Developing a dynamic risk map (DRM) for pipeline construction projects in the Middle East

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Abstract

Project risk analysis must be implemented using a systematic approach where project size, data availability and project team requirements are promptly taken into account. However, complex projects are marred with numerous interconnected causes and effects, which make project dynamics rather difficult to understand and control. One approach to overcome this hardship and provide a facility to understand and visualize such dependencies is risk mapping. With emphasis on the pipeline construction sector in the Middle East, the research at hand aims first to identify the most critical risk factors in the denoted sector and then to develop a dynamic risk map (DRM) for it. N2 Diagrams were employed to construct the interdependency relationships of the DRM. The DRM can be utilized in calculating the significance of project risks via posterior probabilities. In this context, the cross impact analysis (CIA) method is proposed as an appropriate computational and reasoning tool. The CIA method is simply a technique designed to predict chances of future events by capturing the interactions among a set of variables. From the DRM it is possible to envisage not only the ultimate effect of a risk on the project but also the incremental steps leading to it. This makes it possible to evaluate the effect of potential risk factors for unlimited project scenarios.
Keywords: construction projects, risk identification, risk analysis, risk mapping, Delphi technique, N2 Diagram, dynamic map.

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1 Introduction

Risk management is a crucial process for the success of any business. The importance of risk management becomes even greater in an industry that embraces many uncertainties such as the construction industry [1]. With construction projects tending to have a higher likelihood of loss/failure in nowadays highly competitive environment, risk management is becoming more emphasized and systemized than yesteryears. Having that in effect, the difficult decisions that normally encompass a higher level of risk exposures can be improved.

Unfortunately, many pipeline construction projects in the Middle East countries fail to be completed as per the set targets. And a frequently-reported failure is substantial project delays. One of the common reasons for such failure is the existence of many external and internal risks that are inherent in all stages of a project. In real industry practice, many construction managers in these countries still make their decisions based on intuition, judgment, and experience rather than through a formal and systematic risk management process. Contractors working in pipeline construction projects in Middle East are in need of an effective tool to help them manage project risks in a prompt way.

In the late 1980s and early 1990s, there was a general call for more research using cognitive mapping techniques in organizational settings [2–4]. This call led to some edited books and special journal issues that illustrated the use of cognitive mapping techniques [5, 6] and efforts to blend qualitative and quantitative techniques [7–9]. This paper proposes a method of presenting in a visual fashion the risk factors that have a bearing on pipeline project failure and their interrelationships. This allows the different parties in a project to use the diagram to collaborate in the creation of risk models which can simulate the propagation and evolution of risks throughout the project life cycle. Further analytical capabilities of such a diagram will even improve our understanding of the magnitude of project risks on its outcomes.

2 General methodology

This research first aimed to identify the notable risk factors in pipeline construction projects in the Middle East and performed a preliminary qualitative assessment for those factors. The identified risks were then organized into groups according to relevance, for instance, subcontractor risks, political /government risks, etc. Afterwards, research developed the DRM, which is a map that consists of two layers. Layer one of the dynamic risk map, DRM, contains all potential dependency relationships between pairs of risk factors in a given risk group. Whereas layer two of the DRM contains all dependency relationships between pairs of risk factors in two different risk groups. The DRM is a truly advanced tool that can be utilized in evaluating risk significance. The cross impact analysis or CIA method was specifically selected to perform the computations and reasoning operations.

It is worth mentioning that research greatly benefited from literature and the immense data collected through questionnaire surveys that were administered to a large group of qualified experts in pipeline construction projects in the Middle East region.

3 Risk identification and qualitative assessment

The objective of risk identification is to identify, categorize and document risks that could affect the project. The outcome of risk identification is typically a categorized list of risks or a risk breakdown structure (RBS). What is done with that outcome depends on the nature of both the risks and the project. While some recommend that the risk identification process should stop short of assessing or analyzing risks so that it does not inhibit the identification of "minor" risks. In practice, however, risk identification and assessment are often completed in a single step [10].

