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(published jointly with Novática*)

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* This monograph will be also published in Spanish (full version printed; summary, abstracts, and some articles online) by Novática, journal of the Spanish CEPIS society ATI (Asociación de Técnicos de Informática) at <http://www.ati.es/novatica/>.
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Trends and Advances in Risk Management

Darren Dalcher

1 Introduction

Risks can be found in most human endeavours. They come from many sources and influence most participants. Increasingly, they play a part in defining and shaping activities, intentions and interpretations, and thereby directly influencing the future. Accomplishing anything inevitably implies addressing risks. Within organisations and society at large, learning to deal with risk is therefore progressively viewed as a key competence expected at all levels.

Practitioners in computing and information technology are at the forefront of many new developments. Modern society is characterised by powerful technology, instantaneous communication, rising complexity, tangled networks and unprecedented levels of interaction and participation. Devising new ways of integrating with modern society inevitably imply learning to co-exist with higher levels of risk, uncertainty and ignorance. Moreover, society engages in more demanding ventures whilst continuously requiring performance and delivery levels that are better, faster and cheaper. Developers, managers, sponsors, senior executives and stakeholders are thus faced with escalating levels of risk.

In order to accommodate and address risk we have built a variety of mechanisms, approaches and structures that we utilise in different levels and situations. This special issue brings together a collection of reflections, insights and experiences from leading experts working at the forefront of risk assessment, analysis, evaluation, management and communication. The contributions come from a variety of domains addressing a myriad of tools, perspectives and new approaches required for making sense of risk at different levels within organisations. Many of the papers report on new ideas and advances thereby offering novel perspectives and approaches for improving the management of risk. The papers are grounded in both research and practice and therefore deliver insights that summarise the state of the discipline whilst indicating avenues for improvement and placing new trends in the context of risk management and leadership in an organisational setting.

2 Structure and Contents of the Monograph

The thirteen papers selected for the issue showcase four perspectives in terms of the trends identified within the risk management domain. The first three papers report on new tools and approaches that can be used to identify complex dependencies, support decision making and develop improved capability for uncertainty modelling. The following four papers look at new ways of interacting with risk management and the development of new perspectives and lenses for addressing uncertainty and the emergence of risk leadership, thereby encouraging a new understanding of the concept of risk. The next two papers report on results from empirical studies related to differences in the perception of decisions between managers of projects and programmes and on the difference that risk management can make in avoiding IT project failures. The final four papers look at the development of decision making and risk manag-
The paper by Fenton and Neil encourages practitioners to look beyond simple causal explanations available through identification of correlation or the somewhat ‘accidental’ figures developed through registers. In order to obtain a true measure of risk, practitioners must therefore develop a more holistic perspective that embraces a causal view of dependencies and interconnectedness of events. Bayes networks have long been used to depict relationships and conditional dependencies. The authors show how risks can be modelled as event chains with a number of possible outcomes, enabling the integration of risks from multiple perspectives and the decomposition of a risk problem into chains of interrelated events. As a result, control and mitigation measures may become more obvious through the process of modelling risks and the identification of relationships and dependencies that extend beyond simple causal explanations.

Project planning is initiated during the earlier part of a project, when uncertainty is at its greatest. The resulting schedules often fail to capture the full detail of reality. Moreover, they fail to account for change. The paper by Trumper and Virine proposes Event Chain methodology as an approach for modelling uncertainty and evaluating the impacts of events on project schedules. Event chain methodology is informed by ideas from other disciplines and has been used as a network analysis technique in project management. Tools such as event chain diagrams visualise the complex relationships and interdependencies between events. The collection of tools and diagrams support the planning, scheduling and monitoring of projects allowing management to visualise some of the issues and take corrective action. The Event Chain methodology takes into account factors such as delays, chains and complex dynamics that are not acknowledged by other scheduling methods. They attempt to overcome human and knowledge limitations and enable updating of schedules in light of new information that emerges throughout the development process.

Complex relationships and interdependencies between causes and effects require more complex method of modelling the impacts and influences between factors. Moreover, the dynamics emerging from the uncertain knowledge necessitate a deeper understanding of causal interactions. The paper by Rodrigues highlights the use of systems dynamics to capture some of the closed chains of feedback operating with uncertain environments. Feedback loops and impact diagrams can show the effects of positive feedback cycles that can be used to “snowball” alongside other non-linear effects. Dynamic modelling provides an effective tool for identifying emergent risks resulting from complex interactions, interconnected chains of causes and events and chains of feedback. They encourage the adoption of holistic solutions by investigating the full conditions that play a part in a certain interaction, identifying the full chain of events leading to a risk. Moreover, as the model includes multiple variables, it becomes possible to assess the range of impacts on all aspects and objectives and determine the interactions of risks, events and causes in order to derive a better understanding of the true complexity and the behaviour of the risks.

Developing the right strategy for addressing risk depends on the context. Different approaches will appeal depending on the specific circumstances and the knowledge, and uncertainty associated with a situation. Dulcher contends that risk is often associated with danger, and makes use of the idea of safety to identify different positions on a spectrum with regards to our approach to risk. At one extreme, anticipation relies on developing full knowledge of the circumstances in advance. Addressing risks can proceed in a reasonably systematic manner through quantification and adjustments. The other alternative is to develop sufficient flexibility to enable the system to adopt a resilient stance that allows it to be ready to respond to uncertainties, as they emerge, in a more dynamic fashion. This is done by searching for the next acceptable state and allowing the system to evolve and grow through experimentation. While the ideal position is somewhere between the two extremes, organisations can try to balance the different perspectives in a more dynamic fashion. The adoption of alternative metaphors may also help to think about risk management in new ways. We often acknowledge that risk is all about perspective. If managers focus on safety as a resource, they can develop an alternative representation of the impacts of risk. The dynamic management of safety, or well being can thus benefit from a change of perspective that allows managers to engage with opportunities, success and the future in new ways.

Managing risk is closely integrated with project management. However, despite the awareness of risk and the recognition of the role of risk management in successfully delivering projects there is still evidence that risk is not being viewed as an integrated perspective that extends beyond processes. Indeed, the management of risk is not a precise and well-defined science: It is an art that relies on
This special edition brings together a collection of reflections, insights and experiences from leading experts working at the forefront of risk issues.

Risk management is often proposed as a solution to the high failure rate in IT projects. However, the literature is at best inconclusive about the contributions of risk management to project success. The paper by de Bakker reports on a detailed literature review which only identified anecdotal evidence to this effect. A further analysis confirms that risk management needs to be considered in social terms given the interactive nature of the process and the limited knowledge that exists about the project and the desired outcomes.

In the following stage, a collection of case studies identified the activity of risk identification as a crucial step contributing to success, as viewed by all involved stakeholders. It would appear that the action, understanding and reflection generated during that phase make recognisable contributions as identified by the relevant stakeholders. Risk reporting is likewise credited with generating an impact. An experiment with 53 project groups suggests that those that carried out a risk identification and discussed the results performed significantly better than those who did not. These groups also seemed to be more positive about their project and the result. The research suggests that it is the exchange and interaction that make people more aware of the issues. It also helps in forming the expectations of the different stakeholders groups. The discussion also has inevitable side effects, such as changing people’s views about probabilities and values.

Many of the papers report on new ideas and advances thereby offering novel perspectives and approaches for improving the management of risk.
crucial in forming a better understanding of the issues and their scale and magnitude. The long held assumption of utilising linear sequences in order to address problems, guide projects and make decisions have contributed to the perception of project and risk management as engineering or technical domains. Some of the softer aspects related to the human side of interaction have been neglected over the years. Deguire points out that to accommodate complexity the softer aspects of human interaction need to be taken into account. Indeed, problem solving requires reflection, interaction and deliberation. Given that problems and decisions are addressed at the project management and in some organisations, also at programme management level, and that their approaches to solving problems require deliberations and reflection at a different level of granularity, it is interesting to contrast the perceptions and expectations of managers in these domains. In contrast with project managers, programme managers appear to favour inductive processes. The difference might relate to the need to deliver outcomes and benefits, rather than outputs and products. As the level of complexity rises, decisions become more context-related and less mechanistic. Decisions made by programme manager may relate to making choices about specific projects and determining wider direction and thus compel managers to engage with the problem and its context. Indeed, the need to define more of the assumptions in a wider context, forces deeper and wider consideration, involving people, preferences, context and organisational issues.

Early choices need to be made about selecting the right projects, committing resources and maintaining portfolios and programmes which are balanced. These decisions are taken at an early stage under conditions of uncertainty and can be viewed as strategic project decisions. The project appraisal process and the decision making behaviour that accompanies it clearly influence the resulting project. The paper by Harris explores the strategic level risks encountered by managers in different types of projects. This is achieved by developing a project typology identifying eight major types of strategic level projects and their typical characteristics. It provides a rare link between strategic level appraisal and risk management by focusing on the common risks shared by each type. The strategic investment appraisal process proposed in the work further supports the implementation of effective decision making ranging from idea generation and opportunity identification through preliminary assumptions to the findings of the post audit review. Overall, managers can be guided towards implementing a strategy that is better suited to the context of their project thereby enabling the development of a more flexible and adaptable response. Identification of risks at an early stage enables better decision making when uncertainty is at its height.

The choice of the most suitable project is often subject to constraints regarding financial, technical, environmental or geographical constrains. Choices often have to be made at the project portfolio level to select the most viable, or useful approach. Alternatively, even when a project has been agreed in principle, there is still a need to determine the most suitable method for delivering the benefits. The paper by Fernández-Diego and Munier offers the use of linear programming method to support the choice of a particular approach and quantify the risks relevant for each of the options. The approach allows decision maker to maximise on the basis of particular threats (or benefits) and balance various factors. The use of linear programming in project management for quantifying values and measuring constraints is relatively new.

Large corporate failures in the last decade have raised awareness of the need for organisational governance functions to oversee the effectiveness and integrity of decision making in organisations. Governance spans the entire scope of corporate activity extending from strategic aspects and their ethical implications to the execution of projects and tasks. It provides the mechanisms, frameworks and reference points for self-regulation. Project governance is rapidly becoming a major area of interest for many organisations and is the topic of the paper by Müller. Governance sets of boundaries for project management action by defining the objectives, providing the means to achieve them and evaluating and controlling progress. The orientation of the organisation in terms of being share holder and stakeholder oriented, and the control focus on outcome or behaviour would play a key part in identifying the most suitable governance paradigm which can range between conformist, and agile pragmatist to versatile artist. The paradigm in turn can shape the approach of the organisation to development, the processes applied and the overall orientation and structure. The governance of project management plays a part in directing the governance paradigm, which guides the governance of portfolios, programmes and projects. This helps to reduce the risk of conflicts and inconsistencies and support the achievement of organisational goals.

Focusing only on operational risks related to a specific implementation project is insufficient. Risk relates to and impact organisational concerns concerned with the survival, development and growth of an organisation. Specific projects will incur individual risks. They will also contribute to the organisation’s risk and may impact other areas and efforts. The paper by Jonas introduces Enterprise Risk
Management as a wider framework sued by the entire business to assess the overall exposure to risk, and the organisational ability to make timely and well informed decisions. The paper looks at the five steps required to implement a simple and effective enterprise Risk Management framework. The approach encourages horizontal integration of organisational risk allowing different units to become aware of the potential impacts of initiatives in other areas on their own future, targets, and systems. The normal expectation is for vertical integration where guidance and instructions are passed downwards and information is cascaded upwards. However the cross functional perspective allows integration and sharing across different functional units. Vertical management chains can be used to support leadership and provide the basis for improved decision making through enterprise-wide reporting. The required culture change is from risk management to managing risk. Facilitating the shift requires people to look ahead and make risk-focused decisions that will benefit their organisations. It also requires the support and reward mechanisms to recognise and support such a shift.

There are some common themes that run through the papers in this monograph. Most modern undertakings involve people: Processes cannot ignore the human element and focus on computational steps alone and therefore a greater attention to subjective perceptions, stakeholders and expectation pervades many of the articles. The context of risk is also crucial. Most authors refer to complex dynamics and interactions. It would appear that our projects are becoming increasingly more complex and the risks we grapple with increasingly involve technical, social and environmental impacts. The unprecedented level of uncertainty seems to feature in many of the contributions. The direction advocated in many of the papers requires a growing recognition of the dynamics involved in interactions, of the need to lead and guide, of holistic and systemic aspect of solving problems, of the need to adapt and respond and of a need to adopt a more strategic, enterprise-wide view of situations.

3 Looking ahead
Risk management appears to be an active area for researchers and practitioners. It is encouraging to see such a range of view and perspectives and to hear about the advances being proposed. New work in the areas of decision making, uncertainty, complexity, problem solving, enterprise risk management and governance will continue to revitalise risk management knowledge, skills and competences. Risk management has progressed in the last 25 years, but it appears that the new challenges and the focus on organisations, enterprises, and wider systems will add new ideas and insights. In this issue leading researchers and practitioners have surveyed the development of ideas, perspectives and concepts within risk management opened a glimpse and given us a glimpse of the potential solutions. The journey from risk management towards the wider management of risk, opportunity and uncertainty feels exciting and worthwhile. While there is still a long way to go, the journey seems to be both promising, and exciting.

Acknowledgements
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Useful References on "Risk Management"

In addition to the materials referenced by the authors in their articles, we offer the following ones for those who wish to dig deeper into the topics covered by the monograph.

Books
Risk Management


Articles and Papers

Web Sites
The most sophisticated commonly used methods of risk assessment (used especially in the financial sector) involve building statistical models from historical data. Yet such approaches are inadequate when risks are rare or novel because there is insufficient relevant data. Less sophisticated commonly used methods of risk assessment, such as risk registers, make better use of expert judgement but fail to provide adequate quantification of risk. Neither the data-driven nor the risk register approaches are able to model dependencies between different risk factors. Causal probabilistic models (called Bayesian networks) that are based on Bayesian inference provide a potential solution to all of these problems. Such models can capture the complex interdependencies between risk factors and can effectively combine data with expert judgement. The resulting models provide rigorous risk quantification as well as genuine decision support for risk management.

Keywords: Bayes, Bayesian Networks, Causal Models, Risk.

1 Introduction
The 2008-10 credit crisis brought misery to millions around the world, but it at least raised awareness of the need for improved methods of risk assessment. The armies of analysts and statisticians employed by banks and government agencies had failed to predict either the event or its scale until far too late. Yet the methods that could have worked – and which are the subject of this paper – were largely ignored. Moreover, the same methods have the potential to transform risk analysis and decision making in all walks of life. For example:

- Medical: Imagine you are responsible for diagnosing a condition and for prescribing one of a number of possible treatments. You have some background information about the patient (some of which is objective like age and number of previous operations, but some is subjective, like ‘overweight’ and ‘prone to stress’); you also have some prior information about the prevalence of different possible conditions (for example, bronchitis may be ten times more likely than cancer). You run some diagnostic tests about which you have some information of the accuracy (such as the chances of false negative and false positive outcomes). You also have various bits of information about the success rates of the different possible treatments and their side effects. On the basis of all this information how do you arrive at a decision of which treatment pathway to take? And how would you justify that decision if something went wrong?

- Legal: Anybody involved in a legal case (before or

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The 2008-10 credit crisis brought misery to millions around the world, but it at least raised awareness of the need for improved methods of risk assessment
during a trial) will see many pieces of evidence. Some of the evidence favours the prosecution hypothesis of guilty and some of the evidence favours the defence hypothesis of innocence. Some of the evidence is statistical (such as the match probability of a DNA sample) and some is purely subjective, such as a character witness statement. It is your duty to combine the value of all of this evidence either to determine if the case should proceed to trial or to arrive at a probability (‘beyond reasonable doubt’) of innocence. How would you arrive at a decision?

- **Safety:** A transport service (such as a rail network or an air traffic control centre) is continually striving to improve safety, but must nevertheless ensure that any proposed improvements are cost effective and do not degrade efficiency. There are a range of alternative competing proposals for safety improvement, which depend on many different aspects of the current infrastructure (for example, in the case of an air traffic control centre alternatives may include new radar, new collision avoidance detection devices, or improved air traffic management staff training). How do you determine the ‘best’ alternative taking into account not just cost but also impact on safety and efficiency of the overall system? How would you justify any such decision to a team of government auditors?

- **Financial:** A bank needs sufficient liquid capital readily available in the event of exceptionally poor performance, either from credit or market risk events, or from catastrophic operational failures of the type that brought down Barings in 1995 and almost brought down Société Générale in 2007. It therefore has to calculate and justify a capital allocation that properly reflects its ‘value at risk’. Ideally this calculation needs to take account of a multitude of current financial indicators, but given the scarcity of previous catastrophic failures, it is also necessary to consider a range of subjective factors such as the quality of controls in place within the bank. How can all of this information be combined to determine the real value at risk in a way that is acceptable to the regulatory authorities and shareholders?

2 **Bayes Theorem and Bayesian Networks**

At their heart, all of the problems identified in Section 1 incorporate the basic causal structure shown in Figure 1. There is some unknown hypothesis \( H \) about which we wish to assess the uncertainty and make some decision. Does the patient have the particular disease? Is the defendant guilty of the crime? Will the system fail within a given period of time? Is a capital allocation of 5% going to be sufficient to cover operational losses in the next financial year?

Consciously or unconsciously we start with some (unconditional) prior belief about \( H \) (for example, ‘there is a 1 in a 1000 chance this person has the disease’). Then we update our prior belief about \( H \) once we observe evidence

“‘Gut-feel’ decision based on doing all the reasoning ‘in your head’ or on the back of an envelope is fundamentally inadequate and increasingly unacceptable”
Bayesian probability is a rigorous method of quantifying uncertainty that enables us to combine data with expert judgement.

\[ P(H | E) = \frac{P(E | H)P(H)}{P(E | H)P(H) + P(E | \neg H)P(\neg H)} \]

Example 1: Assume one in a thousand people has a particular disease \( H \). Then:
\[ P(H) = 0.001, \text{ so } P(\neg H) = 0.999 \]

Also assume a test to detect the disease has 100% sensitivity (i.e. no false negatives) and 95% specificity (meaning 5% false positives). Then if \( E \) represents the Boolean variable "Test positive for the disease", we have:
\[ P(E | \neg H) = 0.05 \]
\[ P(E | H) = 1 \]

Now suppose a randomly selected person tests positive. What is the probability that the person actually has the disease? By Bayes Theorem this is:
\[ P(H | E) = \frac{P(E | H)P(H)}{P(E | H)P(H) + P(E | \neg H)P(\neg H)} \]
\[ = \frac{1 \times 0.001}{1 \times 0.001 + 0.05 \times 0.999} = 0.01963 \]

So there is a less than 2% chance that a person testing positive actually has the disease.

Bayes theorem has been used for many years in numerous applications ranging from insurance premium calculations [1], through to web-based personalisation (such as with Google and Amazon). Many of the applications pre-date modern computers (see, e.g. [2] for an account of the crucial role of Bayes theorem in code breaking during World War 2).

However, while Bayes theorem is the only rational way of revising beliefs in the light of observing new evidence, it is not easily understood by people without a statistical/mathematical background. Moreover, the results of Bayesian calculations can appear, at first sight, as counter-intuitive.

Indeed, in a classic study [3] when Harvard Medical School staff and students were asked to calculate the probability of the patient having the disease (using the exact assumptions stated in Example 1) most gave the wildly incorrect answer of 95% instead of the correct answer of less than 2%. The potential implications of such incorrect ‘probabilistic risk assessment’ are frightening. In many cases, lay people only accept Bayes theorem as being ‘correct’ and are able to reason correctly, when the information is presented in alternative graphical ways, such as using event trees and frequencies (see [4] and [5] for a comprehensive investigation of these issues). But these alternative presentation techniques do not scale up to more complex problems.

If Bayes theorem is difficult for lay people to compute and understand in the case of a single hypothesis and piece of evidence (as in Figure 1), the difficulties are obviously compounded when there are multiple related hypotheses and evidence as in the example of Figure 2.

As in Figure 1 the nodes in Figure 2 represent variables (which may be known or unknown) and the arcs represent causal (or influential) relationships. Once we have relevant prior and conditional probabilities associated with each variable (such as the examples shown in Figure 3) the model is called a Bayesian network (BN).

The BN in Figure 2 is intended to model the problem of diagnosing diseases (TB, Cancer, Bronchitis) in patients attending a chest clinic. Patients may have symptoms (like dyspnoea – shortness of breath) and can be sent for diagnostic tests (X-ray); there may be also underlying causal relationships.

![Figure 2: Bayesian Network for Diagnosing Disease.](image)
factors that influence certain diseases more than others (such as smoking, visit to Asia).

To use Bayesian inference properly in this type of network necessarily involves multiple applications of Bayes Theorem in which evidence is ‘propagated’ throughout. This process is complex and quickly becomes infeasible when there are many nodes and/or nodes with multiple states. This complexity is the reason why, despite its known benefits, there was for many years little appetite to use Bayesian inference to solve real-world decision and risk problems. Fortunately, due to breakthroughs in the late 1980s that produced efficient calculations algorithms 13 [2][6], there are now widely available tools such as [7] that enable anybody to do the Bayesian calculations without ever having to understand, or even look at, a mathematical formula. These developments were the catalyst for an explosion of interest in BNs. Using such a tool we can do the kind of powerful reasoning shown in Figure 4.

Specifically:

- With the prior assumptions alone (Figure 4a) Bayes
The results of Bayesian calculations can appear, at first sight, as counter-intuitive. The theorem computes what are called the prior marginal probabilities for the different disease nodes (note that we did not ‘specify’ these probabilities – they are computed automatically; what we specified were the conditional probabilities of these diseases given the various states of their parent nodes). So, before any evidence is entered the most likely disease is bronchitis (45%).

- When we enter evidence about a particular patient the probabilities for all of the unknown variables get updated by the Bayesian inference. So, (in Figure 4b) once we enter the evidence that the patient has dyspnoea and is a non-smoker, our belief in bronchitis being the most likely disease increases (75%).

- If a subsequent X-ray test is positive (Figure 4b) our belief in both TB (26%) and cancer (25%) are raised but bronchitis is still the most likely (57%).

- However, if we now discover that the patient visited Asia (Figure 4d) we overturn our belief in bronchitis in favour of TB (63%).

Note that we can enter any number of observations anywhere in the BN and update the marginal probabilities of all the unobserved variables. As the above example demonstrates, this can yield some exceptionally powerful analyses that are simply not possible using other types of reasoning and classical statistical analysis methods.

In particular, BNs offer the following benefits:
- Explicitly model causal factors:
- Reason from effect to cause and vice versa
- Overturn previous beliefs in the light of new evidence (also called ‘explaining away’)
- Make predictions with incomplete data
- Combine diverse types of evidence including both subjective beliefs and objective data.

- Arrive at decisions based on visible auditable reasoning (Unlike black-box modelling techniques there are no "hidden" variables and the inference mechanism is based on a long-established theorem).

With the advent of the BN algorithms and associated tools, it is therefore no surprise that BNs have been used in a range of applications that were not previously possible with Bayes Theorem alone. A comprehensive (and easily accessible) overview of BN applications, with special emphasis on their use in risk assessment, can be found in [8].

It is important to recognise that the core intellectual overhead in using the BN approach is in defining the model structure and the NPTs – the actual Bayesian calculations can and must always be carried out using a tool. However, while these tools enable large-scale BNs to be executed efficiently, most provide little or no support for users to actually build large-scale BNs, nor to interact with them easily. Beyond a graphical interface for building the structure, BN-builders are left to struggle with the following kinds of practical problems that combine to create a barrier to the more widespread use of BNs:
- Eliciting and completing the probabilities in very large NPTs manually (e.g. for a node with 5 states having three parents each with 5 states, the NPT requires 625 entries);
- Dealing with very large graphs that contain similar, but slightly different "patterns" of structure;
- Handling continuous, as well as discrete variables.

Fortunately, recent algorithm and tool developments (also described in [8]) have gone a long way to addressing these problems and may lead to a ‘second wave’ of widespread BN applications. But before BNs are used more widely in critical risk assessment and decision making, there needs to be a fundamental cultural shift away from the current standard approaches to risk assessment, which we address next.

3 From Statistical Models and Risk Registers to Causal Models
3.1 Prediction based on Correlation is not Risk Assessment

Standard statistical approaches to risk assessment seek...
to establish hypotheses from relationships discovered in data. Suppose we are interested, for example, in the risk of fatal automobile crashes. Table 1 gives the number of crashes resulting in fatalities in the USA in 2008 broken down by month (source: US National Highways Traffic Safety Administration). It also gives the average monthly temperature.

