A Dynamic and practical approach to Project Risk Analysis and Management

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Abstract
The paper presents a model for Project Risk Analysis and Management (PRAM) which embarks upon the problems of existing approaches and aims at rectifying these issues. The problems with the existing models are: either they are too complex to be used by all and every project manager or the approach is too simplistic to take into account the total picture and provide a quantified value of benefits of implementing PRAM. This causes PRAM to be viewed as an additional cost for a project while the benefits from PRAM could easily out pay the costs.
The base of the model is Project Risk Network (PRN) which is derived and developed from Project Activity Network (PAN). The model emphasises on assessment of the impact of each risk and suggests a procedure which is a compromise between a relatively complex approach such as system dynamics or simulation and a very simplistic method like ranking of risks which treats each risk discretely and ignores the interaction between the risk factors. The model while simple takes into account risk transferability and accounts for total impact of risks on the project. The result of the analysis is a risk profile for each risk and a Total Project Risk Profile (TPRP) for the whole project. The results of the analysis not only could be used to assess the benefits of using PRAM but also could help in developing risk management decisions and strategies and answering a number of what if questions.

Keywords: Project, Risk, Analysis, Profile, Network, Management

Introduction and Background

The risks affecting a project are highly dependent on the nature and characteristics of the project. Some projects are technology intensive, some are labour intensive, some demand huge sums of money and some are very sensitive to political and economical settings. These diversity of features and characteristics of projects has led to development of a number of PRAM approaches and models.
Project Risk Analysis and Management (PRAM) has been in use for many years. A variety of PRAM procedures have been developed to measure the impact of concealed technical, economical, political, managerial and even social risks and to adopt an appropriate risk strategy to minimise the loss due to those risks.
PRAM has now been formally integrated into project management body of knowledge (PMBOK) and APM has a specific interest group that is actively involved with the development of theoretical and practical PRAM. Simister[1] suggests that there are some evidence that interest in the use of PRAM is growing. The author believes that still there is some reluctance to use PRAM as an integral part of project management. PRAM should be implemented alongside planning and scheduling for the project, i.e. it must be dynamic and continuos and the risk management activities and plans should be updated just like project activity network (PAN). Then and only then all the benefits of PRAM would be realised.
Motivated by the rapid changes in the world today, the notion of risk has become increasingly important. The projects are carried out in environments of rapidly changing markets, technologies and regulatory restrictions, which dictate the need for PRAM.
There are many benefits in using PRAM. PRAM allows plans to be formulated more realistically by giving a better in depth understanding of impact of risks on the project, facilitating greater but more rational risk

taking strategies, thus increasing the benefits that can be gained from risk taking.
Use of PRAM builds up a database of risk information that assists in better formulation and modelling of similar future projects. Not only all the above benefits are good enough justifications for use of PRAM but also most of the time it is a client requirement and it is part of the deal and needs to be carried out. These features demand for a technique, which facilitates understanding of the risks.

Simister[1] reports that PRAM seems currently to be viewed as an additional cost for a project. Clients and the business managers must be persuaded that it is not a cost but an integral part of the project management process, which brings huge benefits and saves large sums of money by preparing the management for potential risks.
Uncertainties increase with the size of the project (physical size, financial value, manpower requirements. etc.), the complexity of project (which is affected by the number of disciplines involved.), the level of involvement of external agencies (i.e. the impact of government regulations), the degree of impact of environmental issues (e.g. weather, local lobbies), the level of impact of international trading condition and currency fluctuation, unknown levels of inflation for long term projects and complexity of financing [2].

Barnes and Wearne [3] state that understanding the nature of risks of major projects is one of the most recent developments in the science of project management. Mastering risk management is perhaps the most important skill of PMBOK for the future. The risks of cost and time overruns and of poor performance can now be shrunk to tolerable levels at operational as well as strategic levels. This will provide a tremendous incentive and benefits for inclusion of Strategic Project Risk Analysis and Management (SPRAM) as well as Operational Project Risk Analysis and Management (OPRAM) for an increased volume of project based activity in future.
The aim of project risk management is to guide the project successively from decision to completion, and to secure it from failure or time and cost overruns due to multidimensional risk factors. So with all the risks surrounding projects one can not afford not to use PRAM as we put the project at risk by not taking advantage of the following benefits:

-Risk analysis and evaluation,
-Comparison of variety of risk reactions and strategies,
-Optimising and deciding the best strategy,
-Provision of early warning,
-Ability to be flexible and responsive to change.

