲	Event		All Participants		
			Likelihood Simulated	Impact Simulated	Risk Simulated
[01]	Design Delay	≡	52.90%	12.65%	6.69%
[02]	Procurement Delay	≡	91.40%	26.20%	23.95%
					Simulated
					Total Risk 30.64%

Figure 5.8-1 Risk of each event - from objective

6.0 Sensitivity Analysis - Risk vs Objectives

6.1 Identifying Controls

In order to begin advising the owner on risks and device a strategy to mitigate them, X&M needed to develop a set of controls that will ultimately reduce the risks and their impacts. So the team sat down in one-on-on interview mode with experts and professional involved in the project , Design Project Manager, Construction Project Manager, Design MEP Engineers, Consular Security Officer, Consular Procurement Officer, Special Political Envoy in Yemen, Construction Scheduler, ...etc.

The one-on-one setting is designed to make the interviewee comfortable in order to obtain the most accurate Intelligence applicable to each previously identified risk.

Three (3) types of Controls are relevant:

- **CONTROLS FOR CAUSES**
- The ability to develop a package of controls to mitigate the impact of certain causes.
- **CONTROLS FOR EVENTS (BY CONTROLS)**
- The ability to develop a package of controls to mitigate the impact of certain Events or avoid the Events all together.
- **CONTROLS FOR OBJECTIVES (BY CONTROLS)**
- The ability to develop a package of controls to mitigate the impact of certain Objectives

As a result, the list below is a set of Controls developed by X&M to reducing. In all 32 different Controls packaged for Causes of Likelihood, Vulnerabilities, and Consequences of events and objectives, 23 were selectable and reflected in the figures below.

Controls for Cause Likelihoods

Control Name	Sources											
	Senior Management disliked proposed schemes	Government Shutdown	Human's error and Engineer mistakes	Dictatorship & Corruption	Lack of good quality construction materials	Lack of skilled labor	Change in policy with new government	No consensus between TEP members	Too many requirements	No Bid came in.	Bids came in too high	Scope changes
<input checked="" type="checkbox"/> 01. Implement Expanded Quality Control System to the Design Process	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> 02. Plan contingency budget beforehand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> 03. A&E Understanding of the specific needs of the Program	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> 04. Bipartisanship in Washington Returns	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 05. Encourage Free Election in Host Country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 06. Approve Line Items in Cost Proposal for Offshore Materials	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 07. Approve Third Country National for Working Visa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 08. Engage with New Government	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 09. Select 3 Voting Members for Proposal Review Panel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 10. Reduce Requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input checked="" type="checkbox"/> 11. Reduce Project Scope	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Figure 5.8-1 Control for cause Likelihoods

Controls for Vulnerabilities of event "Damages to newly built Fire systems" to causes

Select an event: ☒ Enable Multi-select

- ☐ Design Delay
- ☐ Procurement Delay
- ☐ Change in Government
- ☐ Countless of Change orders submitted by contractor
- ☒ Damages to newly built Fire systems
- ☐ Architectural Concrete Facade unachievable
- ☐ Specified Building Automation System is discontinued
- ☐ Construction Delay
- ☐ Resolicitation
- ☐ All technical proposals are disqualified
- ☐ Price proposals too Low
- ☐ Proposed schemes rejected
- ☐ Litigations to resolve REAs
- ☐ New gov imposes tariff on exported materials
- ☐ Construction stoppage
- ☐ Building cannot receive Accreditation
- ☐ More than one bidders protest
- ☐ Design Errors

All | None

Control Name	No specific Cause	Sources						
		Senior Management disliked proposed schemes	Government Shutdown	Human's error and Engineer mistakes	Dictatorship & Corruption	Lack of good quality construction materials	Lack of skilled labor	Chau policy 1 gover
12. Design Meets Scheduled deliverables Milestones	<input type="checkbox"/>							
13. Great Design Package	<input type="checkbox"/>							
14. Quick Response by A&E to the RFIs	<input type="checkbox"/>							
15. Scheduled Fire System Installation After Dust Storm	<input type="checkbox"/>							
16. Ensure facade is buildable first	<input checked="" type="checkbox"/>							
17. Propose alternative equipment at early stage of the construction	<input checked="" type="checkbox"/>							
18. Properly manage the contract per contract clauses	<input checked="" type="checkbox"/>							
19. Meet procurement deliverables Schedule	<input checked="" type="checkbox"/>							
20. Contractors Know how to write a proposal	<input checked="" type="checkbox"/>							
21. Contractors understand project scope	<input type="checkbox"/>							
22. Secure Senior Management approval prior to completing the scheme	<input type="checkbox"/>							
23. Execute the contract per contractual clauses	<input type="checkbox"/>							
24. Avoid trade war and engage in diplomacy	<input type="checkbox"/>							
25. Provide a rapid response to	<input type="checkbox"/>							

Figure 5.8-2 Control for Vulnerabilities

Control "Design Meets Scheduled deliverables Milestones" for vulnerabilities of events to causes

Select a control: 12. Design Meets Scheduled deliverables Milestones

Event Name	No specific Cause	Sources											
		Senior Management disliked proposed schemes	Government Shutdown	Human's error and Engineer mistakes	Dictatorship & Corruption	Lack of good quality construction materials	Lack of skilled labor	Change in policy with new government	No consensus between TEP members	Too many requirements	No Bid came in.	Bids came in too high	Scope changes
<input checked="" type="checkbox"/> 1. Design Delay		<input checked="" type="checkbox"/>											
<input checked="" type="checkbox"/> 2. Procurement Delay		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>							<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> 5. Change in Government					<input checked="" type="checkbox"/>			<input type="checkbox"/>					
<input checked="" type="checkbox"/> 10. Countless of Change orders submitted by contractor				<input checked="" type="checkbox"/>									<input checked="" type="checkbox"/>
<input type="checkbox"/> 11. Damages to newly built Fire systems	<input type="checkbox"/>												
<input checked="" type="checkbox"/> 13. Architectural Concrete Facade unachievable						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>						
<input type="checkbox"/> 14. Specified Building Automation System is discontinued	<input type="checkbox"/>												
<input checked="" type="checkbox"/> 18. Construction Delay						<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> 19. Resolicitation									<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/> 20. All technical proposals are disqualified									<input checked="" type="checkbox"/>				
<input checked="" type="checkbox"/> 21. Price proposals too Low									<input checked="" type="checkbox"/>				
<input checked="" type="checkbox"/> 24. Proposed schemes rejected		<input checked="" type="checkbox"/>											
<input checked="" type="checkbox"/> 25. Litigations to resolve REAs				<input checked="" type="checkbox"/>									
<input checked="" type="checkbox"/> 26. New gov imposes tariff on exported materials					<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>					
<input checked="" type="checkbox"/> 27. Construction stoppage						<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>					
<input checked="" type="checkbox"/> 28. Building cannot receive Accreditation							<input checked="" type="checkbox"/>						
<input checked="" type="checkbox"/> 29. More than one bidders protest									<input checked="" type="checkbox"/>				
<input type="checkbox"/> 30. Design Errors	<input type="checkbox"/>												