We plot the fatalities and temperature data in a scatterplot graph as shown in Figure 5.

There seems to be a clear relationship between temperature and fatalities – fatalities increase as the temperature increases. Indeed, using the standard statistical tools of correlation and $p$-values, statisticians would accept the hypothesis of a relationship as ‘highly significant’ (the correlation

Figure 5: Scatterplot of Temperature against Road Fatalities (each Dot represents a Month).

Figure 6: Causal Model for Fatal Crashes.
However, in addition to serious concerns about the use of p-values generally (as described comprehensively in [6]), there is an inevitable temptation arising from such results to infer causal links such as, in this case, higher temperatures cause more fatalities. Even though any introductory statistics course teaches that correlation is not causation, the regression equation is typically used for prediction (e.g. in this case the equation relating \( N \) to \( T \) is used to predict that at 80F we might expect to see 415 fatal crashes per month).

But there is a grave danger of confusing prediction with risk assessment. For risk assessment and management the regression model is useless, because it provides no explanatory power at all. In fact, from a risk perspective this model would provide irrational, and potentially dangerous, information: it would suggest that if you want to minimise your chances of dying in an automobile crash you should do your driving when the highways are at their most dangerous, in winter.

One obvious improvement to the model, if the data is available, is to factor in the number of miles travelled (i.e. journeys made). But there are other underlying causal and influential factors that might do much to explain the apparently strange statistical observations and provide better insights into risk. With some common sense and careful reflection we can recognise the following:

- Temperature influences the highway conditions (which will be worse as temperature decreases).
- Temperature also influences the number of journeys made; people generally make more journeys in spring and summer and will generally drive less when weather conditions are bad.
- When the highway conditions are bad people tend to reduce their speed and drive more slowly. So highway conditions influence speed.
- The actual number of crashes is influenced not just by the number of journeys, but also the speed. If relatively few people are driving, and taking more care, we might expect fewer fatal crashes than we would otherwise experience.

The influence of these factors is shown in Figure 6:

The crucial message here is that the model no longer involves a simple single causal explanation; instead it combines the statistical information available in a database (the ‘objective’ factors) with other causal ‘subjective’ factors derived from careful reflection. These factors now interact in a non-linear way that helps us to arrive at an explanation for the observed results. Behaviour, such as our natural caution to drive slower when faced with poor road conditions, leads to lower accident rates (people are known to adapt to the perception of risk by tuning the risk to tolerable levels. - this is formally referred to as risk homeostasis). Conversely, if we insist on driving fast in poor road conditions then, irrespective of the temperature, the risk of an accident increases and so the model is able to capture our intuitive beliefs that were contradicted by the counterintuitive results from the simple regression model.

The role played in the causal model by driving speed reflects human behaviour. The fact that the data on the average speed of automobile drivers was not available in a database explains why this variable, despite its apparent obviousness, did not appear in the statistical regression model. The situation whereby a statistical model is based only on available data, rather than on reality, is called "conditioning on the data". This enhances convenience but at the cost of accuracy.

By accepting the statistical model we are asked to defy our senses and experience and actively ignore the role unobserved factors play. In fact, we cannot even explain the results without recourse to factors that do not appear in the database. This is a key point: with causal models we seek to dig deeper behind and underneath the data to explore richer relationships missing from over-simplistic statistical models. In doing so we gain insights into how best to control risk and uncertainty. The regression model, based on the idea that we can predict automobile crash fatalities based on temperature, fails to answer the substantial question: how can we control or influence behaviour to reduce fatalities. This at least is achievable; control of weather is not.

### 3.2 Risk Registers do not help quantify Risk

While statistical models based on historical data represent one end of a spectrum of sophistication for risk assessment, at the other end is the commonly used idea of a ‘risk register’. In this approach, there is no need for past data; in considering the risks of a new project risk managers typically prepare a list of ‘risks’ that could be things like:

- Some key people you were depending on become unavailable
- A piece of technology you were depending on fails.
- You run out of funds or time
- The very act of listing and then prioritising risks, means that mentally at least risk managers are making a decision about which risks are the biggest. Most standard texts on risk propose decomposing each risk into two components:
  - ‘Probability’ (or likelihood) of the risk
  - Impact

\[
\text{Risk} = \text{Probability} \times \text{Impact}
\]

Figure 7: Standard Impact-based Risk Measure.
An Example: Meteor Strike Alarm in the Film "Armageddon"

By destroying the meteor in the film "Armageddon" Bruce Willis saved the world. Both the chance of the meteor strike and the consequences of such a strike were so high, that nothing much else mattered except to try to prevent the strike. In popular terminology what the world was confronting was a truly massive ‘risk’. But if the NASA scientists in the film had measured the size of the risk using the formula in Figure 7 they would have discovered such a measure was irrational, and it certainly would not have explained to Bruce Willis and his crew why their mission made sense. Specifically:

- **Cannot get the Probability number** (for meteor strikes earth). According to the NASA scientists in the film the meteor was on a direct collision course with earth. Does that make it a certainty (i.e. a 100% chance) of it striking Earth? Clearly not, because if it was then there would have been no point in sending Bruce Willis and his crew up in the space shuttle. The probability of the meteor striking Earth is conditional on a number of control events (like intervening to destroy the meteor) and trigger events (like being on a collision course with Earth). It makes no sense to assign a direct probability without considering the events it is conditional on. In general it makes no sense (and would in any case be too difficult) for a risk manager to give the unconditional probability of every ‘risk’ irrespective of relevant controls and triggers. This is especially significant when there are, for example, controls that have never been used before (like destroying the meteor with a nuclear explosion).

- **Cannot get the Impact number** (for meteor striking earth). Just as it makes little sense to attempt to assign an (unconditional) probability to the event 'Meteor strikes Earth', so it makes little sense to assign an (unconditional) number to the impact of the meteor striking. Apart from the obvious question "impact on what?", we cannot say what the impact is without considering the possible mitigating events such as getting people underground and as far away as possible from the impact zone.

- **Risk score is meaningless.** Even if we could get round the two problems above what exactly does the resulting number mean? Suppose the (conditional) probability of the strike is 0.95 and, on a scale of 1 to 10, the impact of the strike is 10 (even accounting for mitigants). The meteor ‘risk’ is 9.5, which is a number close to the highest possible 10. But it does not measure anything in a meaningful sense

- **It does not tell us what we really need to know.** What we really need to know is the probability, given our current state of knowledge, that there will be massive loss of life.

‘Impact’ (or loss) the risk can cause

The most common way to measure each risk is to multiply the probability of the risk (however you happen to measure that) with the impact of the risk (however you happen to measure that) as in Figure 7.

The resulting number is the ‘size’ of the risk - it is based on analogous ‘utility’ measures. This type of risk measure is quite useful for prioritising risks (the bigger the number the ‘greater’ the risk) but it is normally impractical and can be irrational when applied blindly. We are not claiming that this formulation is wrong. Rather, we argue that it is normally not sufficient for decision-making.

One immediate problem with the risk measure of Figure 7 is that, normally, you cannot directly get the numbers you need to calculate the risk without recourse to a much more detailed analysis of the variables involved in the situation at hand.

In addition to the problem of measuring the size of each individual risk in isolation, risk registers suffer from the following problems:

"By destroying the meteor in the film 'Armageddon' Bruce Willis saved the world"

Figure 8: Meteor Strike Risk.

- However the individual risk size is calculated, the cumulative risk score measures the total project risk. Hence, there is a paradox involved in such an approach: the more carefully you think about risk (and hence the more individual risks you record in the risk register) the higher the overall risk score becomes. Since higher risk scores are assumed to indicate greater risk of failure it seems to follow that your best chance of a new project succeeding is to simply ignore, or under-report, any risks.
Different projects or business divisions will assess risk differently and tend to take a localised view of their own risks and ignore that of others. This "externalisation" of risk to others is especially easy to ignore if their interests are not represented when constructing the register. For example, the IT department may be forced to accept the deadlines imposed by the marketing department.

A risk register does not record "opportunities" or "serendipity" and so does not deal with upside uncertainty, only downside.

Risks are not independent. For example, in most circumstances cost, time and quality will be inextricably linked; you might be able to deliver faster but only by sacrificing quality. Yet "poor quality" and "missed delivery" will appear as separate risks on the register giving the illusion that we can control or mitigate one independently of the other. In the subprime loan crisis of 2008 there were three risks: 1) extensive defaults on subprime loans, 2) growth in novelty and complexity of financial products and 3) failure of AIG (American International Group Inc.) to provide insurance to banks when customers default. Individually these risks were assessed as ‘small’. However, when they occurred together the total risk was much larger than the individual risks. In fact, it never made sense to consider the risks individually at all.

Hence, risk analysis needs to be coupled with an assessment of the impact of the underlying events, one on another, and in terms of their effect on the ultimate outcomes being considered. The accuracy of the risk assessment is crucially dependent on the fidelity of the underlying model; the simple formulation of Figure 7 is insufficient. Instead of going through the motions to assign numbers without actually doing much thinking, we need to consider what lies under the bonnet.

Figure 9: Conditional Probability Table for "Meteor strikes Earth".

<table>
<thead>
<tr>
<th>Explode meteor</th>
<th>False</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>False</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>True</td>
<td>0.0</td>
<td>0.0</td>
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</tbody>
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<td>1.0</td>
</tr>
<tr>
<td>True</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 10: Probability Table for "Meteor on Collision Course with Earth".

Figure 11: Initial Risk of Meteor Strike.
Risk Management

Risk is a function of how closely connected events, systems and actors in those systems might be. Proper risk assessment requires a holistic outlook that embraces a causal view of interconnected events. Specifically to get rational measures of risk you need a causal model, as we describe next. Once you do this measuring risk starts to make sense, but it requires an investment in time and thought.

3.2.1 Thinking about Risk using Causal Analysis

It is possible to avoid all the above problems and ambiguities surrounding the term risk by considering the causal context in which risks happen (in fact everything we present here applies equally to opportunities but we will try to keep it as simple as possible). The key thing is that a risk is an event that can be characterised by a causal chain involving (at least):

- the event itself
- at least one consequence event that characterises the impact
- one or more trigger (i.e. initiating) events
- one or more control events which may stop the trigger event from causing the risk event
- one or more mitigating events which help avoid the consequence event

This is shown in the example of Figure 8. With this causal perspective, a risk is therefore actually characterised not by a single event, but by a set of events. These events each have a number of possible outcomes (to keep things as simple as possible in the example here we will assume each has just two outcomes true and false so we can assume “Loss of life” here means something like ‘loss of at least 80% of the world population’).

The ‘uncertainty’ associated with a risk is not a separate notion (as assumed in the classic approach). Every event (and hence every object associated with risk) has uncertainty that is characterised by the event’s probability distribution. Triggers, controls, and mitigants are all inherently uncertain. The sensible risk measures that we are proposing are simply the probabilities you get from running the BN model. Of course, before you can run it you still have to provide the prior probability values. But, in contrast to the classic approach, the probability values you need to supply are relatively simple and they make sense. And you never have to define vague numbers for ‘impact’.

Example. To give you a feel of what you would need to do, in the Armageddon BN example of Figure 8 for the uncertain event “Meteor strikes Earth” we still have to as-
sign some probabilities. But instead of second guessing what this event actually means in terms of other conditional events, the model now makes it explicit and it becomes much easier to define the necessary conditional probability. What we need to do is define the probability of the meteor strike given each combination of parent states as shown in Figure 9.

For example, if the meteor is on a collision course then the probability of it striking the earth is 1, if it is not destroyed, and 0.2, if it is. In completing such a table we no longer have to try to ‘factor in’ any implicit conditioning events like the meteor trajectory.

There are some events in the BN for which we do need to assign unconditional probability values. These are represented by the nodes in the BN that have no parents; it makes sense to get unconditional probabilities for these because, by definition, they are not conditioned on anything (this is obviously a choice we make during our analysis). Such nodes can generally be only triggers, controls or mitigants. An example, based on dialogue from the film, is shown in Figure 10.

Once we have supplied the priors probability values a BN tool will run the model and generate all the measures of risk that you need. For example, when you run the model using only the initial probabilities the model (as shown in Figure 11) computes the probability of the meteor striking Earth as 99.1% and the probability of loss of life (meaning at least 80% of the world population) is about 94%.

In terms of the difference that Bruce Willis and his crew could make we run two scenarios: One where the meteor is exploded and one where it is not. The results of both scenarios are shown together in Figure 12.

Reading off the values for the probability of "loss of life" being false we find that we jump from just over 4% (when the meteor is not exploded) to 81% (when the meteor is exploded). This massive increase in the chance of saving the world clearly explains why it merited an attempt.

Clearly risks in this sense depend on stakeholders and perspectives, but these perspectives can be easily combined as shown in Figure 13 for 'flood risk' in some town.

The types of events are all completely interchangeable depending on the perspective. From the perspective of the local authority the risk event is 'Flood' whose trigger is ‘dam bursts upstream’ and which has ‘flood barrier’ as a control. Its consequences include ‘loss of life’ and also ‘house floods’. But the latter is a trigger for flood risk from a Householder perspective. From the perspective of the Local Authority Solicitor the main risk event is ‘Loss of life’ for which ‘Flood’ is the trigger and ‘Rapid emergency response’ becomes a control rather than a mitigant.

This ability to decompose a risk problem into chains of interrelated events and variables should make risk analysis more meaningful, practical and coherent. The BN tells a story that makes sense. This is in stark contrast with the "risk equals probability times impact" approach where not one of the concepts has a clear unambiguous interpretation. Uncertainty is quantified and at any stage we can simply read off the current probability values associated with any event.

The causal approach can accommodate decision-mak-
ing as well as measures of utility. It provides a visual and formal mechanism for recording and testing subjective probabilities. This is especially important for a risky event for which you do not have much or any relevant data.

4 Conclusions

We have addressed some of the core limitations of both a) the data-driven statistical approaches and b) risk registers, for effective risk management and assessment. We have demonstrated how these limitations are addressed by using BNs. The BN approach helps to identify, understand and quantify the complex interrelationships (underlying even seemingly simple situations) and can help us make sense of how risks emerge, are connected and how we might represent our control and mitigation of them. By thinking about the hypothetical causal relations between events we can investigate alternative explanations, weigh up the consequences of our actions and identify unintended or (un)desirable side effects.

Of course it takes effort to produce a sensible BN model:
- Special care has to be taken to identify cause and effect: in general, a significant correlation between two factors A and B (where, for example A is ‘yellow teeth’ and B is ‘cancer’) could be due to pure coincidence or a causal mechanism, such that:
  - A causes B
  - B causes A
  - Both A and B are caused by C (where in our example C might be ‘smoking’) or some other set of factors

The difference between these possible mechanisms is crucial in interpreting the data, assessing the risks to the individual and society, and setting policy based on the analysis of these risks. In practice causal interpretation may collide with our personal view of the world and the prevailing ideology of the organisation and social group, of which we will be a part. Explanations consistent with the ideological viewpoint of the group may be deemed more worthy and valid than others irrespective of the evidence. Hence simplistic causal explanations (e.g. ‘poverty’ causes ‘violence’) are sometimes favoured by the media and reported unchallenged. This is especially so when the explanation fits the established ideology helping to reinforce ingrained beliefs. Picking apart over-simplistic causal claims and reconstructing them into a richer, more realistic causal model helps separate ideology from reality and determine whether the model explains reality. The richer model may then also help identify more realistic possible policy interventions.
- The states of variables need to be carefully defined and probabilities need to be assigned that reflect our best knowledge.
- It requires an analytical mindset to decompose the problem into “classes” of event and relationships that are granular enough to be meaningful, but not too detailed that they are overwhelming.

If we were omniscient we would have no need of probabilities; the fact that we are not gives rise to our need to model uncertainty at a level of detail that we can grasp, that is useful and which is accurate enough for the purpose required. This is why causal modelling is as much an art (but an art based on insight and analysis) as a science.

The time spent analysing risks must be balanced by the short term need to take action and the magnitude of the risks involved. Therefore, we must make judgements about how deeply we model some risks and how quickly we use this analysis to inform our actions.

References

Event Chain Methodology in Project Management

Michael Trumper and Lev Virine

Risk management has become a critical component of project management processes. Quantitative schedule risk analysis methods enable project managers to assess how risks and uncertainties will affect project schedules and increase the effectiveness of their project planning. Event chain methodology is an uncertainty modeling and schedule network analysis technique that focuses on identifying and managing the events and event chains that affect projects. Event chain methodology improves the accuracy of project planning by simplifying the modeling and analysis of risks and uncertainties in the project schedules. As a result, it helps to mitigate the negative impact of cognitive and motivational biases related to project planning. Event chain methodology is currently used in many organizations as part of their project risk management process.

Keywords: Project Management, Project Scheduling, Quantitative Methods, Schedule Network Analysis.

1 Why Project Managers ignore Risks in Project Schedules

Virtually all projects are affected by multiple risks and uncertainties. These uncertainties are difficult to identify and analyze which can lead to inaccurate project schedules. Due to these inherent uncertainties, most projects do not proceed exactly as planned and, in many cases, they lead to project delays, cost overruns, and even project failures. Therefore, creating accurate project schedules, which reflect potential risks and uncertainties, remains one of the main challenges in project management.

In [1][2][3] the authors reviewed technical, psychological and political explanations for inaccurate scheduling and forecasting. They found that strategic misrepresentation under political and organizational pressure, expressed by project planners as well as cognitive biases, play major roles in inaccurate forecasting. In other words, project planners either unintentionally, due to psychological biases, or intentionally, due to organizational pressures, consistently deliver inaccurate estimates for cost and schedule, which in turn lead to inaccurate forecasts [4].

Among the cognitive biases related to project forecasting is the planning fallacy [5] and the optimism bias [6]. According to one explanation, project managers do not account for risks or other factors that they perceive as lying outside of the specific scope of a project. Project managers may also discount multiple improbable high-impact risks because each has very small probability of occurring. It has been proposed in [7] that limitations in human mental processes cause people to employ various simplifying strategies to ease the burden of mentally processing information when making judgments and decisions. During the planning stage, project managers rely on heuristics or rules of thumb to make their estimates. Under many circumstances, heuristics lead to predictably faulty judgments or cognitive biases [8]. The availability heuristic [9][10] is a rule of thumb with which decision makers assess the probability of an event by the ease with which instances or occurrences can be brought to mind. For example, project managers sometimes estimate task duration based on similar tasks that have been previously completed. If they base their judgments on their most or least successful tasks, this can cause inaccurate estimations. The anchoring heuristic refers to the human tendency to remain close to an initial estimate. Anchoring is related to overconfidence in estimation of probabilities – a tendency to provide overly optimistic estimates of uncertain events. Arbitrary anchors can also affect people’s estimates of how well they will perform certain problem solving tasks [11].

Authors

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Risk management has become a critical component of project management processes

Problems with estimation are also related to selective perception - the tendency for expectations to affect perception [12]. Sometimes selective perception is referred, as "I only see what I want to see". One of the biases related to selective perception is the confirmation bias. This is the tendency of decision makers to actively seek out and assign more weight to evidence that confirms their hypothesis, and to ignore or underweight evidence that could discount their hypothesis [13][14].

Another problem related to improving the accuracy of project schedules is the complex relationship between different uncertainties. Events can occur in the middle of an activity, they can be correlated with each other, one event can cause other events, the same event may have different impacts depending upon circumstances, and different mitigation plans can be executed under different conditions. These complex systems of uncertainties must be identified and visualized to improve the accuracy of project schedules.

Finally, the accuracy of project scheduling can be improved by constantly refining the original plan using actual project performance measurement [15]. This can be achieved through analysis of uncertainties during different phases of the project and incorporating new knowledge into the project schedule. In addition, a number of different techniques such as resource leveling and the incorporation of mitigation plans, and the presence of repeated activities are difficult to model in project schedules with risks and uncertainties. Therefore, the objective is to identify an simpler process, which includes project performance measurement and other analytical techniques.

Event chain methodology has been proposed as an attempt to satisfy the following objectives related to project scheduling and forecasting by:

1. Mitigating the effects negative of motivational and cognitive biases and improve the accuracy of estimating and forecasting.
2. Simplifying the process of modeling risks and uncertainties in project schedules, in particular, by improving the ability to visualize multiple events that affect project schedules and perform reality checks.
3. Performing more accurate quantitative analysis while accounting for such factors as the relationships between different events and the actual moment of events.
4. Providing a flexible framework for scheduling which includes project performance measurement, resource leveling, execution of migration plans, correlations between risks, repeated activities, and other types of analysis.

2 Existing Techniques as Foundations for Event Chain Methodology

The accuracy of project scheduling with risks and uncertainties can be improved by applying a process or workflow tailored to the particular project or set of projects (portfolio) rather than using one particular analytical technique. According to the PMBOK® Guide of the Project Management Institute [16] such processes can include methods of identification of uncertainties, qualitative and quantitative analysis, risk response planning, and risk monitoring and control. The actual processes may involve various tools and visualization techniques.

One of the fundamental issues associated with managing project schedules lies in the identification of uncertainties. If the estimates for input uncertainties are inaccurate, this will lead to inaccurate results regardless of the analysis methodology. The accuracy of project planning can be significantly improved by applying advanced techniques for identification of risks and uncertainties. Extensive sets of techniques and tools which can be used by individuals as well as in groups are available to simplify the process of uncertainty modeling [17][18].

The PMBOK® Guide recommends creating risk templates based on historical data. There are no universal, exhaustive risk templates for all industries and all types of projects. Project management literature includes many examples of different risk lists which can be used as templates [19]. A more advanced type of template is proposed in [20]: risk questionnaires. They provide three choices for each risk where the project manager can select when the risk can manifest itself during the project: a) at anytime b) about half the time, and c) less than half the time. One of the most comprehensive analyses of risk sources and categories was performed by Scheinin and Hefner [21]. Each risk in their risk breakdown structure includes what they call a “frequency” or rank property.

PMBOK® Guide recommends a number of quantitative analysis techniques, such as Monte Carlo analysis, decision trees and sensitivity analysis. Monte Carlo analysis is used to approximate the distribution of potential results based on probabilistic inputs [22][23][24][25]. Each trial is generated by randomly pulling a sample value for each input variable from its defined probability distribution. These input sample values are then used to calculate the results. This procedure is then repeated until the probability distri-
During the planning stage, project managers rely on heuristics or rules of thumb to make their estimates. However, these approaches are not always sufficient to achieve the desired level of accuracy. The main advantage of Monte Carlo simulation is that it helps to incorporate risks and uncertainties into the process of project scheduling.

A number of quantitative risk analysis techniques have been developed to deal with specific issues related to uncertainty. Decisions trees help to calculate the expected value of projects as well as identify project alternatives and select better courses of action. Sensitivity analysis is used to determine which variables, such as risk drivers, have the most potential impact on projects. These types of analysis usually become important components in project planning processes that account for risks and uncertainties.

Another approach to project scheduling with uncertainties was developed by Goldratt [30], who applied the theory of constraints to project management. The cornerstone of the theory is resource constrained critical paths called a "critical chain". Goldratt's approach is based on a deterministic critical path method. To deal with uncertainties, Goldratt suggests using project buffers and encouraging early task completion. Although critical chain has proved to be a very effective methodology for a wide range of projects, it is not fully embraced by many project managers because it requires change to established processes.

A number of quantitative risk analysis techniques have been developed to deal with specific issues related to uncertainty. Decisions trees help to calculate the expected value of projects as well as identify project alternatives and select better courses of action. Sensitivity analysis is used to determine which variables, such as risks, have the most potential impact on projects. These types of analysis usually become important components in a project planning process that accounts for risks and uncertainties.

One of the approaches, which may help to improve accuracy of project forecasts, is the visualization of project plans with uncertainties. Traditional visualization techniques include bar charts or Gantt charts and various schedule network diagrams. Visual modeling tools are widely used to describe complex models in many industries. Unified modeling language (UML) is actively used in software design.

Among integrated processes designed to improve the accuracy of project planning with risks and uncertainties is the reference class forecasting technique [36]. This process includes identifying similar past and present projects, establishing probability distributions for selected reference classes and using them to establish the most likely outcome of a specific project. The American Planning Association officially endorses reference class forecasting. Analysis based on historical data helps to make more accurate forecasts; however, they have the following major shortcomings:

1. Creating sets of references or analogue sets is not a trivial process because it involves a relevance analysis of previous projects and previous projects may not be relevant to the current one.
2. Many projects, especially in the area of research and development, do not have any relevant historical data.