3.1 Questionnaire preparation and data collection

In this stage the identification of risks needs to be conducted with care. The identification of the risk factors affecting pipeline construction projects was carried out in two main subsequent phases, Phase I and Phase II. Phase I was devoted to reviewing the earlier studies cited in the literature, as well as to obtaining industry feedback through unstructured interviews on the subject. Based on the literature review and experts consultation, two initial lists were created. In Phase II, the initial lists were integrated in one lengthy list where each risk was associated with one of twelve risk groups. The combined list was then incorporated into a questionnaire form for industry dissemination and expert feedback elicitation.

The questionnaire consisted of two sections. Section 1 solicited general information about questionnaire participants. Section 2 highlighted the risks common to pipeline construction projects. Potential participants were asked to indicate the likelihood of occurrence and impact on project objectives. These objectives were identified to be cost, time, quality, environment and last but not least safety. Note that the paper in hand primarily focuses on the time objective out of that group. A rating scale of very high (VH), high (H), moderate (M), low (L), and very low (VL) was used to depict likelihood. Meanwhile the level of impact on project objectives was classified according to the scale of critical (CR), very serious (VS), serious (SE), moderate (MD) and minor (MN).

The survey was performed in fourteen weeks between July and October 2011. Postal service was utilized to send the questionnaire to 60 pipeline construction project practitioners in the Middle East. All potential participants were contacted beforehand to make sure that they were willing to take part.

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3.2 Data analysis

The risk significance index developed by Shen *et al*. [11] was used to weigh all identified risks. In this regard, a significance score for each risk was calculated through eqn (1).

$$\mathbf{S_{ij} = \alpha_{ij}\ ß_{ij}} \quad (1)$$

where

S_{ij}: is the significance score for risk i, as acknowledged by questionnaire participant j

α_{ij}: is the probability of occurrence for risk i, as acknowledged by questionnaire participant j

$ß_{ij}$: is the level of contractors' potential loss (degree of impact) for risk i, as acknowledged by questionnaire participant j.

Results for S_{ij} for all participants were then grouped together to obtain a relative significance score as depicted in eqn (2); that is:

$$RSIS_i = (\Sigma\ S_{ij}\ ) / N \quad (2)$$

where

$RSIS_i$ is the relative significance index score for risk i

N is the number of respondents.

The five-point scales for α and ß need to be converted into numerical scales [11]. The matrix presented in table 1 shows the calculation of the risk significance index for various levels of likelihood and impact.

Table 1: Matrix for the calculation of the risk significance index.

α \ ß	Critical (9)	Very Serious (7)	Serious (5)	Moderate (3)	Minor (1)
Very highly likely (0.9)	8.1	6.3	4.5	2.7	0.9
Highly likely (0.7)	6.3	4.9	3.5	2.1	0.7
Moderately likely (0.5)	4.5	3.5	2.5	1.5	0.5
Lowly likely (0.3)	2.7	2.1	1.5	0.9	0.3
Very lowly likely (0.1)	0.9	0.7	0.5	0.3	0.1

3.3 Results

The main purpose of the aforementioned investigation is not to just identify a list of risks but to ascertain that the key risks that can influence the delivery of pipeline construction projects are accounted for and included in the sought DRM. In addition, this step helps in determining the initial probability and impact values for each of the identified risks, which will be used in the DRM computations. After due consideration of the ranked risks – based on the calculated $RSIS_i$ – only the top forty seven risks were considered as significant. These are the risks classified as either high- or medium-significance risks according to the matrix in Table 1. Note that the straightforward method for ranking is applied, where ranking is performed with regard to only one project objective (e.g. time).

That method safeguards against discarding risks with significant impact on a particular project objective when impacts on other objectives are taken into consideration. Even with high impact on a certain objective, risks can very possibly be neglected as the collective significance is offset by their much lower level of impact on other project objectives. For the final results of the industry survey, refer to Table 2.

Table 2: Pipeline construction risks and their significance measures.