Figure 5.8-3 Control "Design Meets Scheduled deliverables"

Control "Securely impenetrable Compound" to mitigate consequences of events to objectives

Select a control: 20. Securely impenetrable Compound

Event Name	Objectives										
	Security and Safety			Avoid Design Errors & Omissions		Existing Facility Collapsing	Construction not substantially Complete				<input type="checkbox"/> Resolicitation
	<input type="checkbox"/> Angry protectors attack existing compound like Benghazi	<input type="checkbox"/> Multiple Casualties from terrorists attack on unsecure existing facility	<input type="checkbox"/> Structurally Deficient Existing building	<input type="checkbox"/> Redesign of chilled water system because of accessibility	<input type="checkbox"/> Additional funds required <input type="checkbox"/> Congressional Scrutiny	<input type="checkbox"/> Existing building is structurally deficient	<input type="checkbox"/> Cannot move into new building on 02/01/2020	<input type="checkbox"/> Windows & Fins Facade system not buildable	<input type="checkbox"/> Site Condition Negative Impacts	<input type="checkbox"/> Building cannot be accredited	
<input type="checkbox"/> 1. Design Delay	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>	<input checked="" type="checkbox"/>				
<input type="checkbox"/> 2. Procurement Delay	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>
<input checked="" type="checkbox"/> 5. Change in Government											
<input checked="" type="checkbox"/> 10. Countless of Change orders submitted by contractor				<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input type="checkbox"/>			
<input type="checkbox"/> 11. Damages to newly built Fire systems							<input type="checkbox"/>		<input type="checkbox"/>		
<input type="checkbox"/> 13. Architectural Concrete Facade unachievable							<input type="checkbox"/>			<input type="checkbox"/>	
<input checked="" type="checkbox"/> 14. Specified Building Automation System is discontinued											
<input type="checkbox"/> 18. Construction Delay											<input type="checkbox"/>
<input checked="" type="checkbox"/> 19. Resolicitation											
<input checked="" type="checkbox"/> 20. All technical proposals are disqualified											
<input checked="" type="checkbox"/> 21. Price proposals too Low											
<input checked="" type="checkbox"/> 24. Proposed schemes rejected											
<input checked="" type="checkbox"/> 25. Litigations to resolve REAs											
<input checked="" type="checkbox"/> 26. New gov imposes tariff on exported materials											
<input checked="" type="checkbox"/> 27. Construction stoppage											
<input checked="" type="checkbox"/> 28. Building cannot receive Accreditation											
<input checked="" type="checkbox"/> 29. More than one bidders protest											
<input type="checkbox"/> 30. Design Errors				<input type="checkbox"/>							

Figure 5.8-4 Control "Securely impenetrable Compound"

6.2 Evaluation of Controls

X&M elected to utilize only one evaluator to appraise the controls.

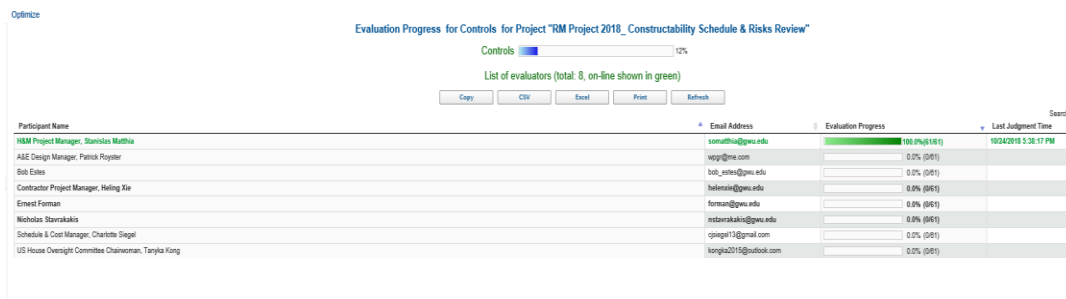


Figure 5.8-1 Evaluation Progress For Control

6.3 Measure Controls (Simulated & Computed)

The only way to measure, the control is to assess the effectiveness of the controls in terms reducing the likelihood or consequence. We elected to focus on the following:

- Measurement for Control For Events (By Controls)
- Measurement For Controls for Objectives (By Controls)