3 Overview of Event Chain Methodology

Event chain methodology is a practical schedule network analysis technique as well as a method of modeling and visualizing of uncertainties. Event chain methodology comes from the notion that regardless of how well project schedules are developed, some events may occur that will alter it. Identifying and managing these events or event chains (when one event causes another event) is the focus of event chain methodology. The methodology focuses on events rather than a continuous process for changing project environments because with continuous problems within a project it is possible to detect and fix them before they have a significant effect upon the project.

Project scheduling and analysis using events chain methodology includes the following steps:

1. Create a project schedule model using best-case scenario estimates of duration, cost, and other parameters. In other words, project managers should use estimates that they are comfortable with, which in many cases will be optimistic. Because of a number of cognitive and motivational factors outlined earlier project managers tend to create optimistic estimates.
2. Define a list of events and event chains with their probabilities and impacts on activities, resources, lags, and calendars. This list of events can be represented in the form of a risk breakdown structure. These events should be identified separately (separate time, separate meeting, different experts, different planning department) from the schedule model to avoid situations where expectations about the project (cost, duration, etc.) affect the event identification.
3. Perform a quantitative analysis using Monte Carlo simulations. The results of Monte Carlo analysis are statis-
4. Perform a sensitivity analysis as part of the quantitative analysis. Sensitivity analysis helps identify the crucial activities and critical events and event chains. Crucial activities and critical events and event chains have the most affect on the main project parameters. Reality checks may be used to validate whether the probability of the events are defined properly.

5. Repeat the analysis on a regular basis during the course of a project based on actual project data and include the actual occurrence of certain risks. The probability and impact of risks can be reassessed based on actual project performance measurement. It helps to provide up to date forecasts of project duration, cost, or other parameters.

4. Foundations of Event Chain Methodology

Event chain methodology expands on the Monte Carlo simulations of project schedules and particularly risk driver (events) approach. Event chain methodology focuses on the relationship between risks, conditions for risk occurrence, and visualization of the risks events.

Some of the terminology used in event chain methodology comes from the field of quantum mechanics. In particular, quantum mechanics introduces the notions of excitation and entanglement, as well as grounded and excited states [37][38]. The notion of event subscription and multicasting is used in object oriented software development as one of the types of interactions between objects [39][40].

5. Basic Principles of Event Chain Methodology

Event chain methodology is based on six major principles. The first principle deals with single events, the second principle focuses on multiple related events or event chains, the third principle defines rules for visualization of the events or event chains, the fourth and fifth principles deals with the analysis of the schedule with event chains, and the sixth principle defines project performance measurement techniques with events or event chains. Event chain methodology is not a completely new technique as it is based on existing quantitative methods such Monte Carlo simulation and Bayesian theorem.

Principle 1: Moment of Event and Excitation States

An activity in most real life processes is not a continuous and uniform procedure. Activities are affected by external events that transform them from one state to another. The notion of state means that activity will be performed differently as a response to the event. This process of changing the state of an activity is called excitation. In quantum mechanics, the notion of excitation is used to describe elevation in energy level above an arbitrary baseline energy state. In Event chain methodology, excitation indicates that something has changed the manner in which an activity is performed. For example, an activity may require different resources, take a longer time, or must be performed under different conditions. As a result, this may alter the activity’s...
cost and duration.

The original or planned state of the activity is called a ground state. Other states, associated with different events are called excited states (Figure 1). For example, in the middle of an activity the project requirements change. As a result, a planned activity must be restarted. Similarly to quantum mechanics, if significant event affects the activities, it will dramatically affect the property of the activity, for example cancel the activity.

Events can affect one or many activities, material or work resources, lags, and calendars. Such event assignment is an important property of the event. An example of an event that can be assigned to a resource is an illness of a project team member. This event may delay all activities to which this resource is assigned. Similarly resources, lags, and calendars may have different grounded and excited states. For example, the event "Bad weather condition" can transform a calendar from a ground state (5 working days per weeks) to an excited state: non working days for the next 10 days.

Each state of activity in particular may subscribe to certain events. It means that an event can affect the activity only if the activity is subscribed to this event. For example, an assembly activity has started outdoors. The ground state the activity is subscribed to the external event "Bad weather". If "Bad weather" actually occurs, the assembly should move indoors. This constitutes an excited state of the activity. This new excited state (indoor assembling) will not be subscribed to the "Bad weather"; if this event occurs it will not affect the activity.

Event subscription has a number of properties. Among them are:

- **Impact of the event** is the property of the state rather than event itself. It means that impact can be different if an activity is in a different state. For example, an activity is subscribed to the external event "Change of requirements". In its ground state of the activity, this event can cause a 50% delay of the activity. However, if the event has occurred, the activity is transformed to an excited state. In an excited state if "Change of requirement" is occurs again, it will cause only a 25% delay of the activity because management has performed certain actions when event first occurred.

- **Probability of occurrence** is also a property of subscription. For example, there is a 50% chance that the event will occur. Similarly to impact, probability of occurrence can be different for different states;

- **Excited state**: the state the activities are transformed to after an event occurs;

- **Moment of event**: the actual moment when the event occurs during the course of an activity. The moment of event can be absolute (certain date and time) or relative to an activity’s start and finish times. In most cases, the moment when the event occurs is probabilistic and can be defined using a statistical distribution (Figure 1). Very often, the overall impact of the event depends on when an event oc-

<table>
<thead>
<tr>
<th>Risk most likely occurs at the end of the activity (triangular distribution for moment of risk)</th>
<th>Equal probability of the risk occurrence during the course of activity</th>
<th>Risk occurs only at the end of activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Risk" /></td>
<td><img src="image2" alt="Risk" /></td>
<td><img src="image3" alt="Risk" /></td>
</tr>
<tr>
<td>Mean activity duration with the event occurred</td>
<td>5.9 days</td>
<td>6.3 days</td>
</tr>
<tr>
<td>90° percentile</td>
<td>7.9 days</td>
<td>9.14 days</td>
</tr>
</tbody>
</table>

**Table 1**: Moment of Risk Significantly affects Activity Duration.

Some of the terminology used in event chain methodology comes from the field of quantum mechanics.
Risk Management

Events can have negative (risks) and positive (opportunities) impacts on projects. Mitigation efforts are considered to be events, which are executed if an activity is in an excited state. Mitigation events may attempt to transform the activity to the ground state.

Impacts of an event affecting activities, a group of activities, or lags can be:
- Delay activity, split activity, or start activity later; delays can be defined as fixed (fixed period of time) and relative (in percent of activity duration); delay also can be negative
  - Restart activity
  - Stop activity and restart it later if required
  - End activity
  - Cancel activity or cancel activity with all successors, which is similar to end activity except activity will be marked as canceled to future calculation of activity’s success rate
  - Fixed or relative increase or reduction of the cost
  - Redeploy resources associated with activity; for example a resource can be moved to another activity
  - Execute events affecting another activity, group of activities, change resource, or update a calendar. For example, this event can start another activity such as mitigation plan, change the excited state of another activity, or update event subscriptions for the excited state of another activity.

The impacts of events are characterised by some additional parameters. For example, a parameter associated with the impact "Fixed delay of activity" is the actual duration of the delay.

The impact of events associated with resources is similar to the impact of activity events. Resource events will affect all activities this resource is assigned to. If a resource is only partially involved in the activity, the probability of event will be proportionally reduced. The impact of events associated with a calendar changes working and non-working times.

One event can have multiple impacts at the same time. For example, a "Bad weather" event can cause an increase of cost and duration at the same time. Event can be local, affecting a particular activity, group of activities, lags, resources, and calendars, or global affecting all activities in the project.

**Principle 2: Event Chains**

Some events can cause other events. These series of events form event chains, which may significantly affect the course of the project by creating a ripple effect through the project (Figure 2). Here is an example of an event chain ripple effect:

1. Requirement changes cause a delay of an activity.
2. To accelerate the activity, the project manager diverts resources from another activity.
3. Diversion of resources causes deadlines to be missed on the other activity.
4. Cumulatively, this reaction leads to the failure of the whole project.

Event chains are defined using event impacts called "Execute event affecting another activity, group of activities, change resources or update calendar". Here is how the aforementioned example can be defined using Event chain methodology:

1. The event "Requirement change" will transform the activity to an excited state which is subscribed to the event "Redeploy resources".
2. Execute the event "Redeploy resources" to transfer resources from another activity. Other activities should be in a state subscribed to the "Redeploy resources" event. Otherwise resources will be not available.
3. As soon as the resources are redeployed, the activity with reduced resources will move to an excited state and the duration of the activity in this state will increase.
4. Successors of the activity with the increased dura-

---

**Table 2:** Event Chain leads to Higher Project Duration compared to the Series of Independent Events with the Same Probability.

<table>
<thead>
<tr>
<th></th>
<th>Independent events in each activity</th>
<th>Event chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean duration</td>
<td>18.9 days</td>
<td>19.0 days</td>
</tr>
<tr>
<td>90th percentile</td>
<td>22.9 days</td>
<td>24.7 days</td>
</tr>
</tbody>
</table>

**Figure 2:** Example of Event Chain.
An event that causes another event is called the sender. The sender can cause multiple events in different activities. This effect is called multicasting. For example, a broken component may cause multiple events: a delay in assembly, additional repair activity, and some new design activities. Events that are caused by the sender are called receivers. Receiver events can also act as a sender for another event.

The actual effect of an event chain on a project schedule can be determined as a result of quantitative analysis. The example below illustrates the difference between event chain and independent events (Figure 2 and Table 2). Monte Carlo simulations were used to perform the analysis. The project includes three activities of 5 days each. Each activity is affected by the event "restart activity" with a probability of 50%.

Below are four different strategies for dealing with risks [41] defined using event chain methodology’s event chain principle:

1. Risk acceptance: excited state of the activity is considered to be acceptable.
2. Risk transfer: represents an event chain; the impact of the original event is an execution of the event in another activity (Figure 3).
3. Risk mitigation: represents an event chain; the original event transforms an activity from a ground state to an excited state, which is subscribed to a mitigation event; the mitigation event that occurs in excited state will try to transform activities to a ground state or a lower excited state (Figure 4).
4. Risk avoidance: original project plan is built in such a way that none of the states of the activities are subscribed to this event.

Principle 3: Event Chain Diagrams and State Tables

Complex relationships between events can be visualized using event chain diagrams (Figure 5). Event chain diagrams are presented on the Gantt chart according to the specification. This specification is a set of rules, which can be understood by anybody using this diagram.

1. All events are shown as arrows. Names and/or IDs of events are shown next to the arrow.
2. Events with negative impacts (threads) are represented by down arrows; events with positive impacts (opportunities) are represented by up arrows.

3. Individual events are connected by lines representing the event chain.

4. A sender event with multiple connecting lines to receivers represents multicasting.

5. Events affecting all activities (global events) are shown outside the Gantt chart. Threats are shown at the top of the diagram. Opportunities are shown at the bottom of the diagram.

Often event chain diagrams can become very complex. In these cases, some details of the diagram do not need to be shown. Here is a list of optional rules for event chain diagrams:

1. Horizontal positions of the event arrows on the Gantt bar correspond with the mean moment of the event.

2. Probability of an event can be shown next to the event arrow.

3. Size of the arrow represents relative probability of an event. If the arrow is small, the probability of the event is correspondingly small.

4. Excited states are represented by elevating the associated section of the bar on the Gantt chart (see Figure 1). The height of the state’s rectangle represents the relative impact of the event.

5. Statistical distributions for the moment of event can be shown together with the event arrow (see Figure 1).

6. Multiple diagrams may be required to represent different event chains for the same schedule.

7. Different colors can be used to represent different events (arrows) and connecting lines associated with different chains.

The central purpose of event chain diagrams is not to show all possible individual events. Rather, event chain diagrams can be used to understand the relationship between events. Therefore, it is recommended that event chain diagrams be used only for the most significant events during the event identification and analysis stage. Event chain diagrams can be used as part of the risk identification process, particularly during brainstorming meetings. Members of project teams can draw arrows between associated activities on the Gantt chart. Event chain diagrams can be used together with other diagramming tools.

Another tool that can be used to simplify the definition of events is a state table. Columns in the state table represent events; rows represent states of activity. Information for each event in each state includes four properties of event subscription: probability, moment of event, excited state, and impact of the event. State table helps to depict an activity’s subscription to the events: if a cell is empty the state is not subscribed to the event.

An example of state table for a software development activity is shown on Table 3. The ground state of the activity is subscribed to two events: "architectural changes" and "development tools issue". If either of these events occur, they transform the activity to a new excited state called "refactoring". "Refactoring" is subscribed to another event: "minor requirement change". Two previous events are not subscribed to the refactoring state and therefore cannot reoccur while the activity is in this state.

**Table 3:** Example of the State Table for Software Development Activity.

<table>
<thead>
<tr>
<th>Event 1: Architectural changes</th>
<th>Event 2: Development tools issue</th>
<th>Event 3: Minor requirements change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground state</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability: 20%</td>
<td>Probability: 10%</td>
<td>Probability: 10%</td>
</tr>
<tr>
<td>Moment of event: any time</td>
<td>Moment of event: any time</td>
<td>Moment of event: any time</td>
</tr>
<tr>
<td><em>Excited state:</em> refactoring</td>
<td><em>Excited state:</em> refactoring</td>
<td><em>Excited state:</em> minor code change</td>
</tr>
<tr>
<td>Impact: delay 2 weeks</td>
<td>Impact: delay 1 week</td>
<td>Impact: delay 2 days</td>
</tr>
<tr>
<td><strong>Excited state: refactoring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Excited state: minor code change</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Principle 4: Monte Carlo Schedule Risk Analysis**

Once events, event chains, and event subscriptions are defined, Monte Carlo analysis of the project schedule can be performed to quantify the cumulative impact of the events. Probabilities and impacts of events are used as an input data for analysis.

In most real life projects, even if all the possible risks are defined, there are always some uncertainties or fluctuations or noise in duration and cost. To take these fluctuations into account, distributions related to activity duration, start time, cost, and other parameters should be defined in addition to the list of events. These statistical distributions must not have the same root cause as the defined events, as this will cause a double-count of the project’s risk.

Monte Carlo simulation process for Event chain methodology has a number of specific features. Before the sampling process starts all event chains should be identified. Particularly, all sender and receiver events should be iden-
tified through an analysis of state tables for each activity. Also, if events are assigned to resources, they need to be reassigned to activities based on resource usage for each particular activity. For example, if a manager is equally involved in two activities, a risk "Manager is not familiar with technology" with a probability 6% will be transferred to both activities with probability of 3% for each activity. Events assigned to summary activities will be assigned to each activity in the group. Events assigned to lags are treated the same way as activities.

Each trial of the Monte Carlo simulation includes the following steps specific to Event chain methodology:
1. Moments of events are calculated based on statistical distribution for moment of event on each state.
2. Determines if sender events have actually occurred at this particular trial based on probability of the sender.
3. Determines if probabilities of receiver events are updated based on sender event. For example, if a sender event unconditionally causes a receiver event, probability of a receiver event will equal 100%.
4. Determines if receiver events have actually occurred; if a receiver event is a sender event at the same time, the process of determining probabilities of receiver events will continue.
5. The process will repeat for all ground and excited states for all activities and lags.
6. If an event that causes the cancellation of an activity occurs, this activity will be identified as canceled and the activity’s duration and cost will be adjusted.
7. If an event that causes the start of another activity occurs, such as execution of mitigation plan, the project schedule will be updated for the particular trial. Number of trials where the particular activity is started will be counted.
8. The cumulative impact of the all events on the activity’s duration and cost will be augmented by accounting for fluctuations of duration and cost.

The results of the analysis are similar to the results of classic Monte Carlo simulations of project schedules. These results include statistical distributions for duration, cost, and success rate of the complete project and each activity or group of activities. Success rates are calculated based on the number of simulations where the event "Cancel activity" or "Cancel group of activities" occurred. Probabilistic and conditional branching, calculating the chance that project will be completed before deadline, probabilistic cashflow and other types of analysis are performed in the same manner as with a classic Monte Carlo analysis of the project schedules. Probability of activity existence is calculated based on two types of inputs: probabilistic and conditional branching and number of trials where an activity is executed as a result of a "Start activity" event.

**Principle 5: Critical Event Chains and Event Cost**

Single events or event chains that have the most potential to affect the projects are the critical events or critical event chains. By identifying critical events or critical event chains, it is possible mitigate their negative effects. These critical event chains can be identified through sensitivity analysis: by analyzing the correlations between the main project parameters, such as project duration or cost, and event chains.

Critical event chains based on cost and duration may differ. Because the same event may affect different activities and have different impact of these activities, the goal is to measure a cumulative impact of the event on the project schedule. Critical event chains based on duration are calculated using the following approach. For each event and event chain on each trial the cumulative impact of event on project duration (\(D_{cum}\)) is calculated based on the formula:

\[
D_{cum} = \sum_{i=1}^{n} (D_i - D)k_i
\]

where \(n\) is number of activities in which this event or event chain occurs, \(D_i\) is the original duration of activity \(i\) and \(D\) is the duration of activity \(i\) with this particular event taken into an account, \(k\) is the Spearman rank order correlation coefficient between total project duration and duration of activity \(i\). If events are assigned to calendars, \(D_i\) is the duration of activity with the calendar used as a result of the event.

Cumulative impact of event on cost (\(C_{cum}\)) is calculated based on formula:

\[
C_{cum} = \sum_{i=1}^{n} (C_i - C_i^c)
\]

where \(C_i\) is the original cost of activity and \(C_i^c\) is the activity cost taking into account the this particular event.

Spearman rank order correlation coefficient is calculated based on the cumulative effect of the event on cost and duration (\(C_{cum}\) and \(D_{cum}\)) and total project cost and duration.

One of the useful measures of the impact of the event is event cost or additional expected cost, which would be added to project as a result of the event. Event cost is not a mitigation cost. Event cost can be used as decision criteria for selection of risk mitigation strategies. Mean event cost \(C_{event}\) is normalized cumulative effect of the event on cost and calculated according to the following formula:

\[
C_{event} = \left( C_{project} - C_{project}^c \right) * k_{event} / \sum_{i=1}^{n} k_i
\]

where \(C_{project}\) is the mean total project cost with risks and uncertainties, \(C_{project}^c\) is the mean total project cost without taking into account events, but with accounting for fluctuations defined by statistical distributions, \(k_{event}\) is the correlation coefficient between total project cost and cumulative impact of the event on cost on the particular activity, \(k\) is correlation coefficient between total cost and cumulative impact of the event on the activity \(i\). Event cost can be calculated based on any percentile associated with statistical distribution of project cost.
Critical events or critical event chains can be visualized using a sensitivity chart, as shown on Figure 6. This chart represents events affecting cost in the schedule shown on Figure 2. Event 1 occurs in Task 1 (probability 47%) and Task 3 (probability 41%). Event 3 occurs in Task 3 (probability 50%) and Event 2 occurs in Task 2 (probability 10%). All events are independent. The impact of all these events is "restart task". All activities have the same variable cost $6,667; therefore, the total project cost without risks and uncertainties equals $20,000. Total project cost with risks as a result of analysis equals $30,120. Cost of Event 1 will be $5,300, Event 2 will be $3,440, and Event 3 will be $1,380. Because this schedule model does not include fluctuations for the activity cost, sum of event costs equals difference between original cost and cost with risks and uncertainties ($10,120).

Critical events and events chains can be used to perform a reality check. If the probability and outcome of events are properly defined, the most important risks, based on subjective expert judgment, should be critical risks as a result of quantitative analysis.

**Principle 6: Project Performance Measurement with Event and Event Chains**

Monitoring the progress of activities ensures that updated information is used to perform the analysis. While this is true for all types of analysis, it is a critical principle of event chain methodology. During the course of the project, using actual performance data it is possible to re-calculate the probability of occurrence and moment of the events. The analysis can be repeated to generate a new project schedule with updated costs or durations.

But what should one do if the activity is partially completed and certain events are assigned to the activity? If the event has already occurred, will it occur again? Or vice versa, if nothing has occurred yet, will it happen?

There are three distinct approaches to this problem:

1. Probabilities of a random event in partially completed activity stay the same regardless of the outcome of previous events. This is mostly related to external events, which cannot be affected by project stakeholders. It was originally determined that "bad weather" event during a course of one-year construction project can occur 10 times. After a half year, bad weather has occurred 8 times. For the remaining half year, the event could still occur 5 times. This approach is related to psychological effect called "gambler’s fallacy" or belief that a successful outcome is due after a run of bad luck [42].

2. Probabilities of events in a partially completed activity depend on the moment of the event. If the moment of risk is earlier than the moment when actual measurement is performed, this event will not affect the activity. For example, activity "software user interface development" takes 10 days. Event "change of requirements" can occur any time during a course of activity and can cause a delay (a uniform distribution of the moment of event). 50% of work is completed within 5 days. If the probabilistic moment of event happens to be between the start of the activity and 5 days, this event will be ignored (not cause any delay). In this case, the probability that the event will occur will be reduced and eventually become zero, when the activity approaches the completion.

3. Probabilities of events need to be defined by the subjective judgment of project managers or other experts at any stage of an activity. For example, the event "change of requirements" has occurred. It may occur again depending on many factors, such as how well these requirements are defined and interpreted and the particular business situation. To implement this approach excited state activities should be explicitly subscribed or not subscribed to certain events. For example, a new excited state after the event "change of requirements" may not be subscribed to this event again, and as a result this event will not affect the activity a second time.

The chance that the project will meet a specific deadline can be monitored and presented on the chart shown on Figure 7. The chance changes constantly as a result of various events and event chains. In most cases, this chance is reducing over time. However, risk response efforts, such as risk mitigations, can increase the chance of successfully meeting a project deadline. The chance of the project meeting the deadline is constantly updated as a result of the quantitative analysis based on the original assessment of the project uncertainties and the actual project performance data.

In the critical chain method, the constant change in the size of the project buffer is monitored to ensure that project is on track. In event chain methodology, the chance of the
project meeting a certain deadline during different phases of the project serves a similar purpose: it is an important indicator of project health. Monitoring the chance of the project meeting a certain deadline does not require a project buffer. It is always possible to attribute particular changes in the chance of meeting a deadline to actual and forecasted events and event chains, and as a result, mitigate their negative impact.

6 Conclusions

Event chain methodology is designed to mitigate the negative impact of cognitive and motivational biases related to the estimation of project uncertainties:

- The task duration, start and finish time, cost, and other project input parameters are influenced by motivational factors such as total project duration to much greater extent than events and event chains. This occurs because events cannot be easily translated into duration, finish time, etc. Therefore, Event chain methodology can help to overcome negative affects of selective perception, in particular the confirmation bias and, within a certain extent, the planning fallacy and overconfidence.

- Event chain methodology relies on the estimation of duration based on best-case scenario estimates and does not necessarily require low, base, and high estimations or statistical distribution and, therefore, mitigates the negative effect of anchoring.

- The probability of events can be easily calculated based on historical data, which can mitigate the effect of the availability heuristic. Compound events can be easy broken into smaller events. The probability of events can be calculated using relative frequency approach where probability equals the number an event occurs divided by the total number of possible outcomes. In classic Monte Carlo simulations, the statistical distribution of input parameters can also be obtained from the historical data; however, the procedure is more complicated and is often not used in practice.

Event chain methodology allows taking into an account factors which were not analyzed by other schedule network analysis techniques: moment of event, chains of events, delays in events, execution of mitigation plans and others. Complex relationship between different events can be visualized using event chain diagrams and state tables, which simplifies event and event chain identification.

Finally, Event chain methodology includes techniques designed to incorporate new information about actual project performance to original project schedule and therefore constantly improve accuracy of the schedule during a course of a project. Event chain methodology offers practical solution for resource leveling, managing mitigation plans, correlations between events and other activities.

Event chain methodology is a practical approach to scheduling software projects that contain multiple uncertainties. A process that utilizes this methodology can be easily used in different projects, regardless of size and complexity. Scheduling using Event chain methodology is an easy to use process, which can be performed using off-the-shelf software tools. Although Event chain methodology is a relatively new approach, it is actively used in many organizations, including large corporations and government agencies.