RISK FACTOR	RSIS	INITIAL IMPACT	INITIAL PROB.	CODE
Owner Generated Risks Category:				
Inability of the owner to finance the project	2.65	7.24	0.36	G1R1
Delay in progress payments	2.97	5.67	0.51	G1R2
Inefficient decision making by the owner	2.08	5.30	0.40	G1R3
Owner's refusal or questioning of the compensations	2.49	5.24	0.48	G1R4
Changes in owner expectations	3.01	5.55	0.52	G1R5
Delay or inability of owner to give full possession	3.22	6.52	0.45	G1R6
Delay or inability of owner to proceed with final acceptance	2.46	5.48	0.43	G1R7
Owner's high expectations for quality beyond standards	1.93	4.39	0.44	G1R8
Sub-Contractor Risks Category				
Sub contractors low credibility	2.47	4.82	0.46	G2R1
Subcontractors lack of required technical skills	2.17	4.94	0.41	G2R2
Sub contractors lack of managerial skills.	2.38	5.06	0.45	G2R3
Lack of labor productivity	2.06	5.30	0.40	G2R4
Poor quality of subcontractor works.	2.66	6.21	0.42	G2R5
Design Risks Category				
Scope creep/shrinkage.	2.26	4.64	0.44	G3R1
Scope vagueness	1.98	5.36	0.37	G3R2
Drawing change.	3.36	5.67	0.63	G3R3
Actual quantities of work	2.25	3.67	0.58	G3R4
Complex design	2.85	5.48	0.48	G3R5
Delay of work shop drawing	2.85	5.12	0.52	G3R6
Incomplete design and information	3.02	5.55	0.52	G3R7
Management Risks Category				
Poor communication between all parties	2.76	5.00	0.52	G4R1
Poor qualification of consultant's supervision staff	2.43	5.30	0.42	G4R2
Delay in approval of contractor submittals	3.07	5.30	0.54	G4R3
Delay in performing testing and inspection	1.96	4.21	0.40	G4R4
Suspension of work	2.34	5.73	0.37	G4R5
Lack of experience,	2.54	5.97	0.42	G4R6
Change in key staffing throughout the project	2.02	5.00	0.37	G4R7
Construction Risks Category				
Bad Quality of work.	2.19	5.18	0.39	G5R1
Low productivity of labor.	2.60	5.18	0.48	G5R2
Surveying mistakes;	2.13	6.45	0.31	G5R3
Delay in the start of the project	2.71	5.42	0.49	G5R4
Deficient and/or insufficient safety rules	1.86	5.30	0.34	G5R5
Shortage of labor	1.89	4.70	0.37	G5R6
Site accidents	1.95	5.58	0.40	G5R7
Material Risks Category				
Material price fluctuation.	2.29	4.58	0.49	G6R1
Material shortage.	2.93	6.27	0.41	G6R2
Delays in material delivery.	4.11	6.82	0.57	G6R3
Equipment Generated Risks Category				
Maintenance cost of equipment.	1.93	3.97	0.43	G7R1
Low productivity and efficiency of equipment.	1.87	4.88	0.38	G7R2
Equipment frequently out of order or damaged.	1.89	4.94	0.35	G7R3
Political /Government Risks Category				
Corruption risks	1.98	4.94	0.38	G8R1
Failure to obtain approvals and permits	3.54	6.45	0.51	G8R2
Import/export restrictions	2.09	5.42	0.38	G8R3
Potential of delay by others.	2.84	5.24	0.49	G8R4
Economical/Financial Risks Category				
Cash shortage	2.40	6.09	0.37	G9R1
Inflation and interest rates risks	2.13	5.30	0.40	G9R2
Economic crisis	2.59	6.21	0.40	G9R3

4 Mapping the interdependency relationships between pipeline construction risks

Risks pertaining to a given project could have a concurrent effect on it. Projects are complex systems where interdependencies exist among the various project variables and such intricacies eventually drive the resulting project performance in some way or another. Without understanding those dependencies, our ability to analyze project risks will be greatly hindered.

Risk maps become handy when interdependencies are rather difficult to model. First, they help visualize the cause-effect relationships. Second, with proper computational capabilities, the risk map can be utilized to analyze and assess project risks in a more sophisticated and realistic manner. Given the set of risks common to pipeline construction projects, as outlined in the previous section, the research proceeded to develop a DRM that models the sought interdependencies. This includes all potential dependency relationships between pairs of risk factors in a given risk group and also those between pairs of risk factors in two different risk groups. This was accomplished in two subsequent stages; first via identifying the potential relationships between risk groups and second by determining the dependency relationships between risk factors within and between groups. For the risk factor dependency relationships, a strength rating is devised to imply the extent to which the driving risks have an influence on both the driven risks and the entire project performance measured in terms of time delays. Details of the DRM development process is outlined hereinafter.