All the measurements method events/controls are Direct

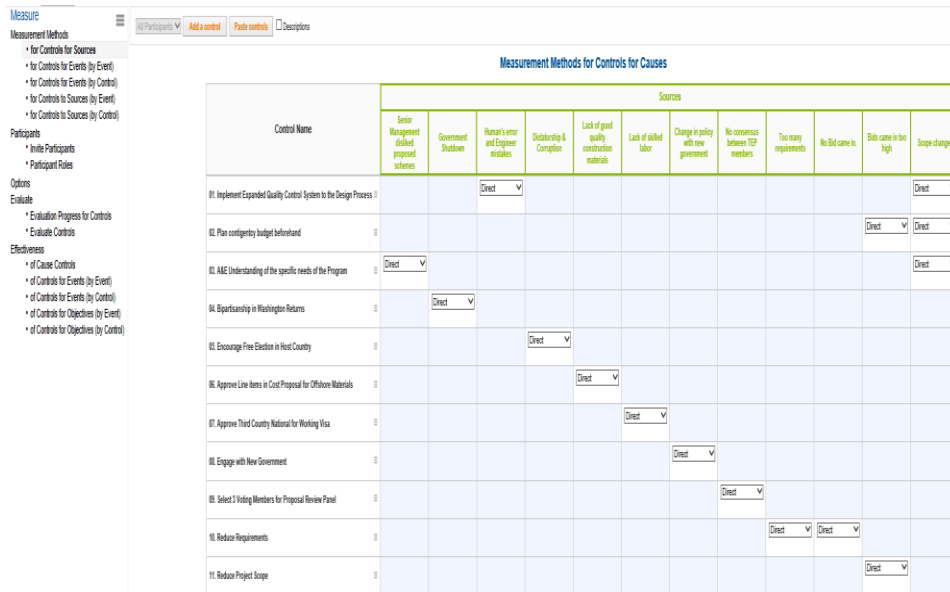


Figure 5.8-1 Measurement For Controls for Courses

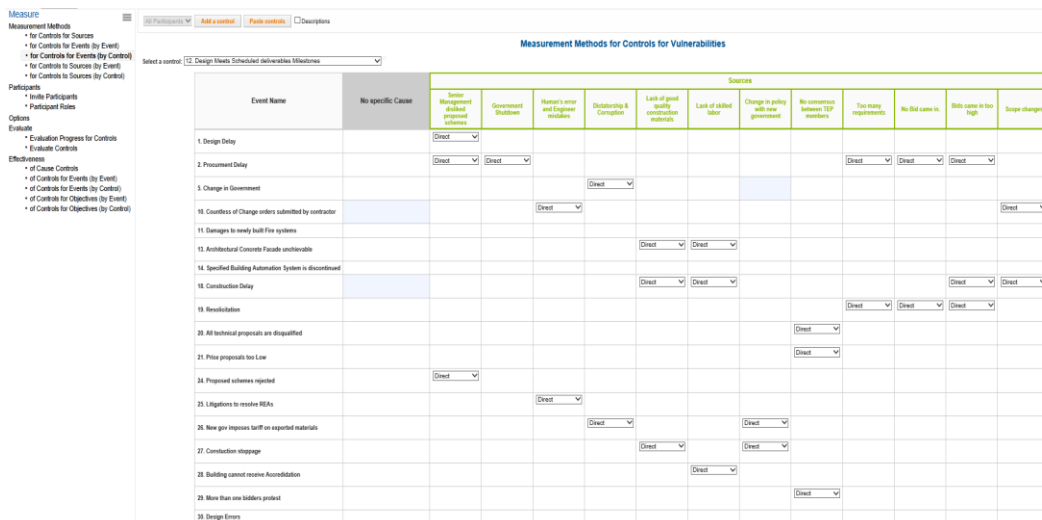


Figure 5.8-2 Measurement Methods for Controls for Vulnerability

In the figure above, Controls for Vulnerability appears to the most measurements and the effectiveness

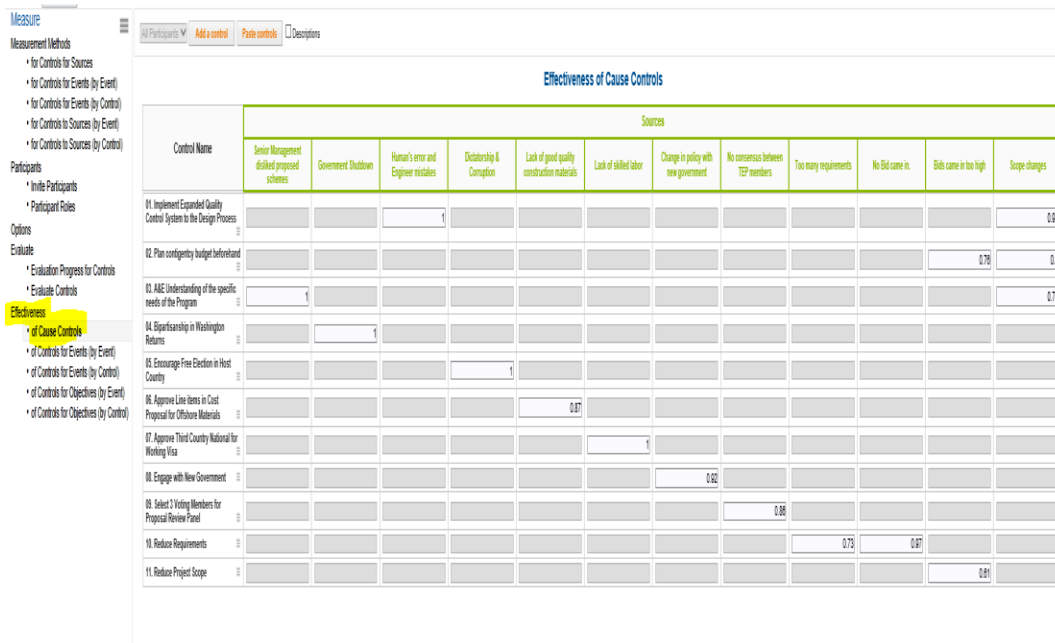


Figure 5.8-3 Effectiveness of Cause Controls

According to the figure above, it appears that the following controls number 01, 03, 04, 05, and 07 have 100% effectiveness on Human's Errors & Engineer Mistakes, Senior management disliking proposed schemes, Government Shutdown, Dictatorship and Corruption, lack of Skilled Labor respectively. Meanwhile reducing project scope has the least effective control (61%) on the cause that the bids came in too high. Similarly, for Plan Contingency Budget provision as a control for bids coming in too high and scope change @ 76% and 80%. The rest of the controls have effectiveness ranges between 80-98%

6.4 Impacts of Controls

In order to appraise the impact of control on event, Source, cause, and objective, one must assign a monetary loss or gain. In this case, amongst a package/set of controls, the inclusion or non-inclusion of certain controls can have the desired impact.

In another words, the process of selecting the controls and understanding the challenges and advantages is the OPTIMIZATION

The three figures below represent cases where all (23) controls were selected, No control was selected, One most impactful control was selected in simulating the result for 1000 trials.

Case 1: All

After selecting all the controls, the model appears to suggest that for an investment of \$14,930,000 of various controls, X&M risk review and mitigation will save \$74,166,595 for the project.