References


Risk Management

Revisiting Managing and Modelling of Project Risk Dynamics — A System Dynamics-based Framework

Alexandre Rodrigues

The fast changing environment and the complexity of projects has increased the exposure to risk. The PMBOK (Project Management Body of Knowledge) standard from the Project Management Institute (PMI) proposes a structured risk management process, integrated within the overall project management framework. However, unresolved difficulties call for further developments in the field. In projects, risks occur within a complex web of numerous interconnected causes and effects, which generate closed chains of feedback. Project risk dynamics are difficult to understand and control and hence not all types of tools and techniques are appropriate to address their systemic nature. As a proven approach to project management, System Dynamics (SD) provides this alternative view. A methodology to integrate the use of SD within the established project management process has been proposed by the author. In this paper, this is further extended to integrate the use of SD modelling within the PMBOK risk management process, providing a useful framework for the effective management project risk dynamics.

Keywords: PMBOK Framework, Project Management Body of Knowledge, Project Risk Dynamics, Risk Management Processes, SYDPIM methodology, System Dynamics.

1 Risk Management in Projects

1.1 Overview

In response to the growing uncertainty in modern projects, over the last decade the project management community has developed project-specific risk management frameworks. The last edition of PMI’s body of knowledge (the PMBOK® Guide [1]), presents perhaps the most complete and commonly accepted framework, which has been further detailed in the Practice Standard for Project Risk Management [2]. Further developments complement this framework like the establishment of project risk management maturity models to help organizations evaluate and improve their ability to control risks in projects. However, most organizations still fall short of implementing these structured frameworks effectively. In addition, there are certain types of risks that are not handled properly by the traditional tools and techniques proposed.

1.2 Current Framework for Project Risk Management

The fourth and latest edition of PMI’s Project Management Body of Knowledge [1] considers six risk management processes: plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk responses, and monitor and control risks. While this framework provides a comprehensive approach to problem solving, its effectiveness relies on the ability of these processes to cope with the multidimensional uncertainty of risks: identification, likelihood, impact, and occurrence. The majority of the traditional tools and techniques used in these processes were not designed to address the increasingly systemic nature of risk uncertainty in modern projects. This problem and limitation calls for further developments in the field.

1.3 Project Risk Dynamics

Risks are dynamic events. Overruns, slippage and other problems can rarely be traced back to the occurrence of a single discrete event in time. In projects, risks take place within a complex web of numerous interconnected causes.

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1 This paper derives from an article entitled "Managing and Modelling Project Risk Dynamics - A System Dynamics-based Framework" which was presented by the author at the Fourth European Project Management Conference, PMI Europe 2001 [3]. As the use of computer simulation based on System Dynamics to support Project Risk Management in a systematic manner is still in its early phases, most likely due to the high level of organizational maturity and expertise required by System Dynamics modelling, the author decided revisit the ideas contained in the aforementioned paper.
Risk Management

and effects which generate closed chains of causal feedback. Risk dynamics are generated by the various feedback loops that take place within the project system.

The feedback perspective is particularly relevant to understand, explain, and act upon the behaviour of complex social systems. Its added value for risk management is that it sheds light on the systemic nature of risks. No single factor can be blamed for generating a risk nor can management find effective solutions by acting only upon individual factors. To understand why risks emerge and to devise effective solutions, management needs to look at the whole. As an example of this analysis, Figure 1 shows the feedback structure of a project, focused on the dynamics that can generate risks related to requirements changes imposed by the client. This understanding of risks is crucial for identifying, assessing, monitoring and controlling them better (see [4] for more details).

Feedback loops identified as "R+" are reinforcing effects (commonly referred to as "snowball effects"), and the ones identified as "B-" are balancing effects (e.g. control decisions). The arrows indicate cause-effect relationships, and have an "o" when the cause and the direct effect change in the opposite direction. The arrows in red identify the cause-effect relationships likely to generate risks. This type of diagram is referred to as "Influence Diagram" (ID).

If we ask the question: what caused quality problems and delays? the right answer is not "staff fatigue", "poor QA implementation" or "schedule pressure". It is the whole feedback structure that, over-time and under certain conditions, generated the quality problems and delays. In other words, the feedback structure causes problems to unfold over-time. To manage systemic risks effectively, it is necessary to act upon this structure. This type of action consists of eliminating problematic feedback loops and creating beneficial ones.

However, project risk dynamics are difficult to understand and control. The major difficulties have to do with the subjective, dynamic and multi-factor nature of systemic risks. Feedback effects include time-delays, non-linear effects and subjective factors. Not all types of tools and tech-

The fast changing environment and the complexity of projects has increased the exposure to risk
Project risk dynamics are difficult to understand and control and hence not all types of tools and techniques are appropriate to address their systemic nature.
traditional project management framework, and formally integrated with the PERT/CPM models. An overview of the process logic is provided in Figure 3. The arrows in black identify the flows within the traditional project control process. SYDPIM places the use of an SD project model at the core of this process, enhancing both planning and monitoring and thereby the overall project control.

The use of the SD model adds new steps to the basic control cycle (the numbers indicate the sequence of the steps). In planning, the SD model is used to pro-actively test and improve the current project plan. This includes forecasting and diagnosing the likely outcome of the current plan, uncover assumptions (e.g. expected productivity), test the plan’s sensitivity to risks, and test the effectiveness of mitigating actions. In monitoring, the SD model is used to explain the current project outcome and status, to enhance progress visibility by uncovering important intangible information (e.g. undiscovered rework), and to carry out retrospective “what-if” analysis for process improvement while the project is underway. Overall, the SD model works as a test laboratory to assess the future plans and to diagnose the project past. The model also works as an important repository of project history and metrics.

4 Using SYDPIM to manage Risk Dynamics within the PMBOK Framework

According to the SYDPIM framework, the SD model can be used in various ways to support the six risk management processes identified in the PMBOK. Given the limited size of this paper, this is now briefly described separately for each risk process. A more detailed explanation is forthcoming in the literature.

**Plan Risk Management**

The implementation of SYDPIM within risk management planning allows for the definition of the appropriate level of structuring for the risk management activity, and for the planning of the use of SD models within this activity.

Adjusting the level of structuring for the risk management activity is crucial for the practical implementation of the risk management process. An SD project model can be used to analyse this problem. Various scenarios reflecting different levels of structuring can be simulated and the full impacts are quantified. Typically, a "U-curve" will result from the analysis of these scenarios, ranging from pure ad hoc to over-structuring. An example of the use of an SD model for this purpose can be found in [3].

**Identify Risks**

An SD project model can support risk identification in two ways: at the qualitative level, through the analysis of influence diagrams, risks that result from feedback forces can be identified; at the quantitative level, intangible project status information (e.g. undiscovered rework) and assumptions in the project plan can be uncovered (e.g. required productivity).

System Dynamics modelling is a very complete technique and tool that covers a wide range of project management needs."
Risks can be identified in an influence diagram as events that result from: (i) balancing loops that limit a desired growth or decay (e.g. the lack of available resources leads to a balancing loop that limits the potential growth of work accomplishment); (ii) reinforcing loops that lead to undesired growth or decay (e.g. schedule pressure leads to QA cuts, which in turn lead to more rework and delays, thereby reinforcing schedule pressure; see "R+" loop L3 in figure 1); (iii) external factors that exacerbate any of these two types of feedback loops (e.g. training delays exacerbate the following reinforcing loop: "the more you hire in the later stages, the worst the slippage due to training overheads."). This type of analysis also allows for risks to be managed as opportunities: feedback loops can be put to work in favour of the project.

SD simulation models allow the project manager to check whether and how certain feedback loops previously identified as "risk generators" will affect the project. In this way, irrelevant risks can be eliminated, preventing unnecessary mitigating efforts. Secondly, the calibration of the SD model uncovers important quantitative information about the project status and past, which typically is not measured because of its intangible and subjective nature. In this way, it forces planning assumptions to be made explicit and thereby identifying potential risks.

**Perform Qualitative Risk Analysis**
Influence diagrams can help to assess risk probability and impacts through feedback loop analysis. Given a specific risk, it is possible to identify in the diagram which feedback loops favour or counter the occurrence of the risk. Each feedback loop can be seen as a dynamic force that pushes the project outcome towards (or away) from the risk occurrence. The likelihood and the impact of each risk can be qualitatively inferred from this feedback loop analysis.

An SD simulation model can be used to identify the specific scenarios in which a risk would occur (i.e. likelihood). Regarding impact, with simple models and preliminary calibrations, quantitative estimates can be taken as qualitative indications of the order of magnitude of the risk impacts.

**Perform Quantitative Risk Analysis**
In quantifying risks, an SD project model provides two additional benefits over traditional models: first, it delivers a wide range of estimates, and secondly these estimates reflect the full impacts of risk occurrence, including both direct and indirect effects.

Quantifying the impact of a risk consists in calibrating the model for a scenario where the risk occurs (e.g. scope changes), and then simulate the project. One can virtually analyse the impact of the risk occurrence in any project variable, by comparing the produced behaviour pattern with the one obtained when a risk-absent scenario is simulated. For example, figure 2(b) shows the behaviour patterns produced by an SD project model when scope changes are introduced by the client over-time (curve 4). These patterns can be compared with the ones of figure 2(a), which shows the scenario where no scope changes are introduced.

This type of analysis allows the project manager to identify a risk’s impact on various aspects of the project (and overtime; not just the final value). In addition, the feedback nature of the SD model ensures that both direct and indirect impacts of risks are quantified – ultimately, when a risk occurs it will affect everything in the project, and the SD model captures the full impacts.

An SD project model generally includes variables related to the various project objectives (cost, time, quality, and scope). One can therefore assess the risk impacts on all dimensions of the project objectives. The SD model also allows for scenarios combining several risks to be simulated, whereby their cross impacts are also captured. Sensitivity analysis can be carried out to analyse the project’s sensitivity to certain risks as well as to their intensity (e.g. what is the critical productivity level below which problems will escalate?).

**Plan Risk Responses**
Influence diagrams and SD simulation models are very powerful tools to support the development of effective risk responses. They provide three main distinctive benefits: (i) support the definition and testing of complex risk-response scenarios, (ii) provide the feedback perspective for the identification of response opportunities, and (iii) they are very effective for diagnosing and understanding better the multifactor causes of risks; these causes can be traced back through the chains of cause-and-effect, with counter-intuitive solutions often being identified.

Influence diagrams provide the complementary feedback perspective. Therefore, the power to influence, change and improve results rests on acting on the project feedback structure. Risk responses can be identified as actions that eliminate vicious loops, or attenuate or reverse their influence on the project behaviour. By looking at the feedback loops and external factors identified as risks, the project manager can devise effective responses.
An SD simulation model provides a powerful test-bed where, at low cost and in a safe environment, various risk-responses can be developed, their effectiveness can be tested for the full impacts and can be improved prior to implementation.

**Risk Monitoring and Control**

An SD project model can be used as an effective tool for risk monitoring and control. The model can be used to identify early signs of risk emergence which otherwise would remain unperceived until problems were aggravated. The implementation of risks responses can also be monitored and their effectiveness can be evaluated.

Risk occurrence can be monitored by analysing the project behavioural aspects of concern (i.e. the risks "symptoms"). An SD model has the ability to produce many of these patterns, which in the real world are not quantified due to their intangible and subjective nature (the amount of undetected defects flowing throughout the development lifecycle is a typical example). The SD model provides a wide range of additional risk triggers, thereby enhancing the effectiveness of monitoring risk occurrence.

The implementation of a risk response can be characterized by changes in project behaviour. These changes can be monitored in the model to check whether the responses are being implemented as planned. The effectiveness of the risk response (i.e. the expected impacts) can be monitored in the same way. When deviations occur, the SD model can be used to diagnose why the results are not as expected.

### 5 Placing System Dynamics in the PMBOK Framework

System Dynamics modelling is a very complete technique and tool that covers a wide range of project management needs by addressing the systemic issues that influence and often dominate the project outcome. Its feedback and endogenous perspective of problems is very powerful, widening the range for devising effective management solutions. It is an appropriate approach to manage and model project risk dynamics, for which most of the traditional modelling techniques are inappropriate. SD therefore has a strong potential to provide a number of distinctive benefits to the overall project management process. One of the necessary conditions is that its application is integrated with the traditional models within that process. The SYDPIM methodology was developed for that purpose, integrating the use of SD project models with the traditional PERT/CPM models, based on the WBS and OBS structures [5]. SYDPIM provides SD models with specific roles within the project control process. One of these roles is to support the risk management activity.

As a proven tool and technique already applied with success to various real projects [10], SD needs to be properly placed in the PMBOK. This paper briefly discussed its potential roles within the six project risk management processes presented in the latest edition of the PMBOK [1]. It is concluded that SD has potential to provide added value to these processes, in particular to risk identification, risk quantification and to response planning.

Influence diagrams are already proposed by the PMBOK for risk identification (process 11.2). System Dynamics modelling is further proposed in the specialized Practice Standard for Project Risk Management [1] (PMI 2008), also for risk identification. This is an important acknowledgement that systemic problems in projects may require specialized techniques, different from and complementary to the more traditional ones. However, from practical experience in real projects and extensive research carried out in this field, it is the author’s opinion that the range of application of SD within the project management process is much wider. There are many other processes in the PMBOK framework where SD can be employed as a useful tool and technique. These benefits can be maximized based on the SYDPIM methodology.

It is also the author’s opinion that by implementing the SYDPIM-based risk framework proposed here, the project manager can take better advantage of the benefits offered by System Dynamics modelling, while enhancing the performance of the existing risk management process.

The use of System Dynamics in the field of Project Management and in particular for Project Risk Management has been deserving growing attention since the author first proposed an integrated process based approach [3], as reported in the literature.

### References


Farewell Edition


Additional Related Literature

Towards a New Perspective: Balancing Risk, Safety and Danger

Darren Dalcher

The management of risk has gradually emerged as a normal activity that is now a constituent part of many professions. The concept of risk has become so ubiquitous that we continually search for risk-based explanations of the world around us. Decisions and projects are often viewed through the lens of risk to determine progress, value and utility. But risk can have more than one face depending on the stance that we adopt. The article looks at the implications of adopting different positions regarding risk thereby opening a wider discussion about the links to danger and safety. In rethinking our position, we are able to appraise the different strategies that are available and reason about the need to adopt a more balanced position as an essential step towards developing a better informed perspective for managing risk and potential.

Keywords: Anticipation, Danger, Resilience, Risk, Risk Management, Safety.

Introduction

Imagine a clash between two worlds, one that is risk-averse, traditional and conservative, the other that is risk-seeking, opportunistic and entrepreneurial. The former is the old world, dedicated to the precautionary principle parading under the banner ‘better safe than sorry’. The latter is the new world, committed to the maxim ‘no pain, no gain’. The question we are asked to address is whether the defensive posture exhibited by the old world or the forever offensive stance of the new world is likely to prevail.

Would their attitude to risk determine the outcome of this question? The answer must be a qualified yes. The notion of risk has become topical and pervasive in many contexts. Indeed Beck [1] argues that risk has become a dominant feature of society, and that it has replaced wealth production as the means of measuring decisions.

In that Case, let’s survey the Combatants

Encamped on one bank, the old world is likely to resist the temptation of genetically modified crops and hormone-induced products despite the advertised potential benefits. Risk is traditionally perceived as negative quantity, danger, hazard or potential harm. Much of risk management is predicated around the concept of the precautionary principle, asserting that acting in anticipation of the worst form of harm should ensure that it does not materialise. Action is therefore biased towards addressing certain forms of risk that are perceived as particularly unacceptable and preventing them from occurring, even if scientific proof of the effects is not fully established. According to this principle, old-world risk regulators cannot afford to take a chance with some (normally highly political) risks.

The concept of risk has become so ubiquitous that we continually search for risk-based explanations of the world around us.

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Old-world thinking supports the adoption of precautionary measures even when some cause and effect relationships are not fully understood. In others words, the principle links hazards or threats with (scientific) uncertainty to demand defensive measures. Following the lead offered by the legal systems of Germany, Sweden and Denmark, the precautionary principle is likely to be fully embraced in guiding European Commission policy (such as the White Paper on Food Safety published by the Commission in 2000). When followed to the extreme, this policy leads to the pursuit of a zero-risk approach, which like zero defects will remain elusive.

Amassed opposite is the new world, where risks convey potential, opportunity and innovation. Risk offers the potential for gains, and occasionally creative chances and opportunities to discover new patterns of behaviour that can lead to serious advantage over the competition. Risk thus offers a key source of innovation. This can be viewed as the aggressive entrepreneurial approach to business.

**Who would you bet your Money on?**

In the old-world camp, risk management is a disciplined way of analysing risk and safety problems in well defined domains. The difficulty lies in the mix of complexity, ambiguity and uncertainty with human values where problems are not amenable to old-world technical solutions. New-world problems manifest themselves as human interactions with systems. They are complex, vexing socio-technical dilemmas involving multiple participants with competing interests and conflicting values (read that as opportunities)

A ground rule for the clash is that total elimination of risk is both impossible and undesirable. It is a natural human tendency to try to eliminate a given risk; however that may increase other risks or introduce new ones. Furthermore, the risks one is likely to attempt to eliminate are the better-known risks that must have occurred in the past and about which more is known. Given that elimination is not an option, we are forced into a more visible coexistence with the unexpected by conserving energy and utilising sur-

**Away with Danger?**

The old world equates risk with danger, in an attempt to achieve a safer environment. If only it were that simple! Safety may result from the experience of danger. Early programmes, models and inventions are fraught with problems. Experience accumulates through interaction with and resolution of these problems. Trial and error leads to the ability to reduce error. Eliminate all errors and you reduce the opportunity for true reflective learning.

Safety, be it in air traffic control systems, business environments, manufacturing or elsewhere, is normally achieved through the accumulated experience of taking risks. In the old world, the ability to know how to reduce risks inevitably grows out of historical interaction with risk. Solutions are shaped by past problems. Without taking risk to know how to reduce risks, you would not know which solutions are safe or useful.

What happens when a risk is actually reduced? Experience reveals that danger also comes with a price. As we feel safe, we tend to take more chances and attract new dangers. Research shows that the generation of added safety, through safety belts in cars or helmets in sport, encourages danger-courting behaviour, leading often to a net increase in overall risk taking. This may be explained by the reduced incentive to avoid a risk, once protection against it has been obtained.

Adding safety measures also adds to the overall complexity of the design process and the designed system, and to the number of interactions, thereby increasing the difficulty of understanding them and the likelihood of accidents and errors. In some computer systems, adding safety devices may likewise decrease the overall level of safety. The more interconnected the technology and the greater the number of components, the greater the potential for components to affect each other unexpectedly and to spread problems, and the greater the number of potential ways for something to go wrong.

So far we have observed that risk and danger maintain a paradoxical relationship, where risks can improve safety and safety measures can increase risks. Danger and benefits are intertwined in complex ways ensuring that safety always comes at a price. Safety, like risk, depends on the perception of participants.

**Predicting Danger**

The mitigation of risk, as practised in the old world, is typically predicated on the assumption of anticipation. It thus assumes that risks can be identified, characterised, quantified and addressed in advance of their occurrence. The separation of cause and effect, implied by these actions, depends on stability and equilibrium within the system. The purpose of intended action is to return the system to the status quo following temporary disturbances. The old world equates danger with deviation from the status quo, which must be reversed. The purpose of risk management is to apply resources to eliminate such disturbances. The old-world is thus busy projecting past experience into the future. It is thus perfectly placed to address previous battles but not new engagements.

The assumption of anticipation offers a bad bet in an uncertain and unpredictable environment. An alternative strategy is resilience, which represents the way an organism or a system adapts itself to new circumstances in a more active and agile search for safety. The type of approach applied by new-world practitioners calls for an ability to absorb change and disruption, keep options open, and deal with the unexpected by conserving energy and utilising sur-
plus resources more effectively and more creatively.

The secret in new-world thinking is to search for the next acceptable state rather than focus on returning to the previous state. In the absence of knowledge about the future, it is still possible to respond to change, by finding a new beneficial state as the result of a disturbance. Bouncing back and grabbing new opportunities becomes the order of the day. Entrepreneurs, like pilots, learn to deal with new situations through the gradual development of a portfolio of coping patterns and strategies that is honed by experience. Above all they learn to adapt and respond.

New-world actors grow up experimenting. Trial and experimentation makes them more knowledgeable and capable. Experiments provide information and varied experience about unknown processes, different strategies and alternative reaction modes. Intelligent risk-taking in the form of trial and error leads to true learning and ultimate improvement. The key to avoiding dramatic failures, and to developing new methods and practice in dealing with them, lies in such learning-in-the-small.

Acceptance of small errors is at the crux of developing the skills and capability to deal with larger problems. Small doses of danger provide the necessary feedback for learning and improvement. Similar efforts are employed by credit card companies, banks and security organisations, who orchestrate frequent threats and organised breaches of security to test their capability and learn new strategies and approaches for coping with problems. In the new world, taking small chances is a part of learning — and so is failure! Small, recognisable and reversible actions permit experimentation with new phenomena at relatively low risks. Once again we paradoxically discover that contained experimentation with danger leads to improved safety.

Large numbers of small moves, with frequent feedback and adjustment permit experimentation on a large scale with new phenomena at relatively low risks. Contained experimentation with danger leads to improved understanding of safety. Risk management is therefore a balancing act between stopping accidents, increasing safety, avoiding catastrophes and receiving rewards. Traditional mechanistically based risk management spends too much time and effort on minimising accidents; increasing safety, avoiding catastrophes and receiving rewards. Traditional mechanistically based risk management spends too much time and effort on minimising accidents: as a result it loses the ability to respond, ignores potential rewards and opportunities, and may face tougher challenges as they accumulate. It also focuses excessively on reducing accidents, to the extent that rewards are often neglected and excluded from decision-making frames. Such fixation with worst-case scenarios and anticipation of worst-case circumstances often leads to an inability to deal with alternative scenarios.

In the new world, safety is not a state or status quo, but a dynamic process that tolerates natural change and discovery cycles. It can thus be viewed as a discovered commodity. This resource needs to be maintained and cherished to preserve its relevance and value. Accepting safety (and even danger?) as a resource makes possible the adoption of a long-term perspective, and it thus becomes natural to strive for the continuous improvement of safety. While many organisations may object to the introduction of risk assessment and risk management because of the negative overtones, it is more difficult to resist an ongoing perspective emphasising improvement and enhanced safety. After all, successful risk assessment, like testing, is primarily concerned with identifying problems (albeit before they occur). The natural extension, therefore, is not to focus simply on risk as a potential for achievement, but to regard the safety to which it can lead as a resource worth cherishing.

Like other commodities, safety degrades and decays with time. The safety asset therefore needs continuous maintenance to reverse entropy and maintain its relevance with respect to an ever-changing environment. Relaxing of this effort will lead to a decline both in the level of safety and in its value as a corporate asset. In order to maintain its value, the process of risk management (or more appealingly, safety management) must be kept central and continuous.

Exploring risks as an ongoing activity offers another strategic advantage, in the form of the continuous discovery of new opportunities. Risk anticipation locks actors into the use of tactics that have worked in the past (even doing nothing reduces the number of available options). Resilience and experimentation can easily uncover new options and innovative methods for dealing with problems. They thus lead to divergence, and the value of the created diversity is in having the ability to call on a host of different types of solutions.

Miller and Freisen observe that successful organisations appear to be sensitive to changes in their environment [2]. Peters and Waterman [3] report that successful companies typically:

- experiment more,
- encourage more tries,
- permit small failures,
- keep things small,
- interact with customers,
- encourage internal competition and allow resultant duplication and overlap, and
- maintain a rich information environment.

Uncertainty and ambiguity lead to potential opportunities as well as ‘unanticipated’ risks. Resilience is built through experimentation, through delaying commitment,
through enabling, recognising and embracing opportunities and, above all, through the acquisition of knowledge, experience and practice in dealing with adversity-in-the-small.

Risk management requires flexible technologies arranged with diversity and agility. Generally, a variety of styles, approaches and methods are required to ensure that more problems can be resolved. This argument can be extended to propose that such a diverse armoury should include anticipation (which is essentially proactive), as well as resilience (essentially reactive in response to unknowable events) in various combinations. The two approaches are not mutually exclusive and can complement one another as each responds to a particular type of situation.

Resilience and exploration are ideal under conditions of ambiguity and extreme uncertainty. Anticipation can be used under risky, yet reasonably certain, conditions; while the vast space in between would qualify for a balanced combination of anticipation and resilience operating in concert.