4.1 Stage one: identifying interdependency relationships between risk groups

A second questionnaire survey was prepared and disseminated to highly experienced practitioners in the pipeline construction sector to help identify the possible dependencies among risk groups. Twenty five experts of that sector were chosen for the mapping process. Their professional roles ranged from Project Managers, Technical/Engineering Managers, Interface Managers, Claim Experts, to QA/QC Managers. To elicit their feedback, the nine risk groups were listed both horizontally and vertically in a tabular form. Following the introductory section of the questionnaire survey where participants are requested to fill in general information, experts were asked to tick any existing dependency relationship between the risks groups on the table in reference. Discarding the cells where the column and row headings denoted the same risk group, each respondent had a chance to indicate whether, from his/her point of view, there was a dependency relationship between each pair of risk groups into consideration.

The survey was performed over a six-week period during October and November 2011. It was envisioned from the beginning that discrepancies between answers could possibly arise. This turned to be the case after responses were collected and analyzed. The sought answer was a Boolean type, i.e., either yes or no, for each pair of interdependency relationship. Considering that the average or most likely values were not acceptable, a mechanism to reach consensus had to be adopted.

Hence, the Delphi technique was applied in multiple rounds to reach the sought-after group consensus on dependencies between the nine risk groups. In realization of the amount of effort that needs to be put by the participants, their long-term commitment was openly discussed. Out of the twenty five experts who participated in the first round, only ten agreed to cooperate in such lengthy process. The Delphi technique ran for two more rounds, besides the first one. This allowed a continuous flow of information and clarifying comments until conflicts between survey participants were fully resolved and a final result reached. Face-to-face meetings also proved necessary to perform the second and third rounds of the process as discussions based on the collective knowledge with regard to any given pair of risk groups was inevitable.

A well-organized strategy was put in place for performing the Delphi technique rounds. Starting from the first round, respondents were given a tabular form that contains the nine risk groups into consideration and the table cells showing all potential dependency combinations. With a total of nine risk groups, thirty six potential dependency relationships were pointed out. Analysis of the responses from the first round confirmed that full consensus was reached with regard to the existence of seven dependency relationships and absence of two dependency relationships for the corresponding risk groups. Meanwhile the remaining 27 dependency relationships were debatable. Only these 27 dependency relationships required further investigation in the second round of applying the Delphi technique.

A fundamental strength of the Delphi technique comes from the chance given to each participant to compare his/her own answers with the statistical results of the entire group of participating experts. This allows a participant to rethink his/her answers and decides whether to concede with the majority or insist on a different opinion he/she can clearly defend. It is the latter case where one of the participating experts can draw the attention of others to some fact or practice that could possibly have skipped their minds. In other words, one participant going initially in a different direction can be convincing the entire group so that they change their minds to coincide with his/hers. Obviously what is being circulated are the opinions while owners of such opinions are kept anonymous throughout the entire process.

In the second round of applying the Delphi technique, and as stated before, 27 dependency relationship were worth further investigation. Similar to the first round, consensus was reached on 19 more dependency relationships; this includes confirming 6 additional dependency relationships and discarding any potential relationships for 13 other combinations. This left the experts in conflict with regard to 8 dependency relationships in need to be further investigated in round three. It was only through this third round that group consensus was reached on all remaining dependencies. Five more dependency relationships out of the remaining set of 8 potential relationships were identified to be in existence. Thus in conclusion, a total of 21 dependency relationships between risk groups were identified. This paved the way for the next step of identifying the dependency relationships between the risk factors themselves. This result is also illustrated in Table 3, where the letter "R" implies an existing dependency.

Table 3: Interdependency relationships between risk groups in pipeline construction projects.