Development of PRAM and Existing Problems

Since the birth of project and project management hundreds of researchers and practitioners have worked on PRAM and nearly they all agree with and accept the three-stage process of risk identification, assessment and management[4,5,6] .

The survey conducted by Simister[1] indicates that most industries one way or another are using PRAM, but traditional techniques such as checklist, Monte Carlo simulation and PERT are still favoured by practitioners for carrying out PRAM at operational level.

Dickmann[7] on the other hand believes that not only risk analysis is not common in project oriented industries but also the problem with existing risk analysis procedures is that these procedures are either too complex for use by normal project personnel or too simplistic to capture the subtlety of risky situations. He argues, those that are complex enough to capture the essence and subtlety of risky situations are so complicated that they require an expert to operate them. This leads to a dilemma as practically minded project personnel are reluctant to use procedures that appear to be too simplistic to yield useful results, and managers

are equally reluctant to allocate scarce resources to the hiring of risk analysis experts. To tackle this issue the very first step is to separate operational risks from strategic risks. Most of the researchers have not separated these risks explicitly and they implicitly refer to operational risks. The external risk factors and specifically strategic risks are much more difficult to quantify and fit into any of the existing models (with the exception of system dynamics modelling which is very specialised technique). Hertz and Thomas[8] link PRAM with strategic planning and management while most of the other researchers have tackled OPRAM only. P T I Lam[9] suggests that financial risks such as interest rate fluctuation and foreign exchange rate fluctuations are accounted for by using techniques such as swap transactions, but still there are other risks called residual risks which are out of the control of project manager. Most of the so-called residual risk could be classified as external, environmental and strategic risks. These risks are not easily quantifiable and normally do not fit into the existing PRAM models.

In most technical projects (e.g. IS/IT projects or engineering projects etc.) an error/risk in design will have a ripple effect on coding/construction and implementation. If this causal effect is important somehow it should be reflected in the model. Many of the proposed models ignore the very important issue of risk transferability, the others have used either simulation or system dynamics to tackle the problem which makes the model less attractive to less PRAM literate project managers.

Another important criticism to the use of traditional methods for assessing project risks in project management is the fact that sequential/iterative nature of the management process is not taken into account, Husbey and Skogen[10].

Analysis of the results of the survey by Steve .J. Simister[1] indicates that PRAM is used in a discrete manner in specific phases of the project and not as a dynamic integral part of project management all the way through from the beginning to the end.

The PRAM methodology has evolved rapidly over the past two decades. There is a spectrum of approaches starting on one end with a purely qualitative approach such as Delphi model to the other end where one can find quantitative approaches such as simulation and system dynamics and even Neural Network and Artificial Intelligent based models.

Most of the traditional approaches to PRAM from quantitative to qualitative models and their implementation problems have been researched for years, the results of which is a trend toward use of simulation and system dynamics for PRAM most of which use influence diagrams the problems of which, namely complexity and need for expertise were discussed above.

The use of influence diagram in project risk analysis and management has been recommended by many researchers, including Diekmann[7], Huseby and Skogen[10].The advantage of using influence diagramming approach is its ease of understanding and descriptiveness. Influence diagramming approach most often has been used in soft systems approaches and qualitative risk analysis, but its value is more recognised when applied as part of quantitative methods. The problem is raised when influence diagramming is integrated with rigorous mathematical models e.g. system dynamics or simulation where the practitioners are not so willing to implement these approaches. Diekmann[7] reports that the use of conditional probabilities to propagate influences is subject to one serious weakness that depends on the topology of the influence diagram. The situation becomes very complex when there are more than two direct input into a risky domain. It has been suggested that one method of overcoming this problem of higher order conditional probability is use of fuzzy logic, which brings more complexity to the model and reduces its applicability.

Huseby and Skogen[10] report that the analysts are heading towards the use of more dynamic models. Though the researchers and practitioners have been developing models and methodologies to tackle the problem, due to the complexity and lack of practicality these approaches have remained within specific sections of the

project management industry and yet not accepted or widely used at all levels.
To summarise there are four problems with the existing PRAM models:

* Over simplicity or complexity of the models
* Lack of integration with project management process
* Lack of consideration given to the interaction of the risk factors
* Lack of a quantifiable measure to assess the benefits of PRAM

In the process of managing a project and during the project life cycle many unexpected events occur, many factors change which are out of the control of the management which have bearing upon the state of the project and the degree with which the project is exposed to risk. As such an applied in contrast to a theoretical risk management approach must look for and adopt a simple yet dynamic process model in which the state of the project could be checked and analysed every so often. Separating OPRAM from SPRAM, it should be emphasised that the need for applied approaches to SPRAM is more pronounced than OPRAM where more practical and established approaches do exist. One should bear in mind that planning is important and not the plan. This suggests that having a good PRAM system, one can always improve the quality of risk plans. Hence, projects should have one.