The management of risks therefore needs to be coupled to the nature of the environment. After all, managing progress is not about fitting an undertaking to a (probably already redundant) plan, but is about reducing the difference between plan and reality. This need not be achieved through the elimination of problems (which may prove to be a source of innovation), but through adaptation to changing circumstances. By overcoming the momentum that resists change, with small incursions and experiments leading to rapid feedback, it becomes possible to avoid major disasters and dramatic failures through acting in-the-small and utilising agile risk management.

**Remember the two Worlds?**

Well, it appears we need both. The old world is outstanding in using available information in an effort to improve efficiency and execution, while the new world is concerned with potential, promise and innovation.

The single most important characteristic of success has often been described as conflict or contention. The clash between the worlds provides just that. It gives rise to a portfolio of attitudes, experiences and expertise that can be used as needed. Skilful manipulation of the safety resource and the knowledge of both worlds would entail balancing a portfolio of risks, ensuring that the right risks are taken and that the right opportunities are exploited while keeping a watchful eye on the balance between safety and danger. A satisfactory balance will thus facilitate the exploration of new possibilities alongside the exploitation of old and well-understood certainties. By consulting all those affected by risks, and by maximising the repertoire, it becomes possible to damp the social amplification of risk and to embrace risk and danger from an intelligent and collective perspective.

If this balance is not achieved, one of the two worlds will prevail. They will bring with them their baggage, which will dominate risk practice. A practice dominated by either ‘better safe than sorry’ or ‘no pain, no gain’ will be unable to combine the benefits of agile exploration and mature exploitation. Intelligent risk management depends on a dynamic balancing act that is responsive to environmental feedback.

Perhaps more importantly, the justification for creating such a balance lies in taking a long-term perspective and viewing safety as an evolving commodity. Risk management is not a service. A specific risk may be discrete, but risk management is a growing and evolving body of knowledge -- an improving asset. In this improvement lies the value of the asset.

"There is no point in getting into a panic about the risks of life until you have compared the risks which worry you with those that don’t, but perhaps should!"

Lord N. Rothschild, 1978

Once we graduate beyond viewing risk management as a fad offered by either world, we can find the middle ground and the benefit of both worlds.

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**To probe further:**

- [http://www.biotech-info.net/precautionary.html](http://www.biotech-info.net/precautionary.html).
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Managing Risk in Projects: What’s New?¹

David Hillson, "The Risk Doctor"

Project Risk Management has continued to evolve into what many organisations consider to be a largely mature discipline. Given this evolution we can ask if there are still new ideas that need to be considered in the context of managing project risks. In this article we consider the state of project risk management and reflect on whether there is still a mismatch between project risk management theory and practice. We also look for gaps in the available practice and suggest some areas where further improvement may be needed, thereby offering insights into new approaches and perspectives.


Humans have been undertaking projects for millennia, with more or less formality, and with greater or lesser degrees of success. We have also recognised the existence of risk for about the same period of time, understanding that things don’t always go according to plan for a range of reasons. In relatively recent times these two phenomena have coalesced into the formal discipline called project risk management, offering a structured framework for identifying and managing risk within the context of projects. Given the prevalence and importance of the subject, we might expect that project risk management would be fully mature by now, only needing occasional minor tweaks and modifications to enhance its efficiency and performance. Surely there is nothing new to be said about managing risk in projects?

While it is true that there is wide consensus on project risk management basics, the continued failure of projects to deliver consistent benefits suggests that the problem of risk in projects has not been completely solved. Clearly there must be some mismatch between project risk management theory and practice, or perhaps there are new aspects to be discovered and implemented, otherwise all project risks would be managed effectively and most projects would succeed.

"Project risk management offers a structured framework for identifying and managing risk within the context of projects"¹

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Project risk management offers a structured framework for identifying and managing risk within the context of projects

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The continued failure of projects to deliver consistent benefits suggests that the problem of risk in projects has not been completely solved.
Problems with Persistence

Even where a project team has a correct concept of risk that includes opportunity and addresses the wider context, and if they ensure that risk responses are implemented effectively and risk-related lessons are learned at the end of their project, and if they take steps to address risk attitudes proactively – it is still possible for the risk process to fail! This is because the risk challenge is dynamic, constantly changing and developing throughout the project. As a result, project risk management must be an iterative process, requiring ongoing commitment and action from the project team. Without such persistence, project risk exposure will get out of control, the project risk process will become ineffective and the project will have increasing difficulty in reaching its goals.

Insights from the new approach of "risk energetics" suggest that there are key points in the risk process where the energy dedicated by the project team to managing risk can decay or be dampened. A range of internal and external Critical Success Factors (CSFs) can be deployed to raise and maintain energy levels within the risk process, seeking to promote positive energy and counter energy losses. Internal CSFs within the control of the project include good risk process design, expert facilitation, and the availability of the required risk resources. Equally important are external CSFs beyond the project, such as the availability of appropriate infrastructure, a supportive risk-aware organisational culture, and visible senior management support.

So perhaps there is still something new to be said about managing risk in projects. Despite our long history in attempting to foresee the future of our projects and address risk proactively, we might do better by extending our concept of risk, addressing weak spots in the risk process, dealing with risk attitudes of both individuals and groups, and taking steps to maintain energy levels for risk management throughout the project. These simple and practical steps offer achievable ways to enhance the effectiveness of project risk management, and might even help us to change the course of future history.

Note: All of these issues are addressed in the book "Managing Risk in Projects" by David Hillson, published in August 2009 by Gower (ISBN 978-0-566-08867-4) as part of the Fundamentals in Project Management series.
Risk Management

Our Uncertain Future

David Cleden

Risk arises from uncertainty but it is difficult to express all types of uncertainty in terms of risks. Therefore managing uncertainty often requires an approach which differs from conventional risk management. A knowledge of the lifecycle of uncertainty (latency, trigger points, early warning signs, escalation into crisis) helps to inform the different strategies which can be used at different stages of the lifecycle. This paper identifies five tenets to help project teams deal more effectively with uncertainty, combining pragmatism (e.g. settle for containing uncertainty, don’t try to eliminate it completely), an emphasis on informed decision-making, and the need for projects to be structured in an agile fashion to increase their resilience in the face of uncertainty.

Keywords: Agility, Decision-Making, Latent Uncertainty, Management Strategies, Resilience, Risk, Trigger Point, Uncertainty, Uncertainty Lifecycle, Unexpected Outcomes.

1 Introduction

There is a fundamental truth that all management professionals would do well to heed: all risks arise from uncertainties, but not all uncertainties can be dealt with as risks. By this we mean that uncertainty is the source of every risk (arising from, for example, information that we don’t possess, something that we can’t forecast, decisions that have not yet been made). However, a set of project risks – no matter how comprehensive the risk analysis – will only address a subset of the uncertainties which threaten a project. We know this empirically. For every credible risk that is identified, we reject (or choose to ignore) a dozen others. These are ‘ghost risks’ – events considered to be most unlikely to occur, or too costly to make any kind of effective provision for. Risk management quite rightly acts on priorities: what are the threats that represent the greatest threat to this project, and what action can be take to reduce this threat? But prioritisation means that at some point the line is drawn: above it are the risks that are planned for and actively managed. Below the line, these risks have a low likelihood of occurring, or will have minimal impact if they do, or (sometimes) have no effective means of prevention or mitigation. Not surprisingly, where the line is drawn very much depends on a project’s ‘risk appetite’. A project with a low risk appetite where human lives or major investment is at stake, will be far more diligent in the risk analysis than one where the prospect of failure may be unwelcome but can be tolerated.

No matter where the line is drawn in terms of risks we choose to recognise, there remain risks that cannot be formulated at this time, no matter how desirable this might be. By definition, if we cannot conceive of a threat, we cannot formulate it as a risk and manage it accordingly, as Figure 1 shows. These may be the so-called ‘black swan’ events, or ‘bolts from the blue’ – things that it would be very difficult, if not impossible to know about in advance – or, just as likely, they may be gaps in our understanding or knowledge of the tasks to be undertaken.

A knowledge-based analytical approach is often helpful to understanding the threat from this kind of uncertainty. Some uncertainty is susceptible to analysis and can be managed as risks, but some cannot. We don’t know anything about these risks (principally because we have not or cannot conceive of them) but it is entirely possible that some of these would rank highly in our risk register if we could.

Let’s examine the possibilities (see Figure 2). The top-left quadrant describes everything that we know (or think we know) about the project. This is the knowledge which plans are built on, which informs our decision-making processes and against which we compare progress. Broadly speaking, these are the facts of the project.

Often there are more facts available than we realise. These are things that we don’t know, but could if we tried. This untapped knowledge can take many forms – a coll-

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league with relevant experience or skills that we haven’t consulted, lessons learnt from a previous project which could aid our decision-making, standards, guidelines and best practices which the project team have overlooked — and many other things besides. In the knowledge-centric view of uncertainty, clearly the more facts and information we possess, the better able we are to deal with uncertainty.

Naturally, no matter how good our understanding of the project’s context, there will always be gaps. By acknowledging this, we accept that there are some things about the project that we don’t know or can’t predict with accuracy (the classic ‘known unknowns’). However, as long as they can be conceived of, they can be addressed as risks using risk management techniques.

What does this leave us with? The fourth quadrant, the ‘unknown unknowns’ represents the heart of uncertainty. This kind of uncertainty is unfathomable; it is not susceptible to analysis in the way that risks are. By definition we have little knowledge of its existence (although if we did, we might be able to do something about it). Some terrible event (a natural disaster or freak combination of circumstances, say) may occur tomorrow which will fundamentally undermine the basis on which the project has been planned, but we have no way of knowing the specifics of this event or how it might impact the project.

Note that it is possible to know a situation is unfathomable without being able to change the fundamental nature of the uncertainty. Someone may tell us that a terrible danger lurks behind a locked door, but we still have no idea (and no practical way of finding out) what uncertainty faces us if we unlock the door and enter. We know the situation is unfathomable but we don’t know what it is that we don’t know. In other words, the future is still unforeseeable.

All this points to a need for a project to have not only a sound risk management strategy in place, but an effective strategy for dealing with uncertainty. The unfathomable uncertainty of ‘unknown unknowns’ may not be susceptible to the kind of analysis techniques used in risk management, but that doesn’t mean a project cannot be prepared to deal with uncertainty.

### 2 The Lifecycle of Uncertainty

Any strategy for managing project uncertainty depends on an understanding of the lifecycle of uncertainty. At different stages in this lifecycle we have different opportunities for addressing the issues.

It begins with a source of uncertainty (see Figure 3). In the moment of crisis we may not always be aware of the source, but hindsight will reveal its existence. If detected early enough, *anticipation strategies* can be used to contain the uncertainty at source. Anticipating uncertainty often means trying to learn more about the nature of the uncertainty; for example by framing the problem it represents, or modelling future scenarios and preparing for them. Using *discovery techniques* such as constructing a knowledge map of what is and isn’t known about a particular issue can highlight key aspects of unfathomable uncertainty. Of course, once a source of uncertainty is revealed, it is no longer unfathomable and can be dealt with as a project risk.

The greatest threat arises towards the end of the uncertainty lifecycle as problems gain momentum and turn into crises. Something happens to trigger a problem, giving rise to an unexpected event. For example, it may not be until two components are integrated that it becomes apparent that incorrect manufacturing tolerances have been used. The latent uncertainty (what manufacturing tolerance is needed?) triggers an unexpected outcome (a bad fit) only at the point of component integration, even though the uncertainty could have been detected much earlier and addressed.

This trigger may be accompanied by early warning signs.

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**Figure 1**: Not All Uncertainties can be analysed and formulated as Risks.

**Figure 2**: A Knowledge-centric View of Uncertainty and Risk.
An alert project manager may be able to respond swiftly and contain the problem even without prior knowledge of the uncertainty, either by recognising the warning signs or removing the source of uncertainty before it has a chance to develop.

It is also worth remembering that many kinds of uncertainty will never undergo the transition which results in an unexpected outcome. Uncertainty which doesn’t manifest as a problem is ultimately no threat to a project. Once again, the economic argument (that it is neither desirable nor possible to eliminate all uncertainty from a project) is a powerful one. The goal is to focus sufficient effort on the areas of uncertainty that represent the greatest threat and have the highest chance of developing into serious problems.

Based on this understanding of the uncertainty lifecycle, different sets of strategies are effective at different points:

- **Knowledge-centric strategies**: These help to reveal the sources of uncertainty, resolve them where possible or prepare appropriately, for example through mitigation planning and risk management.
- **Anticipation strategies**: These offer a more holistic approach than the knowledge-centred view of uncertainty. By looking at a project from different perspectives, for example by visualising future scenarios and examining causal relationships, previously hidden uncertainties are revealed.
- **Resilience strategies**: Trying to contain uncertainty at source will never be 100 percent successful. Therefore, a project needs resilience and must be able to detect and respond rapidly to unexpected events. Whilst it is impossible

"All risks arise from uncertainties, but not all uncertainties can be dealt with as risks"
to predict the nature of the problems in advance, a project manager can employ strategies which will imbue their projects with much greater resilience.

- **Learning strategies:** These give the project manager and the organisation as a whole the ability to improve and benefit from experience over time. No two projects face exactly the same uncertainty, so it is important to be able to adapt and learn lessons.

3 Five Tenets for Dealing Effectively with Project Uncertainty

3.1 **Aim to contain Uncertainty, not eliminate it**

No individual can bring order to the universe, and neither can the project manager protect his or her project from every conceivable threat. Managers who try to do this labour under unworkable risk management regimes, constructing unwieldy risk logs and impossibly costly mitigation plans. Amidst all the effort being poured into managing small, hypothetical risks (the ‘ghost risks’), a project manager may be too busy to notice that the nuts and bolts of the project – where the real focus of attention should be – have come loose. It is much better to concentrate on detecting and reacting swiftly to early signs of problems. Whilst uncertainty can never be entirely eliminated, it can mostly certainly be contained, and that should be good enough. Ultimately this is a far more effective use of resources.

"Managing uncertainty often requires an approach which differs from conventional risk management"

It may be helpful to visualise the project as existing in a continual state of dynamic tension (see Figure 4). The accumulation of uncertainties continually tries to push the project off its planned path. If left unchecked, the problems may grow so severe that there is no possibility of recovering back to the original plan.

The project manager’s role is to act swiftly to correct the deviations, setting actions to resolve issues, implementing contingency plans or nipping problems in the bud. This requires mindfulness and agility: mindfulness to be able to spot things going wrong at the earliest possible stage, and agility in being able to react swiftly and effectively to damp down the problems and bring the project back on track.

3.2 **Uncertainty is an Attribute not an Entity in its Own Right**

We often talk about uncertainties as if they are discrete objects when in fact uncertainty is an attribute of every aspect of the project. The ‘object’ model of uncertainty is unhelpful because it suggests that there are clusters of uncertainties hiding away in the darker corners of the project. If only we could find them, we could dispose of them and our project would be free of uncertainty.

Once this is accepted, it becomes pointless to attempt to manage uncertainty in isolation from everything else. A project manager cannot set aside a certain number of hours each week to manage uncertainty, it is inherent in every decision taken. Uncertainty cannot be compartmentalised.
Figure 5: Collective Team Responsibility to react rapidly during the Transition Period is Key to minimising the Impact of Uncertainty.

“A knowledge of the lifecycle of uncertainty helps to inform the different strategies which can be used at different stages of the lifecycle”

Figure 6: Four Possible Modes for confronting Major Uncertainty.
It lurks in all project tasks, in their dependencies and underlying assumptions.

Alertness to any deviation from the norm is vital. A culture of collective problem ownership and responsibility is also important. All team members need to be capable of resolving issues within their domain as soon as they are spotted. The period between a trigger event and a full-blown crisis is often small, so there may not always be time to refer up the management chain and await a decision. The ability to act decisively – often on individual initiative – needs to be instilled in the team and backed up by clear lines of responsibility and powers of delegation. In time, this should become part of the day job for members of the team at all levels.

Project tolerances can sometimes mask emerging uncertainty. Thresholds need to be set low enough so that issues are picked up early in the uncertainty lifecycle, giving more time to react effectively. It also depends on the nature of the metrics being used to track progress, for example: number of defects appearing at the prototyping stage, individual productivity measures, number of client issues flagged, etc. Choose the metrics carefully. The most obvious metrics will not necessarily give the clearest picture (or the earliest warning) of emerging problems.

3.3 Put Effective Decision-making at the Heart of Managing Uncertainty

When faced with uncertainty, the project manager has several options available (see Figure 6). The project manager must decide how to act – either by suppressing uncertainty (perhaps through plugging knowledge gaps), or adapting to it by drawing up mitigation plans, or detouring around it and finding an alternative path to the project’s goals.

Whichever action is taken, the quality of decision-making determines a project’s survival in the face of uncertainty and is influenced by everything from individual experience, line management structures, to the establishment of a blame-free culture which encourages those put on the spot to act in the project’s best interests with confidence. As the old adage says: Decisions without actions are pointless. Actions without decisions are reckless.

The most commonly used tactic against major uncertainty is to suppress it, reduce the magnitude of the uncertainty and hence the threat it represents. If this can be done pre-emptively by reducing the source of the uncertainty, the greatest benefits will be achieved. Avoiding uncertainty by suppressing it sounds like a safe bet – and it is, providing it can be done cost-effectively. As the first tenet states, reduction is the goal, not elimination. For novel or highly complex projects, particularly those with many co-dependencies, it may be too difficult or costly to suppress all possible areas of uncertainty.

By adapting to uncertainty, the project tolerates a working level of uncertainty but is prepared to act swiftly to limit the most damaging aspects of any unexpected events. This is a highly pragmatic approach. It requires agile and flexible management processes which can firstly detect emerging issues in their infancy and secondly, deal with them swiftly and decisively. For example, imagine a yacht sailing in strong winds. The helmsman cannot predict the strength of sudden gusts or the direction in which the boat will be deflected, but by making frequent and rapid tiller adjustments, the boat continues to travel in an approximately straight line towards its destination.

Given the choice, we should like to detour around all areas of uncertainty. Avoiding the source of uncertainty means that the consequences (that is, the unexpected outcomes) are no longer relevant to the project. Thus there is no need to take costly precautions to resolve unknowns or deal with their repercussions. Unfortunately, detouring around uncertainty is hard to achieve, for two reasons.

Firstly, many sources of uncertainty are simply unavoidable,
able, or the avoidance measures are too costly. Consider the example of a subcontractor who, it later transpires, may be incapable of delivering a critical input on time. We could detox around this uncertainty by dismissing the subcontractor in favour of some competitor who can provide a better service. This will mean cancelling existing contracts, researching the marketplace and renegotiating commercial terms with an alternative supplier – all time-consuming and potentially costly activities – and with the risk of being no better off with the alternative supplier.

Secondly, detouring only works for quantifiable uncertainty (the ‘known unknowns’). Unfathomable uncertainty may well strike too rapidly to permit a detour.

Our final option is reorientation. This is a more dramatic form of detour where we aim for a modified set of objectives in the face of insurmountable uncertainty. Highly novel projects sometimes have to do this. To plough on in the face of extreme uncertainty risks total failure. The only alternative is to redefine the goals, that is, reorient the project in a way that negates the worst of the uncertainty. This is not a tactic for the faint-hearted. Convincing the client that a project cannot be delivered as originally conceived is no easy task. But it is worth asking the question, “Is it better to deliver something different (but broadly equivalent) than nothing at all?”

3.4 Uncertainty encompasses both Opportunity and Threat

It is important to seize opportunities when they arise. If some aspects of a project are uncertain, it means there are still choices to be made, so we must choose well. Too often, the negative consequences dominate the discussion, but perhaps the project can achieve more than was planned, or achieve the same thing by taking a different path. Is there a chance to be innovative? Project managers must always be open to creative solutions. As Einstein said, “We can’t solve problems by using the same kind of thinking we used when we created them.”

All approaches to dealing with uncertainty depend to a greater or lesser extent on being able to forecast future events. The classic approach is sequential: extrapolating from one logical situation to the next, extending out to some point in the future. But with each step, cumulative errors build up until we are no longer forecasting but merely enumerating the possibilities.

Suppose instead we don’t try to forecast what will happen, but focus on what we want to happen? This means visualising a desired outcome and examining which attributes of that scenario are most valuable. Working backwards from this point, it becomes possible to see what circumstances will naturally lead to this scenario. Take another step back, and we see what precursors need to be in place to lead to the penultimate step – and so on until we have stepped back far enough to be within touching distance of the current project status. (See Figure 7).

This approach focuses on positive attributes (what are the project’s success criteria?) not the negative aspects of the risks to be avoided. Both are important, but many project managers forget to pay sufficient attention to nurturing the positive aspects. By ‘thinking backwards’ from a future scenario, the desired path often becomes much clearer. It is ironic that ‘backward thinking’ is often just what is needed to lead a project forward to successful completion.

3.5 Meet Uncertainty with Agility

Perhaps the best defence against uncertainty is to organise and structure a project in a sufficiently agile fashion to be resilient to the problems that uncertainty inevitably brings. This manifests in two ways: how fast can the project adapt and cope with the unexpected, and how flexible is the project in identifying either new objectives or new ways to achieve the same goals?

One approach is to ensure that the project only ever takes small steps. Small steps are easier to conceptualise, plan for and manage. They can be retraced more easily if they haven’t delivered the required results or if it becomes clear they are leading in the wrong direction. Small steps also support the idea of fast learning loops. For instance, a lengthy project phase reduces the opportunity to quickly feedback lessons learned. If the project is too slow to respond, it may fail under the accumulated weight of uncertainty.

More iterative ways of working are becoming increasingly common and do much to increase the agility of a project. A feature of monolithic projects (i.e. those which do not follow an iterative strategy) is the assumption that everything proceeds more or less as a sequence of tasks executed on a ‘right first time’ basis. Generally speaking, more effort is directed at protecting this assumption (for example, by analysing and mitigating risks which may threaten the task sequence) than on planning for a certain level of rework. In contrast, by planning to tackle tasks iteratively, two benefits are gained: firstly, early sight of unfathomable issues which wouldn’t otherwise surface until much later in the schedule, and secondly, greater opportunity to make controlled changes.

Finally, an agile project is continuously looking for ways to improve. A project which is unable (or unwilling) to learn lessons is destined to repeat its early mistakes because it ignores opportunities to learn from the unexpected. Some lessons are obvious, some require much soul-searching, brainstorming or independent analysis. What matters above all else is that the improvements are captured and disseminated and the changes implemented, either in the latter project stages or in the next project the organisation undertakes.
The application of the ‘New Sciences’ to Risk and Project Management

David Hancock

The type of problems that need to be solved in organizations are very variable in terms of their complexity ranging from ‘tame’ problems to ‘wicked messes’. We state that projects tend to have the characteristics of wicked messes where decision making gets confused by behavioural and dynamic complexities which coexist and interact. To address the situation we cannot continue to rely on sequential resolution processes, quantitative assessments and simple qualitative estimates. We propose instead to develop the concept of risk leadership which is intended to capture the activities and knowledge necessary for project managers to accommodate the disorder and unpredictability inherent in project environments through flexible practices leading to negotiated solutions.

Keywords: Behavioural Complexities, Chaotic Systems, Dynamic Complexities, Quantitative Assessments, Qualitative Estimates, Risk Leadership, Risk Management, Scientific Management, Tame Problems, Wicked Problems.

"We’re better at predicting events at the edge of the galaxy or inside the nucleus of an atom than whether it’ll rain on auntie’s garden party three Sundays from now. Because the problem turns out to be different. We can’t even predict the next drip from a dripping tap when it gets irregular. It’s the best possible time to be alive, when almost everything you thought you knew is wrong."

"Arcadia" by Tom Stoppard

Introduction

There is a feeling amongst some risk practitioners, myself included, that theoretical risk management has strayed from our intuition of the world of project management. Historically, project risk management has developed from the numerical disciplines dominated by a preoccupation with statistics (Insurance, accountancy, engineering etc.) This has led to a bias towards the numerical in the world of project management.