	Design Risks	Management Risks	Construction Risks	Sub-Contractor Risks	Political / Government Risks	Economical / Financial Risks	Owner Generated Risks	Material Risks	Equipment Generated Risks
Design Risks		R	R			R	R	R	
Management Risks			R	R			R		
Construction Risks				R	R	R	R	R	R
Sub-Contractor Risks						R			R
Political /Government Risks						R		R	
Economical/Financial Risks							R	R	R
Owner Generated Risks									
Material Risks									
Equipment Generated Risks									

4.2 Stage two: identifying interdependency relationships between risk factors

Risks associated with to the R-denoted cells in Table 3 have to be addressed in more detail, to understand how these risks interact with one another within the same risk group or between different groups.

Reviewing literature and comparing methods led to selecting one for performing the task at hand; that is the N2 Diagram (also referred to in the literature by N-squared Diagram and N2 Chart) (fig. 1).

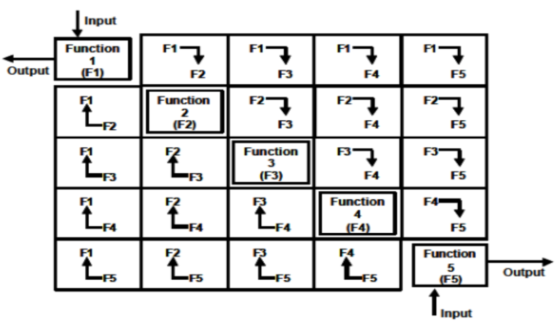

Figure 1: Generic N2 Diagram.

The N2 Diagram was originally developed in the 1970s to show and specify interfaces between the elements of a system. Such diagram is also used in systems engineering to relate system functions [12, 13]. In the context of this research, a project is a complex system having many probable elements (i.e., risk events). Mapping requires that these elements be related to each other, whenever a relationship exists. As per the N2 Diagram terminology, an arrow is used to indicate the dependency from one risk event to another. When a double-headed arrow is used, this implies a two-way dependency.

A total of 1460 potential dependency relationships between risk factors common to pipeline construction were at stake. These had to be organized in 30 N2 Diagrams (21 of those correspond to the inter-group dependencies as identified in the previous section and another 9 to examine risk dependencies within each of the nine risk groups). To better represent the potential impact in a given dependency relationship, a significance scale between "zero" and "three" was employed [14], Table 4. Keeping in mind the need for certain computational capabilities of the sought DRM, the scale used was the one consistent with the cross impact analysis, CIA. The CIA is the technique of choice for performing the computations as outlined in a subsequent section.

Table 4: CIA significance scale.

Impact	Symbol	Score
Significantly in the same direction	Sig +	3
Moderately in the same direction	Mod +	2
Slightly in the same direction	Lig +	1
No impact	0	0

To facilitate this step of the research, structured interviews were arranged with a selective group of pipeline construction experts. Due to the special experiences needed to identify the dependency relationships within a given risk group or between a pair of different risk groups, the structured interviews were performed with the utmost care. Only those experienced in a given field, i.e., QA/QC, procurement, etc., contributed to the N2 Diagram(s) relevant to their own practice/experiences. Since multiple feedbacks for each N2 Diagram were collected, this part of the research had also to be performed in rounds to reconcile outlier-like responses.

A total of 90 structured interviews were conducted using questionnaire-like forms to elicit expert feedback. For research administration purposes, participating experts were divided into nine expert groups depending on their professional background and experiences. Experts were handed the relevant N2 Diagrams. Task was to identify the dependency relationship between the different pairs of risk factors via the significance level or impact of such relationship as per Table 4. If a cell was denoted with a zero, this indicates no impact or recognizable relationship, whereas a value between 1 and 3 implies a dependency relationship of a certain magnitude.

Statistical analysis of the final results followed to determine which risk factors have dependency relationship and which do not. When a dependency relationship exists, the statistical mode of all received answers was the value adopted for the dependency relationship in question. Table 5 illustrates the outcomes of the statistical analysis.

Figure 2 further illustrates the DRM – Layer One, which contains all dependency relationships within the nine risk groups.