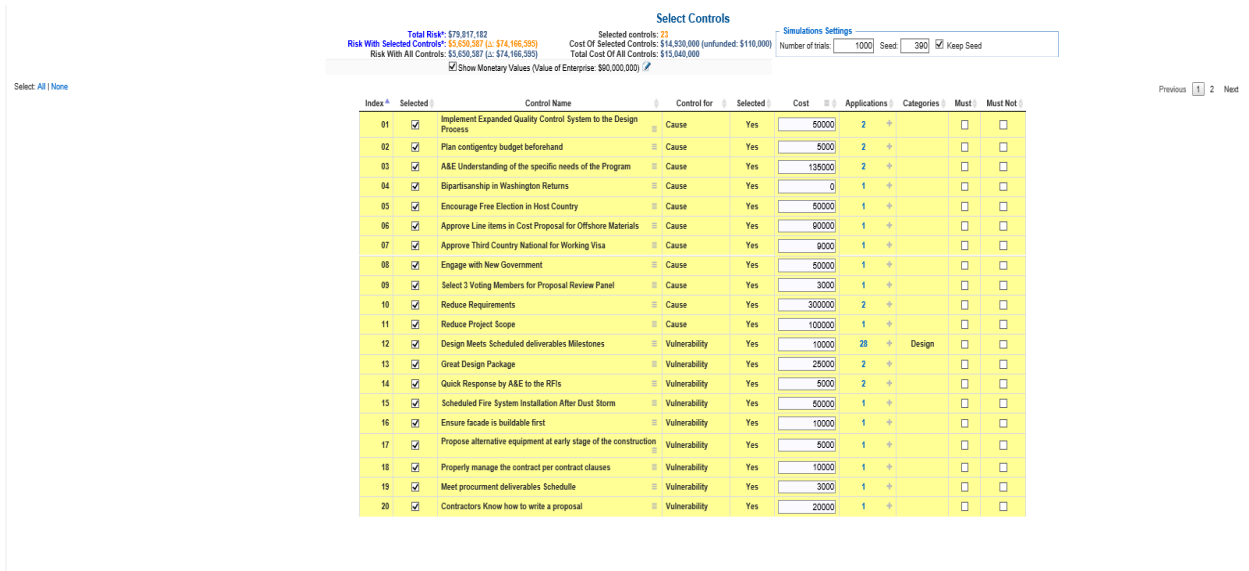


Figure 5.8-4 Impacts of Controls -Case 1

Case 2: None

No control selected, will result into a high risk to the project in sum of \$79,817,182

Case 3: A Combination of Controls Giving 83% of

The figure below appears to reveal that the selection of controls 01 and 12 for a total investment of \$ 60,000 give the best combination of 2 controls for maximum saving of \$61,513,282 in simulated mode. In addition, worth to point out that “Design Meets Scheduled Deliverables Milestones” is the best cost saving measure (control) in this pool of controls.

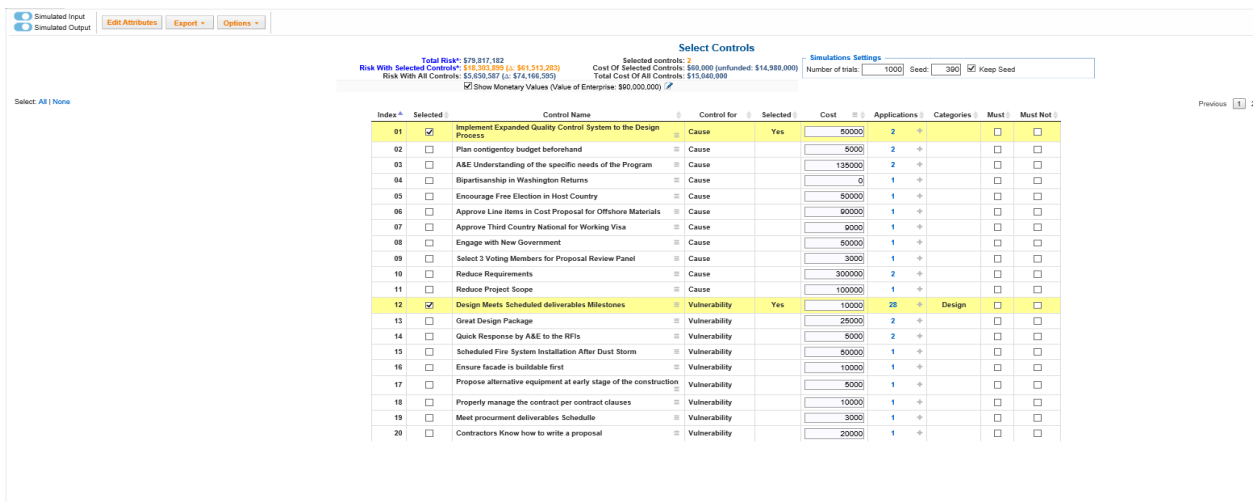


Figure 5.8-5 Impact of Controls - Case 3

In all cases, the indication is that the more you do something, the closer the results will be from the expected value.

6.5 Loss Exceedance Curve

Discussing Loss Exceedance Curve (W/ Controls or W/o Controls- @1000 trials, how many times resulted in no or zero loss)

With Control

From the figure below, it appears that out of 1000 trials, all the results are closer to zero loss and within 5% of probability that loss will exceed \$8.38M. For an average loss cost of \$5.65M except one result.

What is the value at risk or what is the 5% of chance that the loss will exceed \$8.38M. The Efficient Frontier will give us more indications.

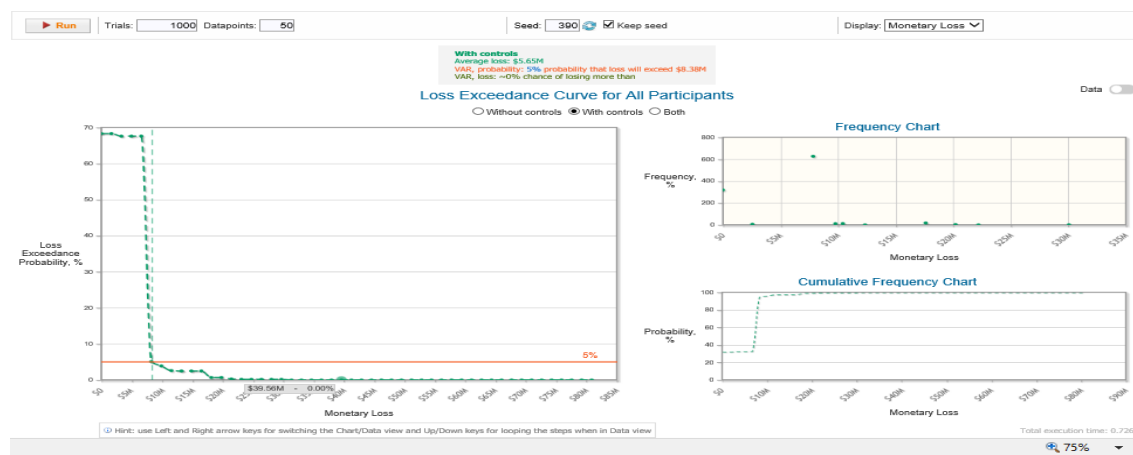


Figure 6.5-1 Loss Exceedance Curve with Controls

Without Control:

It appears in the figure below that, few points in 1000 trials have zero loss and that 95% of them have \$78.57Milloin in loss. In Another words, there is 5% chance to the loss of the project will exceed \$90,000,000

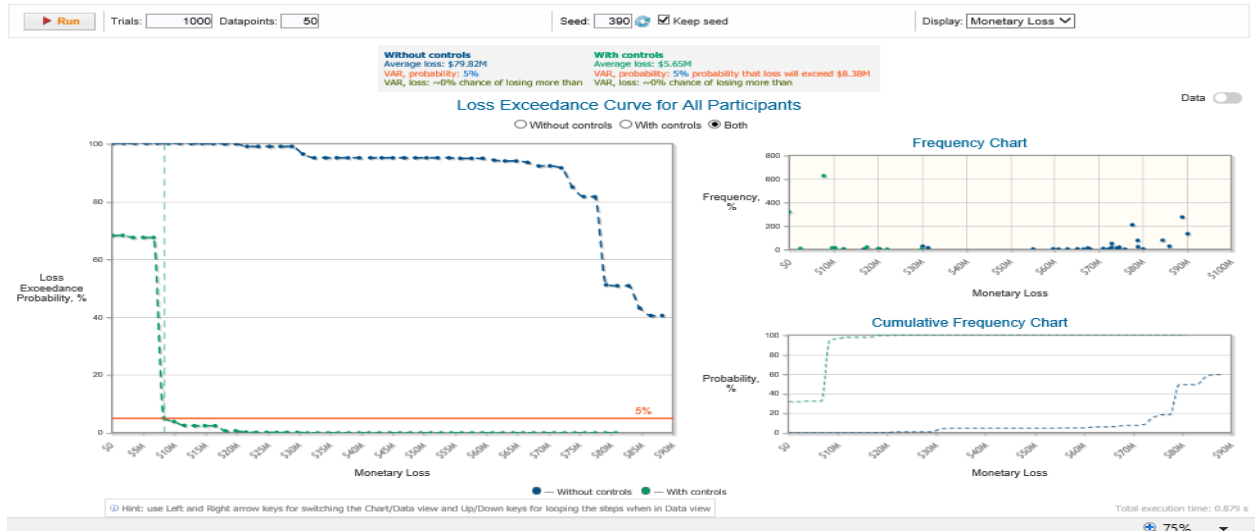


Figure 6.5-2 Loss Exceedance Curve without Control

6.6 Cost Impact

So as indicated in the previous sections, it clear that the controls registered for this project have impacts on the consequence and in more cases reduce the total risk for the project.

Simulated Results:

With all selected controls, this risk review would save an optimum of \$74,166,595 provided that the client accepts to invest \$14,930,000 in cost control. So, selecting more control would not have matter because, the gain has reached an optimum. **However, different combination of controls takes up the majority of the risk reduction. As an example, controls number 01 and 12 make 82% of total risk reduction for this project. Therefore, if you have a small budget you can target these controls and get a maximum of 82% of total risk. Selecting this type of combination can be a strategy in a case budget constraint.**

Optimize

Simulated Input

Simulated Output

Available:

Events

Controls

Causes

Objectives

Edit Attributes

Export

Options

Controls optimization for "RM Project 2018_ Constructability Schedule & Risks Review"

Budget

Risk

Risk Reduction

Budget Limit: \$

16,000,000

Total Risk*: \$79,817,182

Risk With Selected Controls*: \$5,650,587 (Δ: \$74,166,595)

Risk With All Controls: \$5,650,587 (Δ: \$74,166,595)

Selected controls: 23

Cost Of Selected Controls: \$14,930,000 (unfunded: \$110,000)

Total Cost Of All Controls: \$15,040,000

Show Monetary Values (Value of Enterprise: \$90,000,000)

Ignore:

Musts

Must Not

Dependencies

Groups

Simulations Settings

Number of trials:

1000

Seed:

390

Keep Seed

lect: All | None

Previous

1

2

Next

Search:

lex

Selected

Control Name

Control for

Selected

Cost

Applications

Categories

Must

Must Not

01

Implement Expanded Quality Control System to the Design Process

Cause

Yes

50000

2

02

Plan contingency budget beforehand

Cause

Yes

5000

2

03

A&E Understanding of the specific needs of the Program

Cause

Yes

135000

2

04

Bipartisanship in Washington Returns

Cause

Yes

0

1

05

Encourage Free Election in Host Country

Cause

Yes

50000

1

06

Approve Line items in Cost Proposal for Offshore Materials

Cause

Yes

90000

1

07

Approve Third Country National for Working Visa

Cause

Yes

9000

1

08

Engage with New Government

Cause

Yes

50000

1

Figure 6.6-1 Controls optimizations - Simulated Results

Computed Results:

With all selected controls, this risk review would save an optimum of \$173,091,316 provided that the client accepts to invest \$14,930,000 in cost control. It's important to point out that in computed mode, the model tends to carry multiple errors.