In the 1950’s a new type of scientific management was emerging, that of project management. This consisted of the development of formal tools and techniques to help manage large complex projects that were considered uncertain or risky. It was dominated by the construction and engineering industries with companies such as Du Pont developing Critical Path Analysis (CPA) and RAND Corp developing Programme Evaluation and Review Technique (PERT) techniques. Following on the heels of these early project management techniques, institutions began to be formed in the 1970’s as repositories for these developing methodologies. In 1969 the American Project Management Institute (PMI) was founded; in 2009 the organization has more than 420,000 members, with 250 chapters in more than 171 countries. It was followed in 1975 by the UK Association of Project Managers (changed to Association for Project Management in 1999) with its own set of methodologies. In order to explicitly capture and codify the processes by which they believed projects should be managed, they developed qualifications and guidelines to support them. However, whilst the worlds of physics, mathematics, economics and science have moved on beyond Newtonian methods to a more behavioural understanding, the so called new sciences, led by eminent scholars in the field such as Einstein, Lorenz and Feynman. Project and risk management appears largely to have remained stuck to the principles of the 1950’s.

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Box 1: The Butterfly Effect

In 1961 whilst working on long range weather prediction, Edward Lorenz made a startling discovery. Whilst working on a particular weather run rather than starting the second run from the beginning he started it part way through using the figures from the first run. This should have produced an identical run but he found that it started to diverge rapidly until after a few months it bore no resemblance to the first run. At first he thought he had entered the numbers in error. However this turned out to be far from the case, what he had actually done was round the figures and instead of using the output of 6 decimal places had used only three (.506 instead of .506127). The difference one part in a thousand he had considered inconsequential especially as a weather satellite being able to read to this level of accuracy is considered quite unusual. This slight difference had caused a massive difference in the resulting end point. This gave rise to the idea that a butterfly could produce small undetectable changes in pressure which would considered in the model and this difference could result in altering the path, delaying or stopping of a tornado over time.

Edward N Lorenz . 1972 Predictability: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?

Figure: Two pendulums with an initial starting difference of only 1 arcsec (1/3600 of a degree).

Table 1: The implications of the New Concept of Risk Leadership.

Risk Management

The general perception amongst most project and risk managers that we can somehow control the future is, in my opinion, one of the most ill-conceived in risk management. However, we have made at least two advances in the right direction. Firstly, we now have a better understanding about the likelihood of unpleasant surprises and, more importantly, we are learning how to recognise their occurrence early on and subsequently to manage the consequences when they do occur.

Qualitative and Quantitative Risk

The biggest problem facing us is how to measure all these risks in terms of their potential likelihood, their possible consequences, their correlation and the public’s perception of them. Most organisations measure different risks using different tools. They use engineering estimates for property exposures, leading to MFLs (maximum foreseeable loss) and PMLs (probable maximum loss). Actuarial projections are employed for expected loss levels where sufficient loss data is available. Scenario analyses and

“The type of problems that need to be solved in organizations are very variable in terms of their complexity ranging from ‘tame’ problems to ‘wicked messes’”
Monte Carlo simulations are used when data is thin, especially to answer how much should I apply questions. Probabilistic and quantitative risk assessments are used for toxicity estimates for drugs and chemicals, and to support public policy decisions. For political risks, managers rely on qualitative analyses of ‘experts’. When it comes to financial risks (credit, currency, interest rate and market), we are inundated with Greek letters (betas, thetas, and so on) and complex econometric models that are comprehensible only to the trained and initiated. The quantitative tools are often too abstract for laymen, whereas the qualitative tools lack mathematical rigour. Organisations need a combination of both tools, so that they can deliver sensible and practical assessments of their risks to their stakeholders. Finally it is important to remember that the result of quantitative risk assessment development should be continuously checked against one’s own intuition about what constitutes reasonable qualitative behaviour. When such a check reveals disagreement, then the following possibilities must be considered:

1. A mistake has been made in the formal mathematical development;
2. The starting assumptions are incorrect and/or constitute too drastic oversimplification;
3. One’s own intuition about the field is inadequately developed;
4. A penetrating new principle has been discovered.

**Tame Messes and Wicked Problems**

One of the first areas to be investigated is whether our current single classification of projects is a correct assumption. The general view at present appears to treat them as linear, deterministic predictable systems, where a complex system or problem can be reduced into simple forms for the purpose of analysis. It is then believed that the analysis of those individual parts will give an accurate insight into the working of the whole system. The strongly held feeling that science will explain everything. The use of Gant charts with their critical paths and quantitative risk models with their corresponding risk correlations would support this view. However this type of problem which can be termed *tame* appears to be the only part of the story when it comes to defining our projects.

Tame problems are problems which have straight-forward simple linear causal relationships and can be solved by analytical methods, sometimes called the cascade or waterfall method. Here lessons can be learnt from past events and behaviours and applied to future problems, so that best practices and procedures can be identified. In contrast *messes* have high levels of system complexity and are clusters of interrelated or interdependent problems. Here the elements of the system are normally simple, where the complexity lies in the nature of the interaction of its elements. The principle characteristic of which is that they cannot be solved in isolation but need to be considered holistically. Here the solutions lie in the realm of systems thinking. Project management has introduced the concepts of Programme and Portfolio management to attempt to deal with this type of complexity and address the issues of interdependencies. Using strategies for dealing with messes is fine as long as most of us share an overriding social theory or social ethic; if we don’t we face ‘wickedness’. Wicked problems are termed as ‘divergent’, as opposed to ‘convergent’ problems. Wicked problems are characterised by high levels of behavioural complexity. What confuses real decision-making is that behavioural and dynamic complexities co-exist and interact in what we call wicked messes. Dynamic complexity requires high level conceptual and systems thinking skills; behavioural complexity requires high levels of relationship and facilitative skills. The fact that problems cannot be solved in isolation from one another makes it even more difficult to deal with people’s differing assumptions and values; people who think differently must learn about and create a common reality, one which none of them initially understands adequately. The main thrust to the resolution of these types of problems is stakeholder participation and ‘satisficing’. Many risk planning and forecasting exercises are still being undertaken on the basis of tame problems that assume the variables on which they are based are few, that they are fully understood and able to be controlled. However uncertainties in the economy, politics and society have become so great as to render counterproductive, if not futile, this kind of risk management that many projects and organisations still practise.

"To address the situation we cannot continue to rely on sequential resolution processes, quantitative assessments and simple qualitative estimates"

"We propose instead to develop the concept of risk leadership which is intended to capture the required activities and knowledge"
Chaos and Projects

At best I believe projects should be considered as deterministic chaotic systems rather than tame problems. Here I am not using the term Chaos as defined in the English language which tends to be associated with absolute randomness and anarchy (Oxford English Dictionary describes chaos as "complete disorder and confusion") but based on the Chaos theory developed in the 1960's. This theory showed that systems which have a degree of feedback incorporated in them, that tiny differences in input could produce overwhelming differences in output. (The so called Butterfly effect see Box 1[1]). Here chaos is defined as aperiodic (never repeating twice) banded dynamics (a finite range) of a deterministic system (definite rules) that is sensitive on initial conditions. This appears to describe projects much better than the linear deterministic and predictable view. In which both randomness and order could exist simultaneously within those systems. The characteristics of these types of problem are that they are not held in equilibrium either amongst its parts or with its environment but are far from being held in equilibrium and the system operates ‘at the edge of chaos’ where small changes in input can cause the project to either settle into a pattern or just as easily veer into total discord. For those who are sceptical consider the failing project that receives new leadership it can just as easily move into abject failure as settle into successful delivery and at the outset we cannot predict with any certainty which one will prevail. At worst they are wicked messes.

Conclusion

How should the project and risk professional exist in this world of future uncertainty? Not by returning to a reliance on quantitative assessments and statistics where none exists. We need to embrace its complexities and understand the type of problem we face before deploying our armoury of tools and techniques to uncover a solution, be they the application of quantitative data or qualitative estimates. To address risk in the future tense we need to develop the concept of ‘risk leadership’ which consists of:

- Guiding rather than prescribing
- Adapting rather than formalising
- Learning to live with complexity rather than simplifying
- Inclusion rather than exclusion
- Leading rather than managing
- The implications of the new concept of risk leadership are described in Table 1.

What does this all mean? At the least it means we must apply a new approach for project and risk management for problems which are not tame. That we should look to enhance our understanding of the behavioural aspects of the profession and move away from a blind application of process and generic standards towards an informed implementation of guidance. That project and risk management is more of an art than a science and that this truly is the best time to be alive and being in project and risk management.

References

Project management practitioners and scientists assume that risk management contributes to project success through better planning of time, money and requirements. However, current literature on the relation between risk management and IT project success provides hardly any evidence for this assumption. Nevertheless, risk management is used frequently on IT projects. Findings from new research provide evidence that individual risk management activities are able to contribute to project success through "communicative effects". Risk management triggers or stimulates action taking, it influences and synchronizes stakeholders’ perceptions and expectations and it shapes inter-stakeholder relationships. These effects contribute to the success of the project.
Risk management in general deliberately overestimate the benefits of the project and at the same time they underestimate the project risks at the start of the project [6]). Finally, various authors (e.g. [7]) indicate that the complete sequence of risk management activities is often not followed in projects, consequently the assumption of rational problem solving is incorrect.

Not only is there very little evidence from recent literature that risk management contributes to IT project success, empirical findings thus far indicate it is also unlikely that risk management is able to contribute to IT project success. Taking into consideration the remarks made by various authors about the limitations of IT projects, risk management is able to contribute to IT project success if the project: (1) has clear and fixed requirements, (2) uses a strict method of system development, and (3) has historical and applicable data available, collected from previous projects. The combination of the three mentioned criteria will only occasionally be met in IT projects. As an example we can consider the development of a software module of known functionality and function points by a software development organisation, certified on CMM level 4 or 5.

It remains remarkable that there is such a large gap between project risk management in theory and project risk management in practice. Findings from research indicate that the complete risk management process as described for instance in the PMI Body of Knowledge [8], is often not followed [9], or even that practitioners do not see the value of executing particular steps of the risk management process [7]. In addition, it is remarkable that both project management Bodies of Knowledge and established current literature ignore the results from research which indicate the assumptions and mechanisms that underpin project risk management only work in specific situations, or do not work at all. This should at least lead to a discussion about the validity of certain elements of the Bodies of Knowledge, and to the adjustment of the project risk management process, which is claimed to be founded on good practice [8] or even Best Practice [10].

### 3 An Additional View to Project Risk Management

An important assumption in the current literature underpinning both project management and the way risk management influences the project and consequently project success, is the assumption that projects are taking place in a reality that is known, and that reality is responding according to the laws of nature the project stakeholders either know or may be able to know (see e.g. [11]). This so called instrumentalism assumption defines project risk management, its effects, and the object on which project risk management works, i.e. the project, in instrumental terms. Figure 1 depicts the relation between risk management and the project in traditional terms, in other words under the assumption of instrumentalism.

Risk management may work well in situations in which the object of risk management can be described in terms of predictable behaviour (the instrumental context), for instance controlling an airplane or a nuclear power plant, or a piece of well defined software that must be created as part of an IT project. Risk management is then an analytical process in which information is collected and analysed on events that may negatively influence the behaviour of the object of risk management. However, projects, and particularly IT projects, generally consist of a combination of elements that contain both predictable and human behaviour; the latter of
which is not always predictable. The presence of human behaviour makes a project a social object, an object which does not behave completely predictably.

Furthermore, human behaviour, together with human interaction, plays a role in the risk management process itself. During the various activities of the risk management process, participants in these activities interact with each other. Risk management can then no longer be considered instrumental action, but should be considered social action instead. These interactions between participants in the risk management process may be able to create effects in addition to the assumed instrumental effects of risk management.

Figure 2 presents this adjusted view on the relationship between risk management and the project.

This adjusted view, which considers risk management as being social action working on a social object, instead of instrumental action working on an instrumental object, leads to various changes in model definitions and assumptions compared to the traditional view.

The adjusted view considers project success to be the result of a personal evaluation of project outcome characteristics by each stakeholder individually (see e.g. [12]). Timely delivery, delivery within budget limits and delivery according to requirements, being the traditional objective project success criteria, may play an important role in this stakeholder evaluation process, but they are no longer the only outcomes that together determine if the project can be considered a success. Therefore, project success becomes opinionated project success, and is no longer considered as something that can be determined and measured only in objective terms.

The adjusted view, considering risk management in terms of social action, implies that risk management is a process in which participants interact with each other. In addition to the traditional view, which considers risk management only in terms of instrumental action and instrumental effects, the additional view assumes that interaction between participants or social interaction exists, which may lead to additional effects on the project and its success (see Figure 3). This research refers to these effects resulting from interaction as “communicative effects”, and the research assumes that each risk management activity individually may be able to generate communicative effects and may therefore individually contribute to project success.

Generally speaking, this additional view on risk management creates an environment in which human behaviour and perception play central roles in terms of describing the effect of risk management and the success of the project.

New research provides evidence that individual risk management activities are able to contribute to project success through ‘communicative effects’.
### Case 1 Sector: Food industry

**Project description**
SAP system implemented on two geographic locations in four organisational units. System used to support a number of different food production processes and financial activities.

**Duration**
13 months

**Additional information**
Use of method for organisational change, not for project management. Time & Material project contract. External project manager, hired by the customer, and not related to the IT supplier.

### Case 2 Sector: Government

**Project description**
SAP system implemented on 40 locations. System used for production, issuing and administration of personalized cards that provide access to office buildings. SAP linked on all 40 locations to peripheral equipment (photo equipment, card printers).

**Duration**
17 months

**Additional information**
Internal project with internal project manager. Limited number of external personnel. No formal project contract. Limited Prince2 methodological approach, combined with organization specific procedures and templates.

### Case 3 Sector: Government

**Project description**
SAP system implemented on four locations. System used for scheduling duty rosters of around 3000 employees. Time critical project because of expiring licences of previous scheduling system.

**Duration**
24 months (including feasibility study), 21 months excl.

**Additional information**
Internal project with internal project manager. Limited number of external personnel. No formal project contract. Limited Prince2 methodological approach, combined with organization specific procedures and templates.

### Case 4 Sector: Energy

**Project description**
Creation from scratch of a new company, being part of a larger company. SAP designed and implemented to support all business processes of the new company. SAP system with high level of customization.

**Duration**
9 months (for stage 1; time according to original plan, but with scope limited)

**Additional information**
The ERP project was part of a much larger project. Fixed price, fixed time, fixed scope contract with financial incentives. Project manager from IT Supplier. Project restarted and re-scoped after failure of first attempt. Strict use of (internal) project management methodology, procedures and templates.

### Case 5 Sector: Public utility (social housing)

**Project description**
ERP system based on Microsoft Dynamics Navision. Implemented to support various primary business processes, for instance: customer contact, contract administration, property maintenance.

**Duration**
12 months

**Additional information**
Time and material contract. Project restart after failure of first attempt. Project manager from IT supplier organization. Limited Prince2 methodological approach.

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**Table 1A:** Overview of Seven investigated ERP Implementation Projects.
The additional view acknowledges the influence of stakeholders interacting with each other, and influencing each other through communication. By doing so, this additional view positions itself outside the strict instrumental or “traditional” project management approach that can be found in project management Bodies of Knowledge. However, the additional view does not deny the fact that risk management may influence project success in an instrumental way; it only states that in addition to the potential instrumental effect of risk management, there is a communicative effect. Given the limitations of the effectiveness of the instrumental effect, the influence of the communicative effect of risk management on project success may probably be larger than the influence of the instrumental effect.

4 Results from Case Studies

Seven ERP implementation projects were investigated for the presence of communicative effects as a result of the project risk management process. Presented here is a table (Table 1) with an overview of all investigated ERP implementation projects. A total number of 19 stakeholders from the various projects were interviewed. Data collection took place between one and two months after project completion.

Considering project success, two projects score low on objective project success because of serious issues with time, budget and requirements; both projects had a restart. Four projects score medium on objective project success, all having minor issues with one or more of the objective success criteria. One project scores high on objective project success. Variation on opinionated project success is low. Stakeholders from the two low objective success projects score lower on opinionated project success than stakeholders from the other five projects, but based on the objective success scores, the difference is less than expected.

ERP implementation projects that participated in the research were selected based on the criterion that they had done “something” on risk management. The sample of projects therefore does not include projects that performed no risk management at all. Risk identification is conducted on all projects, in various formats including brainstorm sessions, moderated sessions and expert sessions. Risk analysis was carried out in five projects, but only in a rather basic way; none of the projects used techniques for quantitative risk analysis. Other risk management activities, the use of which were investigated in the projects are: the planning of the risk management process, the registration of risks, the allocation of risks to groups or individuals, the report-

Table 1B: Overview of Seven investigated ERP Implementation Projects.

<table>
<thead>
<tr>
<th>Case</th>
<th>Sector</th>
<th>Duration</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Public utility (social housing)</td>
<td>11 months</td>
<td>Time and material contract. External project manager, hired by the customer organization and with no formal relation to the IT Supplier. No formal project management methodology used</td>
</tr>
<tr>
<td>7</td>
<td>Petro-chemical industry</td>
<td>14 months (ready for hand-over as planned)</td>
<td>The ERP project was part of a larger project. The ERP project budget was low (less than 5%) compared to the overall deal (approx. 400 million EUR). Internal project manager. Fixed time project, but delayed several times because of external factors. Internal project management guidelines and templates used</td>
</tr>
</tbody>
</table>

1 This typology of effects is based on The Theory of Communicative Action by Jürgen Habermas (1984) [13]. In order to avoid an excessively wide scope for this article, this theoretical background is not discussed here.
Risk Management

Risks in IT projects cannot be managed by means of the risk management process.

The case studies’ results demonstrate that, according to stakeholders, project risk management activities contribute to the perceived success of the project. Risk identification is, by all stakeholders, considered to be the risk management activity that contributes most to project success. Furthermore, stakeholders provide a large number of indications on how risk identification, in their view, contributes to project success. Finally, risk identification is, by stakeholders, considered to be able to contribute to project success through a number of different effects: Action, Perception, Expectation and Relation effects.

Risk identification triggers, initiates or stimulates action taking or making actions more effective (Action effect). It influences the perception of an individual stakeholder and synchronizes various stakeholders’ perceptions (Perception effect). It influences the expectations of stakeholders towards the final project result or the expectations on stakeholder behaviour during project execution (Expectation effect). Finally, it contributes to the process of building and maintaining a work and interpersonal relationship between project stakeholders (Relation effect). Risk reporting is another risk management activity that influences project success through these four effects. Other risk management activities also generate effects, but less than the four effects mentioned with risk identification and reporting. The research data demonstrate a positive relation (both in quantity and in quality) between the effects generated through risk management activities and project success.

5 Results from an Experiment

The conclusion that individual risk management activities contribute to project success is based upon the opinions of individual stakeholders, meaning that the effect of risk management on project success is directly attributable to those effects as perceived by project stakeholders. Given the case study research setting, the possibilities for “objective” validation of these perceptions are limited. In order to create additional information on the effect of a specific risk management practice on project success, independently of various stakeholders’ perceptions, an experiment was developed with the aim to answer to the following sub-question: Does the use of a specific risk management practice influence objective project success and project success as perceived by project members?

Building on the results of the case studies, risk identification was chosen as the risk management activity for the experiment. Risk identification is the activity which, according to the results from the case studies, has the most impact on project success. Furthermore, a project generally starts with a risk identification session, which makes risk identification relatively easy to implement in an experimental setting. The experiment was conducted with 212 participants in 53 project groups. All participants were members of a project group where, in the project, each member had the same role. The project team had a common goal, which further diminished the chances for strategic behaviour of participants. The common goal situation provided the conditions for open communication and therefore for communicative effects, generated by the risk management activity.

All project groups that performed risk identification before project execution used a risk prompt list to support the risk identification process. 17 groups did risk identification by discussing the risks with team members (type 3 groups); 18 groups that did risk identification did not discuss risks with team members (type 2 groups). The control group projects (type 1 groups, 18 groups) conducted no risk identification at all before project execution. All project groups had to execute the same project, consisting of 20 tasks.

Results from the experiment demonstrate that project groups that conducted risk identification plus discussion...
perform significantly better in the number of correctly completed tasks than the control groups that did not conduct risk identification at all. The number of correctly performed tasks is, in this experiment, one of the indicators for objective project success. A trend test demonstrates a highly significant result, indicating that the number of correctly performed tasks increases when groups perform risk identification, but increases further when groups do risk identification plus discussion. Figure 4 illustrates this trend. Types of projects are on the X-axis. The Y-axis presents the average number of correctly performed tasks by the project team (Q3).

Perceived (opinionated) project success was measured by asking projects to grade the project result. The analysis of grades demonstrates some remarkable research findings. Project groups that did risk identification plus discussion (type 3) score significantly better on the number of correctly performed tasks than control groups (type 1). After project groups have been informed about their own project result (and their own result only), all project groups value their project result equally. There is no difference in grades assigned by project groups from any of the group types. The result of project groups that conducted risk identification plus discussion is objectively better, but apparently this better result is not reflected in the opinion of the project groups who conducted risk identification plus discussion.

It is remarkable to see that, directly after project execution, before project groups are informed about their project result, project groups who conducted risk identification plus discussion are significantly more positive about their result than groups that conducted no risk identification or risk identification without communication. The grades for project success given by project groups directly after project execution indicate that project groups attribute positive effects to risk management in relation to project success.

6 Conclusions and Implications

The main conclusion of this research is: Project risk management as described in handbooks for project management and project risk management [14][8] only occasionally contributes to project success if project risk management is considered solely in terms of instrumental action working on an instrumental object. If, on the other hand, project risk management is considered a set of activities in which actors interact and exchange information, also known as communicative action, working on a social object, individual risk management activities contribute to project success because the activities may generate Action, Perception, Expectation and Relation effects. A positive relation exists between the effects generated through risk management activities and project success.

The experiment demonstrates that an individual risk management activity is able to contribute to elements of project success. For this effect to occur, it is not necessary to measure or to quantify the risk. For instance in a risk identification brainstorm, project stakeholders exchange information on what they individually see as the potential dangers for the project. Such an exchange of information may lead to adjustments of the expectations of individual actors and the creation of mindfulness [15]. Mindfulness includes awareness and attention; actors become sensitive to what is happening around them, and they know when and how to act in case of problems. This leads to a remarkable conclusion, which can be described as “the quantum effect” of project risk management, because its appearance is somewhat similar to what Werner Heisenberg in quantum mechanics described as the uncertainty principle.

Firstly; in order to influence the risk, it is not necessary to measure the risk. The experiment demonstrated that a risk prompt list, in which five risks were mentioned that were realistic, but all of which had very low probability of occurring, is enough to make project members aware of potential project risks and to influence their behaviour. As a result, the project groups who talked about the risks before project execution performed better and gave themselves a higher grade for the performance of their project. Secondly, as a result of this communicative effect, it is impossible to measure risk without changing its probability. The moment the risk is discussed, stakeholders become influenced and this consequently leads to an effect on the probability of the risk.

Based on the research findings the main implication or recommendation for practitioners is to continue the use of risk management on IT projects. However, this research provides some important recommendations that should be taken into account when risk management is used on IT projects. Practitioners should be aware that the assumptions underlying the project risk management process as de-
scribed in handbooks for project management (the instrumental view) are often not correct. Hence, only in specific situations, is the risk management process is able to contribute to project success in terms of "on-time, on-budget" delivery of a predefined IT system. If project risk management is used in a situation in which the assumptions are not met, it will inevitably lead to a situation in which project stakeholders think that the project risks are under control, where in fact they are not.

However, individual risk management activities such as risk identification or risk allocation generate non-instrumental effects, possibly in addition to instrumental effects. These non-instrumental or communicative effects occur as a result of interaction (discussion, exchange of information) between project stakeholders during the execution of risk management activities. Communicative effects stimulate instrumental action taking by stakeholders, and the effects create a common view among project stakeholders about the project situation by influencing stakeholders' perceptions and expectations and shaping the inter-stakeholders' relationships. Practitioners should be aware that the creation of communicative effects can be stimulated by providing capacity for interaction during risk management activities. For instance; a risk identification brainstorm session or moderated meeting will generate more communicative effects than a risk identification session in which only checklists or questionnaires are used. For the communicative effects to occur it is not necessary that the complete risk management process is executed as described in handbooks for project management. Individual risk management activities each have their own effect on project success through the various communicative effects they may generate. The communicative effect contributes to project success, not only in terms of time, budget and quality, but also in terms of perceived success.