A color code is used, where red means sig+, blue means mod+ and finally green for lig+. Developing a similar network for Layer Two is harder to visualize

Table 5: Outcome of the N2 diagramming.

Dependency relationship	Number of potential relationships	Significance level			
		Sig +	**Mod +**	**Lig +**	**0**
Within risk groups	232	15	32	14	171
Between risk groups	1228	31	47	37	1113
ALL	1460	46	79	51	1284

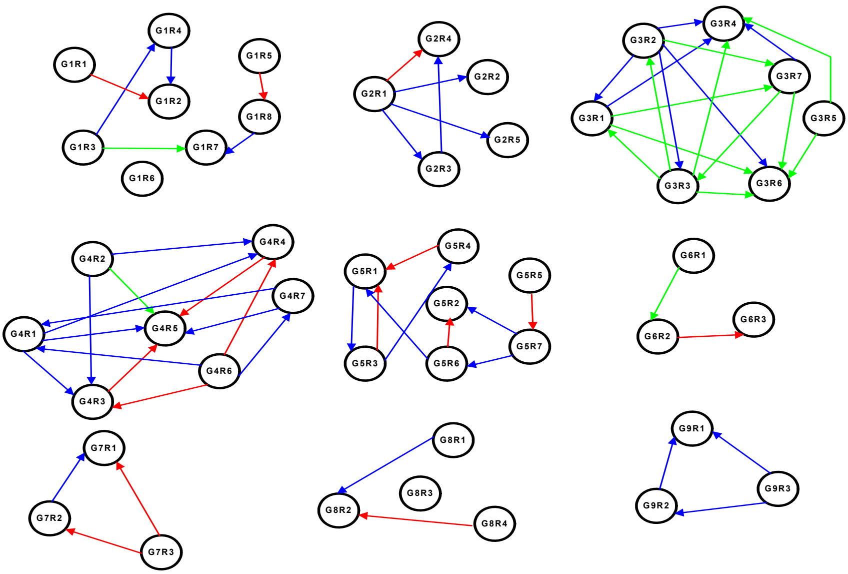

Figure 2: The Dynamic Risk Map (DRM) – Layer One.

on an A4-size page. Instead all within and between group dependency relationships were incorporated in a tabular form, a sample of which is shown in Table 6.

5 Applying the CIA technique for calculating the posterior probabilities

The cross impact analysis, CIA, is a technique specifically designed to study a system's performance and analyze how the numerous chains of impact that can occur within the system collectively affect its terminal performance (which is depicted in probabilistic terms). The pipeline construction project being the system of concern in this paper, the purpose of applying the CIA is to estimate/predict the probabilistic performance of the project outcome. To perform the CIA computations, the prior probabilities of risk factors should be used. Analysis of questionnaire survey 1 produced such values in the form of "initial" probabilities.

In CIA terminology, the computational mechanism for determining the impact of "A" on posterior probability "B" is through the quadratic relationship

Table 6: Levels of significance for sample risk dependency relationships.

Risk Factors	G1R1	G1R2	G1R3	G1R4	G1R5	G1R6	G1R7	G1R8	G2R1	G2R2	G2R3	G2R4	G2R5	G3R1	G3R2	G3R3	G3R4	....
G1R1		Sig+												Lig+				
G1R2																		
G1R3				Mod+			Lig+											
G1R4		Mod+																
G1R5								Sig+						Mod+				
G1R6																		
G1R7																		
G1R8							Mod+											
G2R1										Mod+	Mod+	Mod+	Mod+					
G2R2																		
G2R3												Mod+						
G2R4																		
G2R5																		
G3R1																	Mod+	
G3R2			Lig+											Mod+		Mod+	Mod+	
G3R3														Lig+			Lig+	
G3R4		Lig+																
G3R5			Lig+		Lig+			Lig+							Lig+		Lig+	
G3R6				Lig+														
G3R7			Sig+													Lig+	Mod+	
G4R1			Lig+	Lig+			Sig+					Mod+	Lig+					
G4R2			Mod+				Lig+	Lig+				Mod+	Sig+					
G4R3												Sig+						
G4R4		Mod+					Mod+					Sig+						
G4R5		Mod+																
G4R6												Mod+	Mod+					
G4R7																		
G5R1				Sig+	Lig+		Sig+											
G5R2							Lig+											
G5R3																		
G5R4					Mod+		Sig+											
G5R5																		
G5R6																		
G5R7												Mod+						
G6R1														Lig+				
G6R2														Sig+		Lig+		
G6R3																		
G7R1																		
G7R2												Mod+						
G7R3												Mod+	Mod+					
G8R1																		
G8R2																		
G8R3																		
G8R4																		
G9R1												Sig+	Mod+	Lig+		Mod+		
G9R2													Mod+	Sig+		Sig+		
G9R3		Sig+												Sig+		Sig+		