Total Project Risk Profile (TPRP) Model

The model is aimed at PRAM from an operational perspective focusing on risks, which are in the domain of jurisdiction of the project manager. When analysing a project for risks it is preferred to separate SPRAM from OPRAM. Then the impact of external risk factors on the project in contrast to internal and operational type of risks such as lack of availability of resources, risk of an inaccurate time or cost estimate could easily be assessed separately.

Irrespective of the focus of PRAM (operational or strategic), the Chapman[11] generic steps summarised as risk identification, risk assessment and risk management are applicable and it must be emphasised that the whole process need to be continuos and dynamic as shown below:

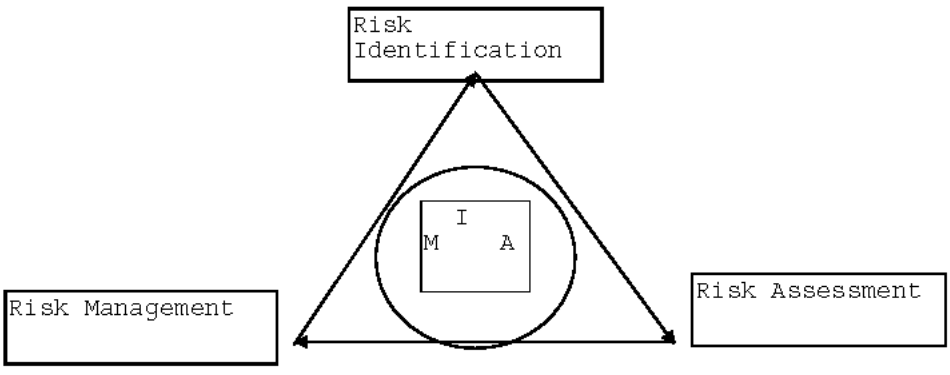


Figure 1: Generic PRAM Process

Stage 1: Risk Identification

It is needless to emphasise that risk identification is the most important stage of the PRAM as this is the process through which the input into the system is produced. The processor or the model used quantitative or qualitative, processes this data and produces an assessment of the situation for each risk and the project

as a whole. Therefore the acquisition of this fundamental information for any PRAM model is extremely important and seriously affects the quality of the output and efficiency and effectiveness of the proposed courses of action.

The spectrum of projects is so huge and diverse and the nature of projects so different that it is very difficult to find a simple way of categorising risks. Extensive research has been conducted on categorisation and classification of risks. Classes such as managerial, technical, economical, political environmental etc. is common[14,15]. Though these classifications could help in identifying risks to a project, by no means one can claim that these lists are exhaustive. The author strongly believes that the implementation of PRAM is the best way of getting access to easy identification of risks within specific type of projects handled within the organisation. One should scrutinise the project as a system and identify the likely risks and add them to the database of relevant risks for the project. It needs to be emphasised that the number of risks identified and their impact upon the project are driving forces for the design and development of a risk management strategy or risk management decision.

Though there are extensive literature on risk identification approaches, it is very difficult to recommend any specific one. R J Chapman[12] classifies these approaches into three categories:

(1)- identification conducted solely by the risk analyst
(2)- identification by the analyst interviewing project team
(3)- identification by the analyst leading a working group

Each method has its own merits and problems and it is quite difficult to recommend any one approach. To identify risks project could be looked at from two perspectives top down and bottom up. The top down approach should provide the list of risks associated with the project, as it is perceived by top-level management, mostly strategic issues. The bottom up approach should provide the list of risks associated with the project from an operational point of view.

Selection of an appropriate risk identification process is a function of project characteristics, namely size, complexity, industry, technology required etc. and also the level of PRAM whether it is SPRAM or OPRAM. As the main objective of this paper is to look at risk assessment it is assumed that one way or another the risks are identified.

In arriving at risks any preferred method of choice could be used. Examples of operational risks include bad weather condition, lack of quality in design, unavailability of resources, lack of expertise, lack of motivation between personnel.