At the same time, practitioners should be aware that communicative effects with an effect on project success will not occur in every project situation, not that the effect is, in all situations, a positive effect. If, for instance during risk identification, certain information about risks is labelled as being important for the project, where in fact these risks were relevant in an earlier project, but not in the forthcoming project, the risk communication can lead to project members to focus upon (what later will appear to be) the "wrong risks". By focussing upon the wrong risks, project members are unable to detect and respond to risks that have not been identified; one of the cases (case 7) of this research provides an example of this type of problem. Furthermore, communicative effects with a positive effect on project success occur predominantly in situations where information is not used strategically. In situations in which information on risks is not shared openly, the positive communicative effect may not occur. One other case (case 4) of this research provides some indications that not sharing risk related information between customer and IT supplier leads to lower communicative effects, resulting in lower project success.

References

Decision-Making:
A Dialogue between Project and Programme Environments

Manon Deguire

This paper proposes to revisit and examine the underlying thought processes which have led to our present state of DM knowledge at project and programme levels. The paper presents an overview of the Decision Making literature, observations and comments from practitioners and proposes a DM framework which may lead to empowering project and programme managers in the future.

1 Decision Making
"Decision-making is considered to be the most crucial part of managerial work and organizational functioning." — Mintzberg in [2 p.829]

According to some definitions, a decision is an allocation of resources. For others, it can be likened to writing a cheque and delivering it to the payee. It is irrevocable, except that a new decision may reverse it. Similarly, the decision maker who has authority over the resources being allocated makes a decision. Presumably, he/she makes the decision in order to further some objective, which he/she hopes to achieve by allocating the resources [1].

Different definitions of what a decision is and involves abound in literature that spreads through the knowledge of many centuries of all disciplines [2]. Decision Making (DM) is very important to most companies and modern organizational definitions can be traced back to von Neuman and Morgenstein in 1947 [3], who developed a normative decision theory from the mathematical elaboration of the utility theory applied to economic DM. Their approach was deeply rooted in sixteenth century probability theory, has persisted until today and can be found relatively intact in present decision analysis models such as those defined under the linear decision processes. This well-known approach uses probability theory to structure and quantify the process of making choices among alternatives. Issues are structured and decomposed to small decisional levels, and re-aggregated with the underlying assumption that many good small decisions will lead to a good big decision. Analysis involves putting each fact in consequent order and deciding on its respective weight and importance.

Although most descriptive research in the area of DM concludes that humans tend to use both an automatic non-conscious thought process as well as a more controlled one when making decisions [4], the more controlled approach to DM remains the most important trend in both theoretical and practical models of DM. However, this dual thought process is possible because of the human mind’s capability to create patterns from facts and experiences, store them in

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“The paper presents an overview of the Decision Making literature, observations and comments from practitioners.”

The registers of long-term memory and re-access them in the course of assessing and choosing options. Many authors refer to this mechanism as "intuitive DM" a term that has not gained much credibility in the business environment and is still looked down upon by many decision analysts.

Given the years during which modern Project Management was developed (as well as other management trends), it is not surprising to find that the more controlled, linear mechanistic approach to DM permeates its literature and the project context seems to have neglected the importance of the softer and/or more qualitative aspects of the management domain that are now being recognized as essential for good business to develop. Therefore, in the new context of projects and programmes, quantitative aspects of the DM process are progressively becoming secondary issues to such qualitative issues as the meaningfulness of a decision for different stakeholders and for the overall organization.

Project managers are repetitively expected to listen to different stakeholders’ needs and account for the numerous qualitative and quantitative variables when making decisions, however, both information overload and organizational constraints usually make this difficult to implement and very little guidance can be found in the project literature. If anything, the overwhelming importance of the DM issue seems rather accepted as common knowledge for project managers as it is not mentioned or explored in the PMBOK® Guide [5] or in other popular project approaches despite the bulk of recent research and growing interest in this domain. In spite of the increasing importance placed on DM knowledge and skills, many project and programme managers continue to struggle with the concept that can stand in the way of career progression and may be one of the primary factors preventing project and programme success.

Project management practice is permeated with the thought that in order to facilitate DM in the project context, simple (linear) evaluation tools should be widely used. However, it has now long been documented that these decision-support tools are no longer sufficient when project managers’ roles have grown to accommodate the ever-changing complexity of the business environment. This situation has added considerably to the number of variables and the dimensions of an already complex web of relationships brought about by the stakeholder focus. With such changes as the implementation of Project Management Offices, Portfolio Management, Program Management and Project-Based Or-
ganizations, project managers are now called upon to interact with an ever-expanding pool of stakeholders and other tools, such as meetings, reports and electronic networks which are also important. Intuition, judgment and vision have become essential for successful strategic project and programme management.

Without an appropriate framework, some authors have suggested that managers do not characteristically solve problems but only apply rules and copy solutions from others [6]. Managers do not seem to use new decision-support tools that address potential all-encompassing sector-based elements, such as flexibility, organizational impact, communication and adaptability, nor technological and employee developments. There is therefore a potential for managerial application of new, value creation decision-support tools. Because these are not mature tools, in the first instance they might be introduced in a more qualitative way – ‘a way of thinking’, as suggested in [7], to reduce the managerial skepticism. Recent decision-support tools might be fruitfully combined with traditional tools to address critical elements and systematize strategic project management.

It is now a well-accepted fact that traditional problem-solving techniques are no longer sufficient as they lead to restrictive, linear Cartesian conclusions on which decisions were usually based in the past. Instead, practitioners need to be able to construct and reconstruct the body of knowledge according to the demands and needs of their ongoing practice [8]. Reflecting, questioning and creating processes must gain formal status in the workplace [9].

In [10] it is implied that management is a series of DM processes and assert that DM is at the heart of executive activity in business. In the new business world, decisions need to be made fast and most often will need to evolve in time. However, most of the research is based on a traditional linear understanding of the DM process. In this linear model, predictions are made about a known future and decisions are made at the start of a project, taking for granted that the future will remain an extension of the past.

2 DM at Project Level

The commonly accepted definition of a project as a unique interrelated set of tasks with a beginning, an end and a well defined outcome [5] assumes that everyone can identify the tasks at the outset, provide contingency alternatives, and maintain a consistent project vision throughout the course of the project [11]. The ‘performance paradigm’ [12][13] used to guide project management holds true only under stable conditions or in a time-limited, change-limited, context [14][15]. This is acceptable as long as, by definition, the project is a time-limited activity, and for the sake of theoretical integrity, is restricted to "the foreseeable future."

The traditional DM model has provided project managers with a logical step-by-step sequence for making a decision. This is typical of models proposed in the decision-making literature of corporate planning and management science of the past. It describes how decisions should be
made, rather than how they are made. The ability of this process to deliver best decisions rests upon the activities that make up the process and the order in which they are attended to. In this framework, the process of defining a problem is similar to making a medical diagnosis, the performance gap becomes a symptom of problems in the organization’s health and identification of the problem is followed by a search for alternative solutions. The purpose of this phase of the decision-making process is to seek the best solution [16, Ch. 1]. Several authors have identified a basic structure, or shared logic, underlying how organizations and decision-makers handle decisions. Three main decision-making phases can be defined: Identification by which situations that require a decision-making response come to be recognized, Development involving two basic routines (a search routine for locating ready-made solutions and a design routine to modify or develop custom made solutions) and Selection with its three routines (screening, evaluation-choice and authorization) [17].

3 DM at Programme Level

More recently, many organizations have felt a need to further develop towards a fully projectised structure, which goes beyond a simple portfolio approach and involves the management of strategic decisions through programmes [18][19]. This move has somewhat shifted the responsibilities and decision-making roles of project and programme managers. At this level, several projects needs to be managed together in order to create synergies and deliver benefits to the organization rather than delivering a specific product or service in isolation and in most organizations programme managers are actively working within a paradox. They have an official role in a legitimate control system (project level), facilitating an integrated transactional change process, and simultaneously participate in a shadow system in which no one is in control [20].

A mechanistic style of management warranting a more rational and linear approach to DM is appropriate when goals are clear and little uncertainty exists in the prevailing environment [11][21]. programme management practice is not meant to replace this management focus; rather, it encompasses it in a larger context. Here, managers cannot control their organization to the degree that the mechanistic perspective implies, but they can see the direction of its evolution [22]. When several variables are added to a system or when the environment is changed, the relationships quickly lose any resemblance to linearity [23]. This has been raised by many authors in reference to strategic issues such as the organization’s competitive position, the achievement of the programme’s benefits and the effects of changes on the programme business case [24][25]. These same issues have traditionally been processed through a project view of change control rather than a strategic view of change management with one of the main drawbacks being that these standard approaches focus on a linear programme lifecycle [26][27]. According to these authors, focus on early definition and control of scope severely restricts flexibility thus negating the value of having a programme. Furthermore, insistence on a rigid life cycle intrinsically limits the ability of the programme to adapt in response to evolving business strategy [26].

When studying the implementation of strategic projects, Grundy [25] found that cognitive, emotional and territorial themes were so intrinsically interwoven to the decision-making process that he suggested using the concept of "muddling through" originally introduced by Lindblom in 1959 [28]. Similarly unsatisfied with the rational model of decision-making at top management levels, Isenberg stated in [29] that managers "rely heavily on a mix of intuition and disciplined analysis" and "might improve their thinking by combining rational analysis with intuition, imagination and rules of thumb" (p.105).

Much of the literature concerning decision-making at higher management levels seems to manifest perplexity and more questions than answers. By increasing our knowledge in this domain and providing an appropriate framework, project and programme managers might find material to reflect and possibly enhance their skills to better fit each environment.

4 Discovering Project and Programme Level Views

Beer [30] felt that most organizational research was irrelevant to practitioners because practitioners worked in a world of chaos and complex systems, whereas research was still about simple and equilibrated systems operated by researchers who maintain their objectivity. In order to respond to such concerns, this research project was set in a participatory paradigm [31] and uses a mix of observation and semi-structured interviews. The interview questions are based on the theoretical framework that was developed from the literature review and designed to capture the complex web of thought processes leading to decisions. The main objective was to uncover characteristics of linear and non-linear decision situations at project and programme levels. All respondents were either project or programme managers and had a good understanding of the differences between these roles and responsibilities.

Project managers typically described their working environment as consisting of "the team of people on the project" and DM activities involved either these specific people or the project specific tasks and goals. DM analysis was often restricted to project level variables and remained
Decision Making is very important to most companies

confined to the scope limits and constraints of the project. On the other hand, as this example clearly demonstrates, one programme manager described her work environment from an organizational point of view and her discourse was not programme specific: "The programme manager has to relate not only to the different projects involved in the programme, but also to the organization in terms of people (horizontal and vertical relationships) as well as the short, medium and long term strategy". This view was also coherent with how project managers in our study perceive the programme managers’ roles and responsibilities.

Programme managers were described as seeing things from above implying that the thought processes used at their level of analysis is different than those useful to oversee one project. The general impression is one of managing many ongoing concurrent decisions rather than a sequenced series of bounded decisions. A typical response from a project manager describing the programme management role was: "programme managers look down from above at different projects and need to pace several projects and the resources involved in groups of projects together." When describing her own role, one programme manager states: "developing strategic goals that are in line with the governance is really important, that’s one part of the job. Then figuring out how to deliver that strategy is the other part."

Project managers speak of themselves and are referred to by programme managers as dealing with single projects and having to make more sequenced isolated decisions (technical, human related…). Decisions at this level are referred to as being more independent from one another and sequenced in time. One decision is followed by resolution until another decision has to be made. Each decision is more discrete in nature (technical, human resource, procurement related) whereas programme decisions are often interrelated, covering many areas simultaneously.

One project manager described his work in the following way: "My projects have a beginning and an end. I am involved mainly in engineering projects at the moment and they have specific finish dates." A programme manager’s descriptions of the project manager’s role was that "a project manager deals more precisely with things like budgets and constraints of the project that they are in charge of, they seem to operate within specific parameters." The vocabulary used to describe decisions at the project level was generally more precise and specific.

Both project and programme managers feel that DM activities occupy a major part of their day or time at work. It was extremely difficult for both groups of respondents to evaluate the number of decisions taken in the course of any fixed period of time (day, month…). A typical response from one project manager illustrates this when he says: "I would say I can spend the better part of my nine hours at work making decisions, from small ones like deciding to change activity or big ones like for example a large screen project […] this could mean making hundreds of decisions per day." Similarly, one programme manager states that "A great deal of time is devoted to decision making activities at the beginning of the programme, perhaps 100% of my time gets devoted to it at this phase as I am looking at things like risks involved."

Although it was difficult for both project and programme managers to quantify the time spent on DM activities or the number of decisions involved in their work, their subjective evaluations all converged to say that they felt they spent a great deal of time in DM activities.

Both groups also feel that in the initial phase of the project or programme, they spend almost all their time making and taking decisions. This was described as an acute DM time. Later phase decisions seem to focus on more specific issues for project managers; either described as technical or human relation issues. Programme managers mention the technical issues sporadically and mainly in the context of understanding what is going on. But unlike project managers, technical versus human resources is not one of the important dichotomies in the themes of their DM discourse. When technical DM was discussed it was usually in terms of grasping a better understanding of what people actually did, the skills or appropriate environment to enhance their performance, but not to actually solve the technical problem at hand or to make any decision about it.

When questioned about the use of specific DM tools one project manager spontaneously described the traditional rational method of DM: "When the problem is purely a technical one, it is easy in a way because we have tools to measure what is going on like oscilloscopes and things. Even if it looks like a complicated problem with thousands of cables, then we look at the symptoms and we come up with a diagnosis often this is based just on our experience of similar problems […] We have a discussion on how to go about it, how to measure it, we cut the problem in half and we
Risk Management

Figure 1: Decision-Making Model in Projects.

Figure 2: Model DM in Programmes.

again look at the symptoms. So, in a way, in the decision making process we breakdown the problem to something that we can observe or measure." This description could have been taken from a number of DM texts that are concerned with the way decisions should be made. In fact, for project managers, most purely technical decisions seem to follow the traditional DM model, breaking down into more manageable small decisions and exploring alternatives against each other. However, even in this group, many state that few decisions are purely technical and say that most decisions involve a human component that varies in importance. The importance of this aspect ranges from at least equal to out-weighting the technical aspect. Together with the traditional DM breakdown process, experience is usually mentioned as a key factor of the DM process.

Contrary to the discourse held by project managers, there are no such straightforward textbook answers from programme managers. This could be simply symptomatic of the sample; however, programme managers describe an iterative ongoing process of information gathering in order to make sense of holistic situations. One programme manager saw herself as constantly gathering information in or-
Three main decision-making phases can be defined: Identification, Development and Selection.

Three main decision-making phases can be defined: Identification, Development and Selection.

5 Discussion
The data analysis shows that project managers seem to have a natural predisposition toward using a more traditional and structured approach to DM. This observation can be accounted for in more than one way and the research method employed does not enable the establishment of causal relationships. The difference could be caused by the nature of their roles and responsibilities or that people who have personal affinities for this type of DM approach tend to be attracted to this type of work. Further psychological testing would be necessary to establish this second type of relationship. Nevertheless, project managers have described logical step-by-step sequences that could actually have been used as examples for the typical models proposed in the DM literature such as those described in [16] and [17]. Although critics of this approach have outlined the fact that the ability of this process to deliver best decisions rests upon the activities that make up the process and the order in which they are attended to, the project managers interviewed seem comfortable with, and skilled at, using this method to resolve problems.

Within this DM model, project managers also tend to use a process of deductive reasoning more often than programme managers who have described processes of inductive reasoning as a preferential thought process when engaged in DM activities. Aristotle, Thales and Pythagoras first described deductive reasoning around 600 to 300 B.C. This is the type of reasoning that proceeds from general principles or premises to derive particular information (Merriam-Webster). It is characteristic of most linear DM tools used in the context of high certainty. These tools are aimed at achieving an optimal solution to a problem that has been modeled with two essential requirements:

a) Each of the variables involved in the decision-making process behaves in a linear fashion and
b) The number of feasible solutions is limited by constraints on the solution.

These tools rely almost entirely on the logic and basic underlying assumptions of statistical analysis, regression analysis, past examples and the linear expectations and predictions they stimulate. A good example is the story of Aristotle who is said to have told of how Thales used predictive logic to deduct, from accumulated historical data, that the next season’s olive crop would be a very large one and bought all the olive presses, making a fortune in the process. However, given that deductive reasoning is dependent on its premises, a false premise can lead to a false result. In the best circumstances, results from deductive reasoning are typically qualified as non-false conclusions such as: “All humans are mortal. Paul is a human è Paul is mortal”.

From the project managers’ perspective, the project’s basic assumptions and constraints are the starting premises for all further decisional processes. In fact, these initial conditions of the project environment act as limits or boundaries, necessary for this type of DM process to be effective. Project managers generally feel that most large decisions are actually made during the first phases of the project, before and during the planning stage. Project management typically delivers outputs in the form of products and services and most project decisions are made to commit to the achievement of these specific outputs [32]. This perspective infers that a series of small decisions that amount to the project plan, are made during the planning phase and finally add up to what is referred to as a large decision: the approved project plan. All these decisions, that shape the project, are made at the onset of the project. All later decisions are considered less important, more specific, and aimed at problem solving; often limited to one domain of knowledge at a time (i.e. technical, human relations...). Because most large decisions have been made at the onset, once the scope is defined, it limits the number of possible dependant variables in the DM process. The number of significant stakeholders involved is also limited and the overall situation is described as limited to the project’s immediate environment. Much of the DM follows a relatively traditional structured model to which the deductive thought process seems to adapt readily. Figure 1 illustrates this DM model for projects.

6 Programme Management Framework
A particularly interesting finding is the fact that deductive reasoning does not seem quite as popular or as universally called for in the DM processes of the programme managers we interviewed. However, the use of inductive reasoning seems more popular than for project managers. De-
DM processes at project and programme level differ significantly in the timing, pacing and number of major decisions, as well as the nature of the DM processes employed.

Deductive reasoning applies general principles to reach specific conclusions, whereas inductive reasoning examines specific information, perhaps many pieces of specific information, to derive a general principle.

A well known example of this type of thought process is found in the story of Isaac Newton. By observation and thinking about phenomena such as how apples fall and how the planets move, he induced the theory of gravity. In much the same way, programme managers relate stories about having to collect information through observation, questions and numerous exchanges in order to put the pieces together into a cohesive story to manage the programme. The use of Analogy (plausible conclusion) is often apparent in the programme managers’ discourse. This process uses comparisons such as between the atom and the solar system and the DM process is then based on the solutions of similar past problems, intuition or what is often referred to as experience. Contrary to project management where most decisions are taken to commit to the achievement of specific outputs, programme management typically delivers outcomes in the form of benefits and business case decisions are taken over longer periods of time depending on the number of projects that are progressively integrated to the programme and to the timing scale of these different projects [32].

These decisions increasingly commit an organization to the achievement of the outcomes or benefits and the DM period, although important at the beginning continues progressively as the situation evolves to accommodate the changes in this larger environment. Typical responses from programme managers tend to converge toward an ongoing series of large decisions (affecting the totality of entire projects) as the programme evolves over time. This can be compared to the project level discourse that described large decisions at the onset and smaller ones (not affecting the overall business case of the project) as the project evolved. This is in keeping with the fact that, since programmes deliver benefits as opposed to specific products or services, the limits of the programme environment are not as specific or as clearly defined as those for the project. Organizational benefits are inherently linked to organizational strategy, value systems, culture, vision and mission. This creates an unbounded environment and basic assumptions are not as clear as for the project environment. This could account for the fact that deductive thought processes are less suited than inductive ones in the DM processes of programme managers.

7 Conclusion

Both project and programme managers were unanimous in recognizing the importance and the amount of time spent in decision-making activities and that further knowledge is needed in this domain.

It would seem that a more mechanistic style of management warranting a more rational and linear approach to decision making is appropriate when goals are clear and little uncertainty exists in the prevailing environment. The time-limited definition of projects makes them well adapted to this performance paradigm.

These observations do not aim to lessen the requirements for traditional DM, but highlight the fact that programme management DM practice encompasses a larger context. Here, managers cannot control their organizations to the degree that the mechanistic perspective implies, but have to develop an awareness of their future evolution. The implications are readily felt at the decisional level; when several variables are added to a system or when the environment is changed and relationships quickly lose any semblance of linearity.

Finally, this dialog has highlighted the fact that the DM processes at project and programme level differ significantly in the timing, pacing and number of major decisions, as well as the nature of the DM processes employed. Most large or important project decisions are bound by the project’s basic assumptions and project managers tend to have a preference for deductive mental processes when making decisions. The occurrence of large or important programme decisions seems to persist throughout the programme life cycle as they are prompted by setting the assumptions for each project when these kick off. Because the programme delivers benefits and that these cannot be as clearly defined as products or services its environment is not as clearly defined or bound by set basic assumptions and inductive reasoning seems more suited to meet the programme managers’ decision making needs.

References


Risk Management

Decisions in an Uncertain World: Strategic Project Risk Appraisal

Elaine Harris

This article is developed from the author’s book on strategic project risk appraisal [1] and her special report on project management for the ICAEW [2]. The book is based on over eight years of research in the area of risk and uncertainty in strategic decision making, including a project funded by CIMA [3] and explores the strategic level risks encountered by managers involved in different types of project. The special report classifies these using the suits from a pack of cards. This article illustrates the key risks for three types of project including IT projects and suggests how managers can deal with these risks. It makes a link between strategic analysis, risk assessment and project management, offering a new approach to thinking about project risk management.

Keywords: Decisions, Managerial Judgement, Project Appraisal, Risk, Uncertainty.

1 Investing in Projects in an Uncertain World

Projects are often thought of as a sequence of activities with a life cycle from start to finish. One of the biggest problems at or before the start is being able to foresee the end, at some time in the future. Uncertainty poses a range of issues for project planning and risk assessment. If we think of projects as temporary endeavours, not all outcomes may be measurable by the end, where lasting benefits may be desirable. This provides the problem of how we judge projects to be successful. Performance of projects has typically been measured by the three constraints of time, money and quality. Whilst it may be easy to ascertain whether a project is delivered on time and within budget, it is harder to assess quality, especially when a project is first delivered. Many projects, even those that were famously late and well over budget like the Sydney Opera House, can become icons in society and be perceived as very successful after a longer period of time. The classic issue in project management is that only a small minority of projects achieve success in all three measures, so academics have been searching for better ways to measure the success of projects, which involves unpicking ‘quality’, and in whose eyes projects are perceived to succeed or fail [2].

All strategic decisions that select which projects an organisation should invest in are taken without certain knowledge of what the future will hold and how successful the project will be. Faced with this uncertainty, we can attempt to predict the factors that can impact on a project. Once we can identify these factors and their possible impacts we can call them risks and attempt to analyse and respond to them. Risks can be both positive, such as embedded opportunities, perhaps to do more business with a new client or customer in future, or negative, things that can go wrong, and those indeed require more focus in most risk management processes. Project risk assessment should begin before the organisation makes its decision about whether to undertake a project, or if faced with several options, which alternative to choose.

One common weakness in the approach that organisations take to project risk management is the failure to identify the sources of project risk early enough, before the organisation commits resources to the project (appraisal stage). Another is not to share that risk assessment information with project managers so that they can develop suitable risk management strategies. Through action research in a large European logistics company, a new project risk assessment technique (Pragmatix®) has been developed to overcome these problems. It provides an alternative method for risk identification, ongoing risk management, project review and learning. This technique has been applied to eight of the most common types of projects that organisations experience.

"This article illustrates the key risks for three types of project including IT projects and suggests how managers can deal with these risks"
Risk Management

2 Project Typology

Whilst the definition of a project as a temporary activity with a start and finish implies that each project will be different in some way from previous projects, there are many which share common characteristics. Table 1 shows the most commonly experienced projects, informed by finance professionals in a recent survey. Each is marked with a suit from a pack of cards which attempts to classify projects as follows:

- **Hearts** – need to engage participants hearts and minds to succeed
- **Clubs** – need to work to a fixed schedule of events
- **Diamonds** – products need to capture the imagination and look attractive in the marketplace
- **Spades** – physical structures e.g. buildings, roads, bridges, tunnels

This article features three types of project (1, 2 and 6) shown in Table 1 to give a flavour of the research findings.

3 Project Appraisal and Selection

In order to generate a suitable project proposal for this purpose, the project needs to be scoped and alternative options may need to be developed from which the most suitable option may be selected. The way the project is defined and described in presenting a business case for investment can influence decision makers. It is important for senior managers, both financial and non-financial to understand the underlying psychological issues in managerial judgement, such as heuristics (using mental models, personal bias and rules of thumb), framing (use of positive, negative or emotive language in the presentation of data) and consensus (use of political lobbying and social practice to build support for a case). These behaviours can be positively encouraged to draw on the valuable knowledge and experience of organisational members, or impact negatively, for example status quo bias creating barriers to change [3].