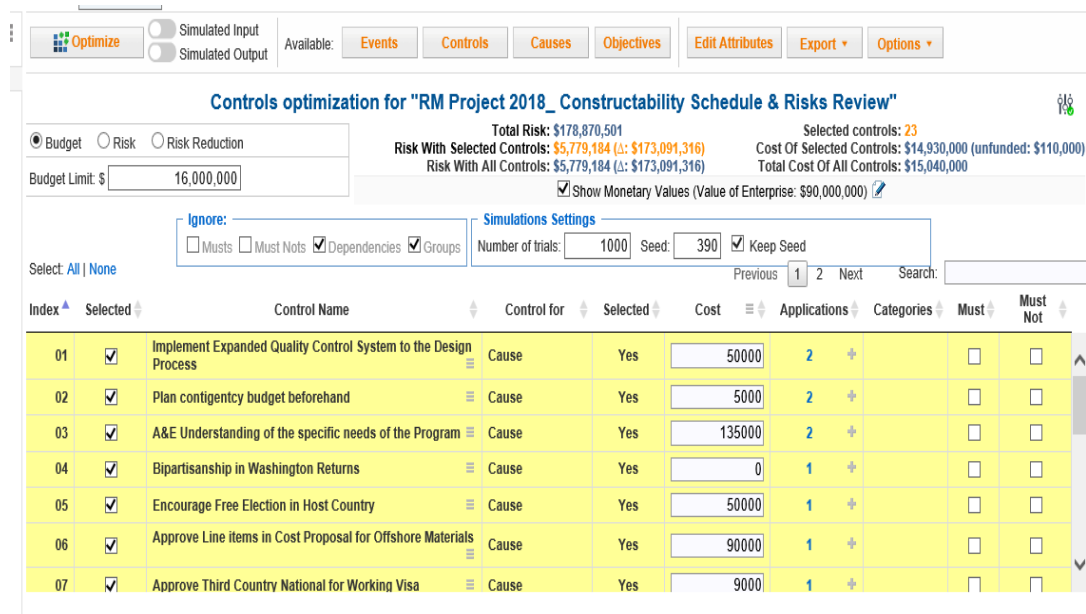


Figure 6.6-2 Controls optimizations - Computed Result

7.0 Budget Optimization (Simulated vs. Computed)

Simulated Optimization- Figure below shows the set of 23 controls selected for \$14,930,000 total investment reducing the total risk from \$79,817,182 to \$5,650,587 saving \$74,166,595

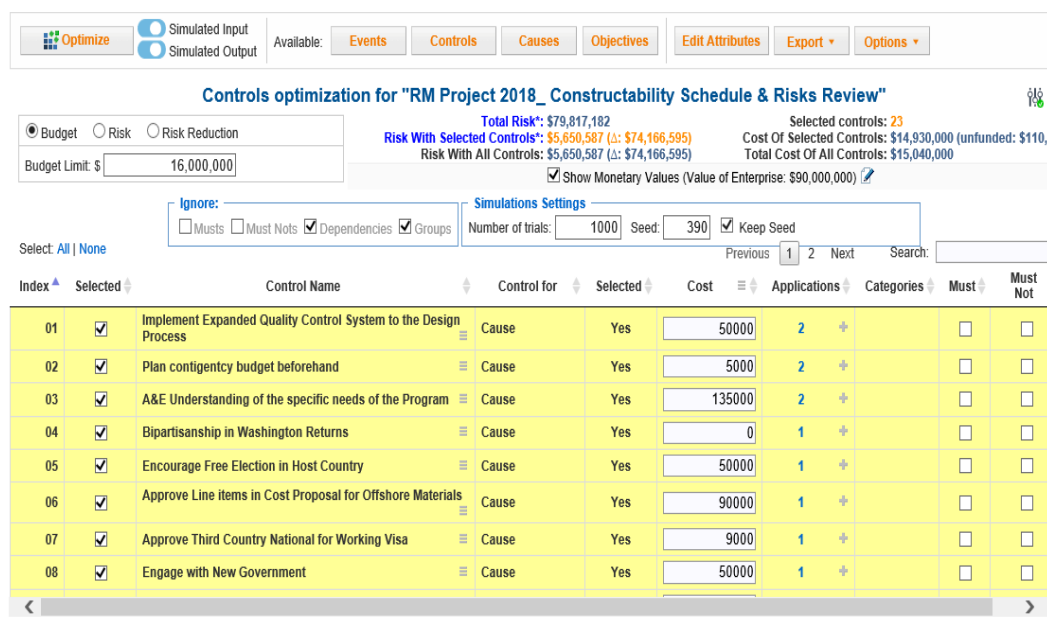


Figure 6.6-1 Budget Optimization - Simulated Result

Computed Optimization- Figure below shows the set of 23 controls selected for \$14,930,000 total investment reducing the total risk from \$178,870,501 to \$5,779,184 saving \$173,091,316

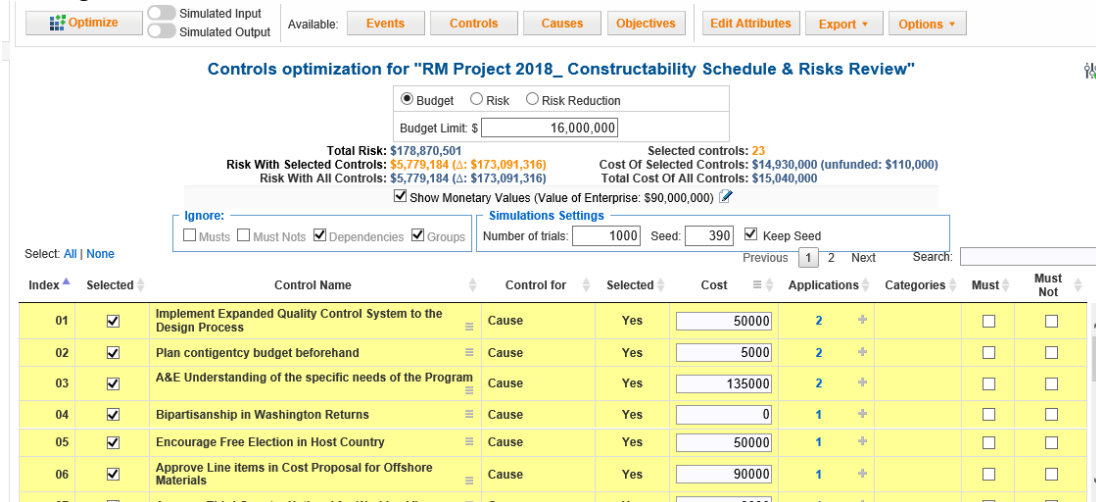


Figure 6.6-2 Budget Optimization -Computed Result

8.0 Efficient Frontier (Simulated vs. Computed)

Discuss Efficient Frontier (Recommendation of Controls for Implementation given a Budget Range) – How much it will cost and what are the remaining Risks and Impacts. The figure below shows what or which set of controls needs to be implemented if you have a certain budget. With the Efficient Frontier showing the optimized risk with graph showing the reduction of the risk to the project starting a huge drop in risk impact. **Therefore, the majority of the risk to the project is reduced within the first few controls.**