The end product of this phase should be a list of risks, which affect the project.

Stage 2 Risk Assessment

It is done via an integration of influence diagramming and network analysis. The process starts by showing which risks affect which activity/product. Hence a decision should be taken on level of detail by which, project activity network is drawn. These are called **Direct Risks (DR)**, which directly affect the products, performance or operations of the projects. The **Indirect or Transferred Risks (TR)** are the risks, which materialise if a direct risk happens. Using the information collected on identified risks and the Project Activity Network (PAN), the Project Risk Network (PRN) is derived. Then the impact of each direct risk is estimated. The estimation of risk loss could be made very mathematical and rigorous or kept simple. However, it is believed that a simple representation of the risk loss or the risk impact is preferred as the starting point. Later on the organisation can build into their PRAM system as much rigour as necessary depending on size, complexity, cost and strategic/ operational importance of the project.

Depending on the nature of the risk, we can assume the distribution of its loss to be uniform, increasing or even decreasing over its life cycle (the life cycle of a risk is defined as the period in which the risk is active and damages the project and produces loss). For simplicity life cycle of a risk could be assumed to

be the same as duration of the activity being affected.
Next step is to determine the transferability of direct risks and estimate the risk loss due to indirect risks or so called transferred risks. As in any model the recommendation is to start with a simple transfer function and modify it as and when needed. It should be emphasised that the accuracy of this function is not a prime concern and just like any first estimate it is bound to errors and misjudgement. The PRAM system corrects itself as it is implemented over a number of similar projects.
From the information collected in risk identification phase, that is direct and indirect risks, PAN, and influence diagram, PRN (Project Risk Network) could be drawn. The PRN and risk loss distribution functions are used to produce risk profiles and the Total Project Risk Profiles (TPRP).

Stage 3 Risk Management

Using TPRP a total picture of impact of risks on the project is portrayed. It is not so difficult to analyse the impact of each risk on the project and the total potential loss, which could be caused, by each risk. Also using a number of what if analysis questions combined with cost benefit analysis one can decide on an appropriate risk management strategy and implement a risk reduction or elimination course of action if possible at all.
To summarise the steps required to implement the model are:

1-Develop and establish project activity network (PAN) at the level of detail of your choice,
2-Identify the direct risks acting upon the tasks and products,
3-Identify transfer risks or impact of direct risks which could cause other risks to emerge. Influence diagramming will be used at this stage,
4-Estimate the risk losses for direct risks and decide on a distribution function (Uniform, Normal, Triangular),
5- Analyse and decide on a risk transfer function (in its simplest form it could be just a coefficient e.g. 10% of original direct risk loss),
6-Produce a project risk network (PRN),
7-Analyse PRN for risk profiles and produce a TPRP,
8-Using TPRP and individual risk profiles make decisions on managing the risks.

TPRP an Illustrative example

Let us assume that the following theoretical project is in hand:

Activity description	duration	start	Finish	predecessor	ID
Specify Terms of Reference	1d	17/01/03	17/01/03	-	1
Study Existing System	5d	18/01/03	22/01/03	1	2
Specify User Requirements	10d	23/01/03	01/02/03	2	3
Design the System	12d	02/02/03	13/02/03	3	4
Formulate Test Procedures	2d	14/02/03	15/02/03	4	5
Develop the System	48d	14/02/03	01/04/03	4	6
Prepare Operating Manuals	4d	02/04/03	05/04/03	6	7
Design and Develop Forms	12d	14/02/03	25/02/03	4	8
Write User Manuals	14d	02/04/03	15/04/03	6,8	9
Commission the system	8d	16/04/03	23/04/03	5,7,9	10
Final Installation	4d	24/04/03	27/04/03	10	11

Step 1: produce Project Activity Network (PAN):

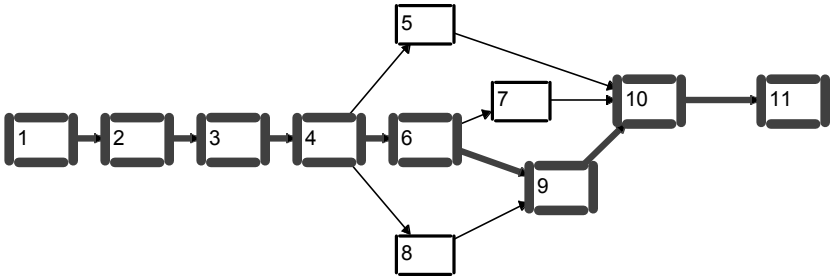


Figure 2: Project Activity Network (PAN) for the example project

Step 2 & 3: identify the risks, direct and transferred and decide on the risk life cycle that is start, duration and finish. Figure 3 shows PAN annotated with the identified risks.