equation. Gordon and Hayword [15] assumed that posterior probability variable "B" if variable "A" will occur can be expressed in the following equation:

$$\text{Posterior probability} = \text{Initial prob.} * \frac{\text{CV}}{(1-\text{initial prob.}) + \text{initial prob.} * \text{CV}} \qquad (3)$$

CV = impact + 1, where impact equals 3 in case of Sig^{+}, 2 for Mod^{+}, and finally 1 for Lig^{+}.

The concept adopted here is based on revising the initial probability values for each risk factor to account for impacts from the other risk factors in association. The functionality of the CIA technique is verified and validated using actual survey data. Refer to Table 7 for a sample of the CIA's final probability values.

Table 7: Calculated cross impacts for sample dependency relationships.

Initial Probability		0.36	0.51	0.40	0.48	0.52	0.45	0.43	0.44	0.46	0.41	0.45	0.40	0.42	0.44	0.37	0.63	0.58	.....
	Risk Factors	G1 R1	G1 R2	G1 R3	G1 R4	G1 R5	G1 R6	G1 R7	G1 R8	G2 R1	G2 R2	G2 R3	G2 R4	G2 R5	G3 R1	G3 R2	G3 R3	G3 R4	.....
0.36	G1R1		0.81												0.70				
0.51	G1R2																		
0.40	G1R3				0.73			0.6											
0.48	G1R4		0.76																
0.52	G1R5								0.76						0.70				
0.45	G1R6																		
0.43	G1R7																		
0.44	G1R8							0.69											
0.46	G2R1										0.68	0.71	0.67	0.68					
0.41	G2R2																		
0.45	G2R3												0.67						
0.40	G2R4																		
0.42	G2R5																		
0.44	G3R1																	0.81	
0.37	G3R2			0.57											0.70		0.84	0.81	
0.63	G3R3														0.61			0.73	
0.58	G3R4		0.68																
0.48	G3R5			0.57		0.68			0.61							0.54		0.73	
0.52	G3R6				0.65														
0.52	G3R7			0.73													0.77	0.81	
0.52	G4R1			0.57	0.65			0.75					0.67	0.59					
0.42	G4R2			0.67				0.57	0.65				0.67	0.74					
0.54	G4R3												0.73						
0.40	G4R4		0.76					0.69					0.73						
0.37	G4R5		0.76																
0.42	G4R6												0.67	0.68					
0.37	G4R7																		
0.39	G5R1				0.79	0.81		0.75											
0.48	G5R2							0.6											
0.31	G5R3																		
0.49	G5R4					0.76		0.75											
0.34	G5R5																		
0.37	G5R6																		
0.40	G5R7												0.67						
0.49	G6R1														0.61				
0.41	G6R2														0.76		0.77		
0.57	G6R3																		
0.43	G7R1																		
0.38	G7R2												0.67						
0.35	G7R3												0.67	0.68					
0.38	G8R1																		
0.51	G8R2																		
0.38	G8R3																		
0.49	G8R4																		
0.37	G9R1												0.73	0.68	0.61		0.84		
0.40	G9R2													0.68	0.76		0.87		
0.40	G9R3		0.81												0.76		0.87		

6 Conclusion

This paper has introduced a dynamic risk map, DRM, that gives industry practitioners a means to better understand project risks/uncertainties and how they relate to each other. This mechanism further provides a handy tool to assess project risks in a more thoroughly manner and right where they can best be managed. Analytical risk mapping can simply help us stop the snow ball from accumulating.

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