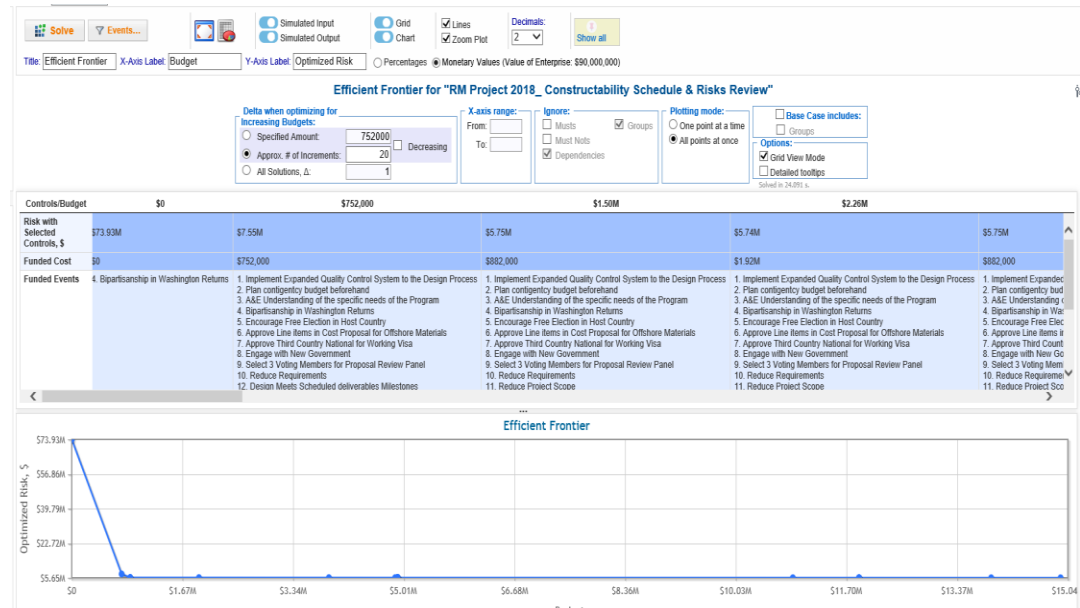


Figure 6.6-1 Efficient Frontier - Simulated Result

In fact. The figure below shows that if the client spends less than \$752,000 in risk control, the project will save more. Also in the yellow color, the selected controls can be seen given that budget.

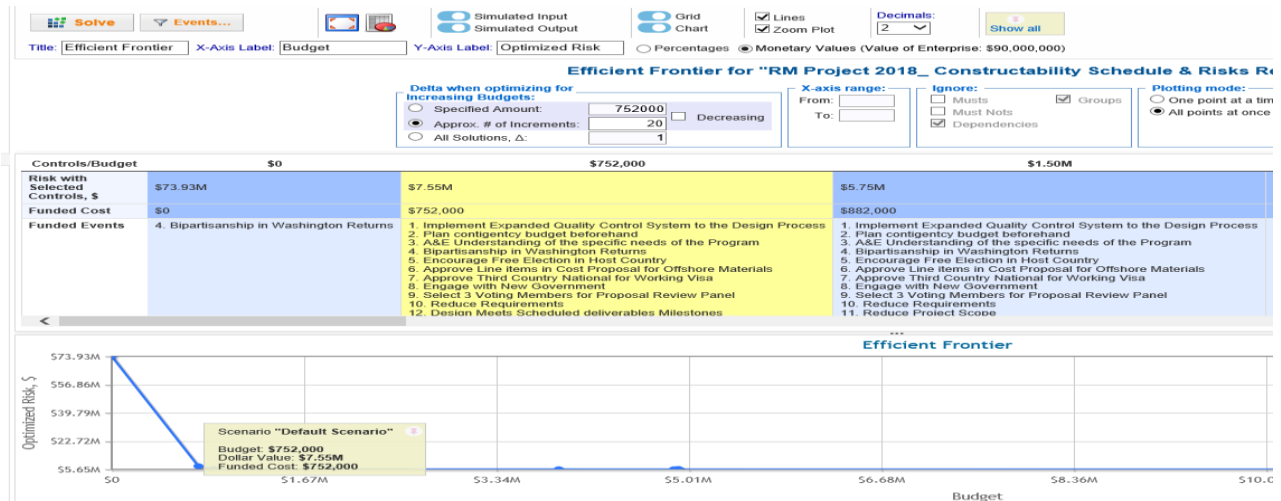


Figure 6.6-2 Efficient Frontier - Simulated Result

To decide on risk tolerance as a function of the budget, we need to present to the management the loss exceedance curve showing the value of losing more than certain controls.

For a certain budget, or risk reduction, the Efficient Frontier gives a set of controls that can be bring the expected saved value. For instance, for a budget less than \$752,000 the list of controls is highlighted in yellow in figure 6.6-2

9.0 Risk Map & Discussions

Risk as a Power of Budget (Giving Options to Clients to reduce Risks)

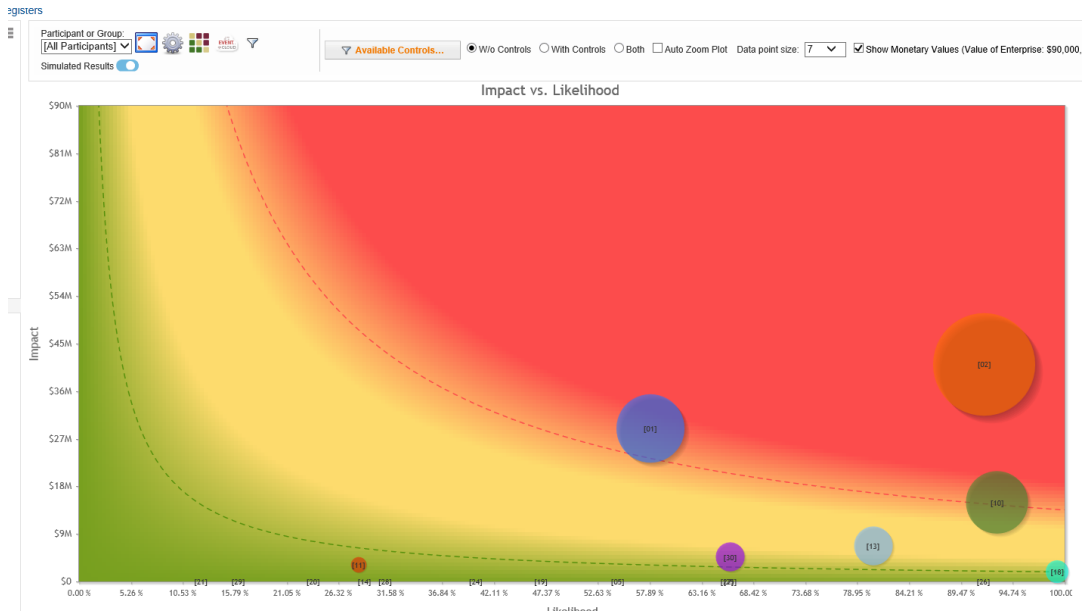
Dependencies (Controls implying that certain things cannot be done unless specific things are done)