Risks identified	duration	start	end	predecessors	ID
Start	0d	17/01/03	17/01/03	-	1
$DR_{1,1}$: Unclear terms of reference	1d	17/01/03	17/01/03	1	2
$DR_{1,2}$: Lack of communication with users	5d	18/01/03	22/01/03	1	3
$TR_{1,3}$: Not getting the user requirements right	10d	23/01/03	01/02/03	2,3	4
$DR_{1,4}$: Error in Design	12d	02/02/03	13/02/03	1	5
$TR_{2,4}$: Wrong design strategy	12d	02/02/03	13/02/03	3	6
$TR_{1,5}$: Incorrect test procedures	2d	14/02/03	15/02/03	5,6	7
$DR_{1,6}$: Lack of expertise and experience	48d	14/02/03	01/04/03	1	8
$TR_{2,6}$: Error in development	48d	14/02/03	01/04/03	6,8	9
$TR_{1,10}$: Delay	8d	16/04/03	23/04/03	7,9	10

Note: DR_{ij} shows direct risk i acting on activity j
TR_{ij} shows transferred risk i acting on activity j

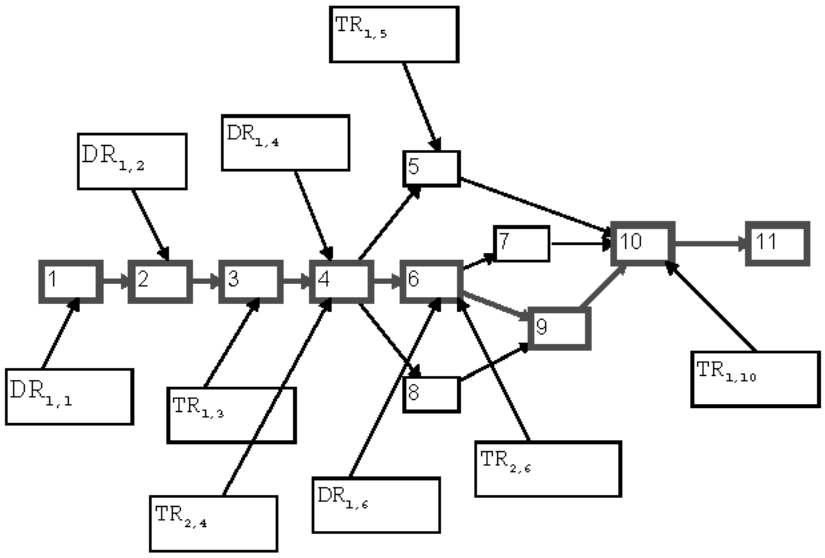


Figure 3:PAN annotated with identified risks

Step 4: estimate risk loss and decide on a distribution for each direct or transferred risk.

Project Risks	duration	Loss	Distribution	ID
Start	0d	-	-	1
$DR_{1,1}$: Unclear terms of reference	1d	-	-	2
$DR_{1,2}$: Lack of communication with users	5d	-	-	3
$TR_{1,3}$: Not getting the user requirements right	10d	20303	Uniform	4
$DR_{1,4}$: Error in Design	12d	7803	Triangular/increasing	5
$TR_{2,4}$: Wrong design strategy	12d	30303	Uniform	6
$TR_{1,5}$: Incorrect test procedures	2d	2030	Uniform	7
$DR_{1,6}$:Lack of expertise and experience	48d	20160	Uniform	8
$TR_{2,6}$:Errors in development	48d	30240	Uniform	9
$TR_{1,10}$:Delay	8d	64030	Triangular /Increasing	10

Step 6: the following project risk network (PRN) was produced using the above information:

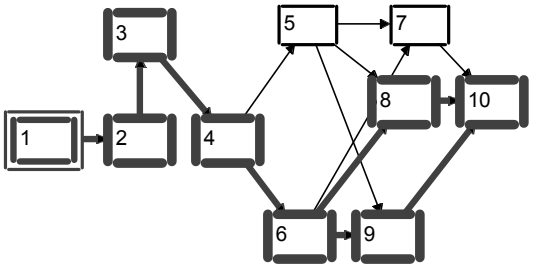


Figure 4: Risk Network Diagram for the example project

Step 7: the last or final step of risk assessment is to analyse the risk network and produce a Total Project Risk Profile. Assuming that the project schedule has been established, the earliest point in time where each risk could be expected to materialise is assumed to be coincident with the start of the activity being affected. Then using the PRN risk impact analysis could be carried out. The analysis helps to identify which risks contribute more to the TPRP. At which point in time and by how much more risks are expected to damage the project and which risks are the contributing factors. What could happen if we reduce the probability of occurrence of a risk or reduce its impact? In its simplest form, if we assign a risk loss per time unit rate for each of the risks involved in the project (implies assuming a uniform distribution for the risk loss function) using any project management software, one can produce a TPRP suing the cost report of the package. The PRN Gantt chart could help in developing TPRP. The TPRP and the cumulative TPRP based on the given information for the example project is shown in Figures 5 & 6.

Figure 5: Total Project Risk Profile TPRP

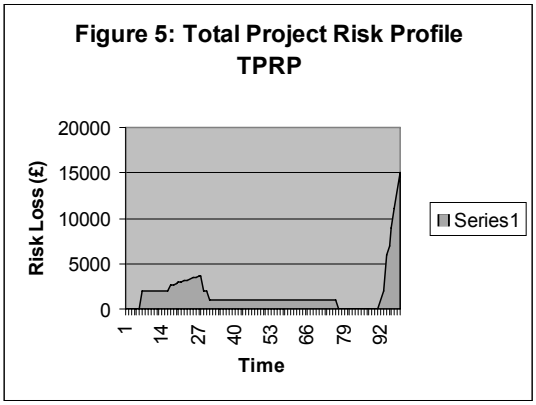
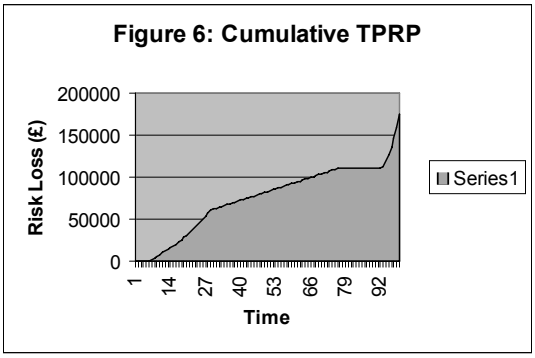


Figure 6: Cumulative TPRP



The TPRP is produced using PRN, loading the loss for each risk as per their distribution over the life cycle of the risks then adding the loss associated with all the risks running at the same time or in parallel for each time unit and over the project duration.

Conclusion

The proposed approach is based on traditional network planning method, which is familiar to any one in the field of project management. The method could be simplified if the project team do not wish to get involved in mathematical formulation of risk loss distribution. They can simply assume that the loss will be distributed over the duration of the task affected by the risk. Alternatively they can incorporate any distribution and define the risk life cycle more rigorously. In either case they input the data for the occurrence of the risk and the associated risk loss or impact into the PRN, which will then produce TPRP.

The output of the model is Total Project Risk Profile, which gives a clear picture regarding the spread of impact of risk over the project life cycle. The model though not so complex provide a better understanding of the behaviour of the system which is not so easy to understand intuitively while the impact of a risk factor on one phase is integrated with the impact transferred to other parts of the project.

The model could be used to test different strategies and observe the impact of the adopted strategy on the risk profile and reduction /elimination and transfer of risk within the project life cycle. The model could be run on any project management software, as the approach is based on network diagram and the associated loss could be entered as the cost figure for each risk factor.

It is important to note that the degree of uncertainty and the resulting risk are not wholly exogenous. They are relative to the internal ability of the firm to frame and solve complex technical and other related problems. Such an internal capability depends on the availability of adequate and relevant mental model(s) pos-

sessed by individuals and the organisation as a whole.
The PRAM process is enhanced by the understanding of the concept of PRAM. An adequate and relevant PRAM model is constructed and reconstructed repeatedly through intensive risk planning and multi-learning process. The entire learning, planning and strategy formulating process allows the enterprise to organise necessary internal and external supports, including research and development, education and training, building leadership and commitment in order to enhance the probability of success in risk management.
It may seem paradoxical that the changing environment that eventually makes projects fail is often the same as that which initiates them in the first place.

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