Risk Map (W/ Controls and W/o Controls)

Without Controls:

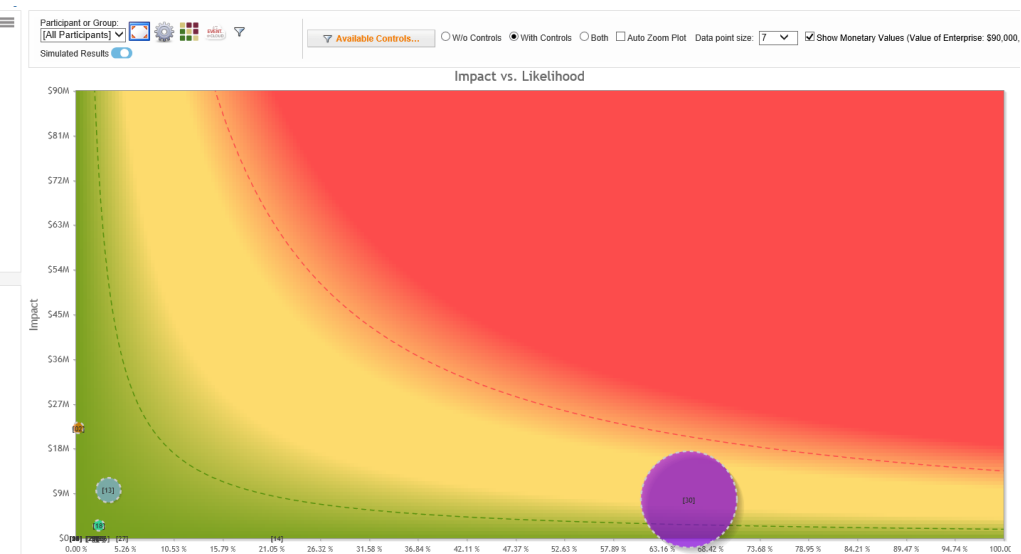
The model is showing six risks (Likelihood, Impact, and Risk) as following from the most consequential to the least one:

- **Procurement Delay** (91.90%, \$41.12M, \$37,79M)
- **Design Delay** (58%, \$28.98M, 16.8M)
- **Countless of Change Submitted by Contractor** (93.20%, \$15M, \$13.98M)
- **Architectural Façade Unachievable** (80.60%, \$6.71M, \$5.41M)
- **Design Errors** (66.1%, \$4.61M, \$3.05M)
- **Construction Delay** (99.3%, \$1.94M, \$1.98M)



With Control

It seems that most of the risks were reduced except for **Design Errors** at 66.10% Likelihood, with \$7.88 Impact, and \$5.18M risk.



10.0 Recommendations to Client

In summarizing the options to the client in terms of investment and cost saving, the following are recommended:

From the **Risk Register**, it appears that Design Errors is more likely and has the most risk with or without controls at 66.10% and 5.75% respectively. Procurement Delay is the most impactful at 24.63% with or without controls.

Risk Register
RM Project 2018_Constructability Schedule & Risks Review

ID ▲	Event Name	Likelihood	Impact	Risk	Likelihood with controls	Impact with controls	Risk with controls
1	Design Delay	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	Procurement Delay	0.30%	24.63%	0.07%	0.30%	24.63%	0.07%
3	Change in Government	2.60%	0.00%	0.00%	2.60%	0.00%	0.00%
4	Countless of Change orders submitted by contractor	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	Damages to newly built Fire systems	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	Architectural Concrete Facade unchievable	3.50%	10.85%	0.38%	3.50%	10.85%	0.38%
7	Specified Building Automation System is discontinued	21.70%	0.00%	0.00%	21.70%	0.00%	0.00%
8	Construction Delay	2.50%	2.86%	0.07%	2.50%	2.86%	0.07%
9	Resolicitation	2.40%	0.00%	0.00%	2.40%	0.00%	0.00%
10	All technical proposals are disqualified	1.80%	0.00%	0.00%	1.80%	0.00%	0.00%
11	Price proposals too Low	1.80%	0.00%	0.00%	1.80%	0.00%	0.00%
12	Proposed schemes rejected	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13	Litigations to resolve REAs	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14	New gov imposes tariff on exported materials	3.00%	0.00%	0.00%	3.00%	0.00%	0.00%
15	Constuction stoppage	5.00%	0.00%	0.00%	5.00%	0.00%	0.00%
16	Building cannot receive Accreditation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
17	More than one bidders protest	1.70%	0.00%	0.00%	1.70%	0.00%	0.00%
18	Design Errors	66.10%	8.70%	5.75%	66.10%	8.70%	5.75%

Figure 6.6-1 Risk Register

X&M would recommend to the Client that given a project of \$90M, it is very critical to invest atleast \$14,930,000 surgically in controlling certain risks like, Design Delay and Procurement Delay to reduce the likelihood, the impact, and risk. Taking the project from \$79,817,182 in risk to \$5,650,587 saving \$74,166,595 in the process.

11.0 Conclusion

X&M is grateful for the opportunity to work on this project and to review the risk and registered the mitigations that are required to reduce 95% saving close to \$80M for the project if management accepts to invest close to \$15M in the set of controls identified. X&M arrived at the results by utilizing Analysis Hierarchy Process (AHP) within Expert Choice Riskion Software to perform risk review. As a result, it was determined that by focusing on specific risks like Design Delay and Procurement Delay as well as Countless of Change Order by Submitted by Contractors, the project will save an important amount. A strategy for risk reduction can also be developed in a case of budget constraint by simply understanding what which allowable controls to implement for a maximum saving.

It is important that point out that without monitoring the progress of the implementation of the controls, the risks registered will not give cost reduction and in fact may increase in size and scope.