In many organisations it is possible to observe bottom-up ideas being translated into approved projects by a team at business unit level working up a business case to justify a proposal using standard capital budgeting templates and procedures for group board approval (Figure 1). There are feedback loops and projects may be delayed while sufficient information is gathered, analysed and presented. This process can take days (for example corporate events), months (for example new client or business development) or even years (for example new products where health and safety features in approval such as drugs or aeroplanes). Where delay is feasible, where the opportunity will not be lost in competitive market situations, a real options approach is possible. The use of the term real options here is an approach or way of thinking, not a calculable risk as in derivatives. It simply means that there is an option to delay, disaggregate or redefine the project decision to maximise the benefit of options, for example to build in embedded opportunities for further business. This may be more important in difficult economic times as capital may be rationed.

However, where projects are initiated by senior management in a top-down process, the usual steps in capital investment appraisal may not be followed, as there may be external pressure brought to bear on a chief executive or finance director, for example in business acquisitions, strategic alliances etc. Appraisal procedures may be over-rid-

<table>
<thead>
<tr>
<th>Type of project</th>
<th>Characteristics</th>
<th>Suit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. IT systems dev’t</td>
<td>Advanced technology manufacturing or new information systems</td>
<td>♠️</td>
</tr>
<tr>
<td>2. Site or relocation</td>
<td>New building or site, relocation or site development</td>
<td>♥️</td>
</tr>
<tr>
<td>3. Business acquisition</td>
<td>Takeovers and mergers of all or part of another business</td>
<td>♣️</td>
</tr>
<tr>
<td>4. New product dev’t</td>
<td>Innovation, R &amp; D, new products or services in established markets</td>
<td>♠️</td>
</tr>
<tr>
<td>5. Change e.g. closure</td>
<td>Decommissioning, reorganisation or business process redesign</td>
<td>♥️</td>
</tr>
<tr>
<td>6. Business dev’t</td>
<td>New customers or markets, may be defined by invitation to tender</td>
<td>♥️</td>
</tr>
<tr>
<td>7. Compliance</td>
<td>New legislation or professional standards, e.g. health &amp; safety</td>
<td>♣️</td>
</tr>
<tr>
<td>8. Events</td>
<td>Cultural, performing arts or sporting events, e.g. Olympics</td>
<td>♣️</td>
</tr>
</tbody>
</table>

Table 1: Types of Projects. (Source: [2, p. 4].)
Performance of projects has typically been measured by the three constraints of time, money and quality.

Figure 1: IT Project Risk Map. (Source [4].)
4 Risk Analysis

There is a common risk management framework in business organisations that can be applied to projects as well as continuing operations. The number and labelling of steps might differ, but the process usually involves:

1. Identify risks (where will the risk come from?)
2. Assess or evaluate risks (quantify and/or prioritise)
3. Respond to risks (take decisions e.g. avoid, mitigate or limit effect)
4. Take action to manage risks (adopt risk management strategies)
5. Monitor and review risks (update risk assessment and evaluate risk strategies)

Linking these to the project life cycle, steps 1 and 2 form the risk analysis that should be undertaken during the project initiation stage, step 3 links to the planning stage, and steps 4 and 5 should occur during project execution. Risks should also be reviewed as part of the project review stage to improve project risk management knowledge and skills for the future [2].

Evidence from practice suggests that steps 1 and 2 are rarely carried out early enough in the project life cycle, step 5 monitoring is often undertaken in a fairly mechanical way, and comprehensive review at project level is hardly found to occur at all after the project has ended, especially in non-project based organisations.

The difficulty in identifying the risks relating to projects, especially at an early stage when the project may not be well defined, is that no two projects are exactly the same. However, using the project typology in box 1 it can be seen that headline or strategic risks are likely to be similar for projects of a similar type. In [9] a range of qualitative methods for project risk identification is presented, including cognitive mapping, and examples are given for several types of project.

"A new project risk assessment technique (Pragmatix®) has been developed to overcome these problems"
Knowledge of where the risks are likely to come from is usually developed intuitively by managers through their experience in the organisation and industry. Advanced methods used in the research reported here included repertory grid\(^1\) and cognitive mapping\(^2\) techniques to elicit this valuable knowledge. However common risks may be found in projects of a similar type, and up to half may be identified by applying common management techniques. These are explained for the three project examples presented.

\(^1\) Repertory grid technique (RGT) is a method of discovering how people subconsciously make sense of a complex topic from their range of experience. This was used to identify the project risk attributes in Table 2.
\(^2\) Cognitive mapping uses a visual representation of concepts around a central theme. This was used to display risk attributes in a project risk map in figure 2.

![Figure 2: IT Project Risk Map.](image_url)

<table>
<thead>
<tr>
<th>Source of Risk</th>
<th>Mitigating actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Employees</strong></td>
<td></td>
</tr>
<tr>
<td>Loss of staff</td>
<td>Offer positive and consistent benefits package</td>
</tr>
<tr>
<td>Loss of expertise</td>
<td>Negotiate key employees benefits package to encourage move</td>
</tr>
<tr>
<td>Effect on morale</td>
<td>Good communications with staff &amp; transparency of business case</td>
</tr>
<tr>
<td>Poor local labour market</td>
<td>Establish good market intelligence (before choice of location)</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>Establish dedicated project management team with strong leader</td>
</tr>
<tr>
<td><strong>Continuity</strong></td>
<td></td>
</tr>
<tr>
<td>Current projects</td>
<td>Maintain extra resources during move</td>
</tr>
<tr>
<td>Flex project schedules for projects spanning relocation period</td>
<td></td>
</tr>
<tr>
<td><strong>Organisational impact</strong></td>
<td></td>
</tr>
<tr>
<td>Culture</td>
<td>Use relocation as a catalyst for change, improve existing culture</td>
</tr>
<tr>
<td>Business procedures</td>
<td>Requires a development plan</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
<tr>
<td>Office equipment</td>
<td>Transport all office equipment from current site, reduce need for new</td>
</tr>
<tr>
<td>Capacity</td>
<td>Determine capacity required and ensure building completed in time</td>
</tr>
</tbody>
</table>

Table 3: Mitigating Actions. (Source: adapted from unpublished MBA group coursework with permission.)
Example 1: Business Development Projects (BDP)

These projects involve securing new customers and markets for existing products or services. The strategic analysis of the organisational and environmental context for a BDP can help to generate several possible risks. The analysis of strengths, weaknesses, opportunities and threats (SWOT) can identify risk areas for the organisation (corporate factors in Table A), and help to analyse the strategic fit of the project. Then a more detailed analysis of the external factors, political, economic, social, technical, legal and environmental (PESTLE) can identify further risk areas (external and market factors in Table 2). The invitation to tender might also help to identify risks in a BDP project, for example the ‘demands of the customer’ in Table 2.

Example 2: Systems Development or IT Projects

For an IT project, which is essentially a supply problem, the chain from software supplier to client (users) via sponsor (owner) can reveal at least half of the sources of risk. The functional requirements of the system are defined by the client, and the risks here may determine whether the client will be satisfied that the system does what it is supposed to do. Internal clients in IT projects may be more demanding than external clients in BDP projects.

Figure 2 shows a typical project risk map for an IT project. The figure shows the high risk areas shaded darker and the lower risk areas lighter. The key to managing these risks is understanding and responding to stakeholder motivations and expectations.

Example 3: New Site or Relocation Projects

A new site may involve the choice of location, acquisition, construction or refurbishment of buildings. In a relocation project, stakeholder analysis can reveal key groups of people who need managing closely. The employees are the principal group, followed by management and customers (continuity). Infrastructure risks (geographic factors) may be revealed by PESTLE analysis. Table 3 shows how risk management strategies can be developed to mitigate these risks.

The final section of this article shows the analysis of 100 risk management strategies into six categories, and draws conclusions for the use of a strategic approach to project risk identification, assessment and management [1].

The final section of this article shows the analysis of 100 risk management strategies into six categories.

5 Risk Management Strategies

For each type of project covered in the research a set of risk management strategies like those shown in Table 3 were identified. These totalled 100 and the following six categories emerge from their analysis, in the order of frequency of observation:

1: Project Management (23%)

This category includes the deployment of project management methodologies such as work breakdown structure, scheduling, critical path analysis etc. and the establishment of a project leader and project team, as found in the PM body of knowledge. The most observations for this type of risk management strategy were in IT projects, relocation and events management, where timing is critical.

2: Human Resource Management (21%)

This category includes recruitment, training and development of personnel, including managers and the management of change in work practices. This type of strategy featured most strongly in acquisitions, IT projects and relocation.

3: Stakeholder Management (19%)

This category includes stakeholder analysis and management through consultation, relationship management and communications. It featured most strongly in systems development projects, NPD projects and events management, which are necessarily customer-focussed. In IT projects and events management there are many more stakeholder groups with diverse interests to manage.

4: Knowledge Management (18%)

This category includes searching for information, recording, analysing, sharing and documenting information, for example in market research and feasibility studies. It features most strongly in BDP and NPD projects and in acquisitions. It is closely related to training and development, so overlaps with that aspect of human resource management.

5: Financial Management (10%)

This category includes credit checking of suppliers and customers, financial modelling and budget management as well as business valuation, pricing strategies and contract terms. It is no surprise that it features most in business acquisitions, where a high level of financial expertise is required, and next in BDPs where terms are agreed and new customers vetted.
6: Trials and Pilot Testing (9%)

This category includes testing ideas at the feasibility study stage, testing possible solutions and new products. This could be clinical trials in pharmaceuticals, tasting panels with new food products or system testing in IT products, so features most strongly in IT and NPD projects.

Project reviews are recommended to evaluate how well risk management strategies have worked and to identify how risk management can be improved as part of organisation learning. The evaluation of Pragmatix® for risk identification, assessment and management revealed important benefits for the case organisation, not least the opportunity to link risk assessment to later project management and post audit review of projects. This joined up thinking links strategic choice to strategy implementation through project management.

In conclusion, the identification of likely risks at an early stage helps managers make better decisions in the face of uncertainty. However, unless these risks are fully appraised and communicated to those responsible for managing the implementation of the project and monitoring the risks, the full benefits of risk appraisal will not be realised.

References
Selection of Project Alternatives while Considering Risks

Marta Fernández-Diego and Nolberto Munier

The selection of projects consists in choosing the most suitable out of a portfolio of projects, or the most fitting alternative when there are constraints in regard to financing, commercial, environmental, technical, capacity, location, etc.. Unfortunately the selection process does not place the same importance on the various risks inherent in any project. It is possible however, to determine quantitative values of risk for each pair of alternative/threat in order to assess these risk constraints.

Keywords: Free Software, Linear Programming, Project, Risk Management, Threat.

1 Introduction

Failing to satisfy project objectives is a major concern in project management. Risks can generate problems with consequences that are not often considered, and indeed, in many cases risk management is not even taken into account [1]. However, the benefits of risk management are considerable. Risk management allows, at the beginning of the project, the detection of problems that could be otherwise ignored, and so effectively to help the Project Manager in delivering the project on time, under budget and with the required quality [2]. However, if risk management is not performed along the whole project, the Project Manager probably will not be able to take advantage of its full benefits.

This paper proposes a methodology that consists in building, from a final value of risk for each project pair (threat or alternative) and a decision matrix to determine, using Linear Programming (LP), which is the most effective alternative considering the risks. Of course, in a real case these same constraints, plus others, can be added to the battery of constraints that address environmental matters, economic, technical, financial, political, and so on. The result will reflect the best selection on the basis of all the constraints considered simultaneously.

The application of LP to this decision-making problem is new in the treatment of risk. It opens a series of possibilities in the field of risk management in such a way that this methodology represents more accurately than other methods a project’s features, solving problems with all kinds of constraints, including those related to risk, and therefore placing risks at the same level as the economic, social and environmental constraints normally considered, with the idea of raising the discipline of risk management in projects. In short, although an even higher level of organizational maturity in terms of risk management would correspond to the integrated risk management of the portfolio of projects, it is expected that the outcome will be projects driven by risk management [3].

The paper presents in the next section an application example. The following describes in detail the characteristics of the problem to determine the choice of one alternative or another according to various criteria, along with its constraints. Finally, once the problem is solved by LP, the results are discussed.

This paper proposes a methodology that consists in building the most effective alternative considering the risk.
2 Application Example

2.1 Background

In the past decade, free software has exploded, even challenging the inertia that still exists in software engineering, mainly derived from proprietary software, resulting in new business models and product offerings that enable real choice for consumers.

To understand free software, let us begin by clarifying that the fundamental characteristic of proprietary software is that all ownership rights therein are exclusively held by the owner, as well as any possibility of improvement or adaptation. The user merely pays for the right to use the product, rather than buying it outright.

The problems associated with software, regardless of whether free or proprietary, lie in its own nature. The key problem addressed by free software is precisely the possibility of reusing it, in the logical sense that you can use parts already coded by others and create derivatives. For any transformation of a person’s work authorization of the copyright holder is required. Instead of using the simple copyright of the proprietary software licenses which means “all rights reserved”, these other free software licenses only reserve some rights, and report whether or not to allow the user to make copies, create derivative works such as adaptations or translations, or give commercial uses to the copies or derivatives.

In contrast, the essential feature of free software is that it is freely used. Specifically, it allows the user to exercise four basic freedoms. These freedoms are:

- The freedom to run the program for any purpose,
- The freedom to study how the program works, and change it to make it do what you wish,
- The freedom to redistribute copies,
- The freedom to improve the program, and release your improvements to the user.

Open source code is required to meet these freedoms. With open source code we mean that the source code is always available with the program. In addition, the exercise of these freedoms facilitates software evolution, exposing it as much as possible to its use and change – because greater exposure means that the software receives more testing – and by removing artificial constraints to the evolution – being more subject to the environment.

2.2 Background of the Case: Alternatives and Objective

Considering the future commercialization of computer models with free software preinstalled, an entrepreneur, who plans to start a small business, analyzes the possibility of buying for his business computers with free software installed. Given this possibility, he needs to make a decision between both alternatives, that is, proprietary software or free software according to risk criteria, with the objective consisting in minimizing the total cost, taking into account an estimated difference of 100 favoring a computer with free software operating system.

<table>
<thead>
<tr>
<th>x1 (Free software)</th>
<th>x2 (Proprietary software)</th>
<th>Action</th>
<th>Operator</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to change</td>
<td>0.85</td>
<td>0.15</td>
<td>MIN</td>
<td>≥</td>
</tr>
<tr>
<td>Dependency</td>
<td>0.16</td>
<td>0.64</td>
<td>MIN</td>
<td>≥</td>
</tr>
<tr>
<td>Lack of security</td>
<td>0.125</td>
<td>0.375</td>
<td>MIN</td>
<td>≥</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of the Problem.

“Failing to satisfy project objectives is a major concern in project management”
3 Problem Characteristics

The characteristics of the problem are summarized in Table 1.

The options and constraints of the problem, reflected in this table, are explained in the following points.

3.1 Criteria

This case raises two alternatives, effectively two projects which will be analyzed on the basis of criteria that take into account the various risks covered by both projects. Specifically, we consider three selection criteria that correspond to three of the potential threats related to the software, and which are mirrored in the main differences between free software and proprietary software. Of course, in a real case there may be many other criteria related to the economy, availability and experience of personnel, environment, etc., but all are considered simultaneously, together with the risk criteria. Therefore, the alternatives or options will have to comply simultaneously with all factors.

The risk in a project involves a deviation from its objectives in terms of the three major project success criteria; schedule, cost and functionality. In this sense, risk indicates the probability that something can happen which endangers the project outcome.

Risk can be measured as the combination of the probability that an incident occurs and the severity of impact [5]. Mathematically, risk can be expressed as follows:

\[ Risk = Likelihood \times Impact \]  

In the certainty of the materialization of the threat, the risk would be equal to the impact; if the probability of the threat materialization is zero, then there is no risk at all. However, risk is a combination of both probability and impact, and in statistics, risk is often modeled as the expected value of some impact. This combines the probabilities of various possible threats and some assessment of the corresponding outcomes into a single value. Consequently, each pair threat contributes partially to this expected value or risk.

The threats considered, which appear as rows in Table 1, are as follows:

- **Resistance to change**
  It is clear that there is still a lot of inertia and reluctance to move from the proprietary model, and despite the advantages of free software, this is the main barrier. Inertia is the resistance of the user to give up something he knows (proprietary software), i.e. there is a resistance to change (to free software), supported by the other side in the laws of physics (e.g., resistance to initiate a movement).
  Although the data are dependent on many factors including company size, the software’s purpose, its scope, field of application, etc., 85% of small businesses would opt for proprietary software products by inertia, lack of knowledge about free software alternatives or simply the fear of moving to a new field, compared with 15% who would venture into something new. Therefore the likelihood of resistance to change for free software is higher (85%) than the one for proprietary software (15%). On the other hand, we consider both the impact is total, i.e. 100%, since what is at stake is the choice of an alternative or another.

- **Dependency**
  A non-technical advantage of free software is its independence from the supplier, ensuring business continuity even though the original manufacturer disappears.
  Initially, free software arose from abusive practices used by leading developers of proprietary software, which requires users to permanently buy all updates and upgrades; in this sense the user has their hands tied since they have very limited rights on the product purchased. But when companies turn to free software, they liberate themselves from the constraints imposed by the software vendor. Indeed, free software appears to ensure the user certain freedoms.
  In addition the user is dependent not only on the manufacturer, but also on the manufacturer’s related products. The product often works best with other products from the same manufacturer. With free software, however, users have the power to make their own decisions.
  To simplify the problem equal values of probability and impact have been considered, resulting in a dependency risk of 16% for free software and 64% for proprietary software.

- **Lack of security**
  There is a widely held belief that free software operating systems are inherently more secure than a proprietary one because of their Unix heritage, which was built specifically to provide a high degree of security. This statement can be justified as follows:
  On the one hand, a coding error can potentially cause security risk (such as problems due to lack of validation). Free software is higher quality software, since more people can see and test a set of code, improving the chance of detecting a failure and to correct it quickly. This means that quality is assured by public review of the software and by the open collaboration of a large number of people. This is why free software is less vulnerable to viruses and malicious attacks. We could estimate that the vulnerability of
The main advantage of Linear Programming is that it is possible to represent real world scenarios with some degree of accuracy.

free software against security issues is 25%, while for proprietary software such vulnerability amounts to 50%.

On the other hand, the impact of a security problem is generally lower in the case of free software, because these bugs are usually addressed with speedy fixes wherever possible because of an entire global community of developers and users providing input. In contrast, in the world of proprietary software, security patches take considerably longer to resolve. We might consider impacts 50% for free software and 75% for proprietary software.

In short, considering risk as a combination of vulnerability and impact, the risk due to lack of security results in 12.5% for free software versus 37.5% for proprietary software.

Furthermore, since in fact transparency hinders the introduction of malicious code, free software is usually more secure.

3.2 Constraints
Since in the three cases we are talking of negative events, or threats, and we have not considered any opportunity, the constraints that we impose on these criteria respond to minimization, effectively finding a solution greater than or equal the value of minimal risk, since we cannot find a solution with lower risk than this.

For example, the opposite of resistance to change could have been considered. The term inertia may refer to the difficulty in accepting a change. While not applying any force, we follow our own inertia, which is an opportunity for the favored option. In this approach, the appropriate action had been to maximize, or find a solution less than or equal to the maximum benefit because we cannot find a solution with greater benefit.

4 Linear Programming Resolution
The matrix expression of the LP problem is as follows:

$$A \cdot X = B$$  \hspace{1cm} (2)

Where:

$$A = \begin{pmatrix} 0.85 & 0.15 \\ 0.16 & 0.64 \\ 0.125 & 0.375 \end{pmatrix}$$

is the decision matrix, shown boxed in Table 1.

The components $A_i$ of this matrix are the values of risk that each threat brings for each alternative.

$$X = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

is the vector of unknowns, i.e. the option to choose in this case.

$$A_i$$ is the vector of thresholds, i.e. the limits of each constraint according to the discussion in Section 3.2.

To meet the objective of minimizing the objective function $Z$, this objective function is expressed as the sum of the products between the cost of each alternative for the value of each of them (i.e. the unknown $X$ represents what we wish to determine).

Thus, assuming that the cost of a computer with free software operating system preinstalled is 600 , and the one for proprietary software is 700 , the objective function is:

$$Z = 600x_1 + 700x_2 \text{ (Minimize)}$$  \hspace{1cm} (3)

Applying the LP simplex method [6] which is essentially a repeated matrix inversion (2) according to certain rules, one gets, if it exists, the optimal solution of the problem. That is, the best combination or selection of alternatives to optimize the objective function (3).

5 Discussion of Results
5.1 Optimal Solution
The optimal solution to the LP problem is as follows:

$$X = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 0.125 \\ 0.292 \end{pmatrix}$$  \hspace{1cm} (4)

We choose the higher value because, although both contribute to obtaining the goal, if only one option is actually possible it is clear that the one with the higher value contributes more efficiently than the other and therefore is chosen. In the case above, proprietary software ($x_1$) should be chosen.

In our case both values are very close but since the LP indicates that the alternative with proprietary software contributes more efficiently to the objective, taking into account risk constraints, it is chosen.

5.2 Dual Problem
Every direct LP problem, such as this one, can be converted into ‘his image’, which is called the ‘dual problem’. In the dual problem the columns represent threats while the rows represent the alternatives. While the direct problem variables indicate which option contributes best to the goal, the dual problem variables provide us with the values of the ‘marginal contributions of each constraint’ or ‘shadow prices’, which is an economic term. In essence, this means knowing how much the objective function changes per unit variation in a constraint, which ultimately gives an idea of the importance of each constraint.

In this case we obtain the results shown in Table 2.
It turns out that the problem of lack of security is the most decisive in the choice of the alternatives, while resistance to change comes in a second place, which intuitively might be seen as the most decisive. The problem of dependency does not affect the solution since its marginal value is zero.

This powerful tool will allow, for example, a discussion of the cost difference that makes the solution change, and thus the selection, making the selection of computers with free software operating system preinstalled more interesting. Moreover, in this case we would observe that the component of inertia fails to be key or even to influence the selection process, and the real criteria for selecting the alternative is in this case the security issue first, and the problem of dependency, second.

6 Conclusions
The use of LP is a new application in the treatment of risks in projects. Its main advantage is that it is possible to represent real world scenarios with some degree of accuracy, as the number of constraints – and alternatives – can be measured in the hundreds. On the other hand, when analyzing the objective function for various scenarios it is possible to infer which is the best option [7].

Another major advantage is that, if there is a solution, this is optimal. i.e. the solution cannot be improved, thus confirming the Pareto optimal.

References

<table>
<thead>
<tr>
<th></th>
<th>Equal value</th>
<th>Marginal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of security</td>
<td>0.125</td>
<td>1683.333</td>
</tr>
<tr>
<td>Dependency</td>
<td>0.207</td>
<td>0.000</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>0.150</td>
<td>458.333</td>
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</tbody>
</table>

Table 2: Equal Value and Marginal Value.
Project Governance

Ralf Müller

Having a governance structure in organizations provides a framework to guide managers in decision making and action taking and helps to alleviate the risk of conflicts and inconsistencies between the various means of achieving organizational goals such as processes and resources. This article introduces project governance, a major area of interest in organizations, which is intended to guide, direct and lead project work in a more successful setting. To that purpose a new three step governance model is presented and described.

Keywords: Behaviour Control, Framework for Governance, Governance Model for Project Management, Governance Structures, Outcome Control, Project Governance, Project Management Action, Shareholder Orientation, Stakeholder Orientation.

Governance starts at the corporate level and provides a framework to guide managers in their daily work of decision making and action taking. At the level of projects governance is often implemented through defined policies, processes, roles and responsibilities, which set the framework for peoples’ behaviour, which, in turn, influences the project. Governance sets the boundaries for project management action, by

- **Defining the objectives of a project.** These should be derived from the organization’s strategy and clearly outline the specific contribution a project makes to the achievement of the strategic objectives
- **Providing the means to achieve those objectives.** This is the provision of or enabling the access to the resources required by the project manager
- **Controlling progress.** This is the evaluation of the appropriate use of resources, processes, tools, techniques and quality standards in the project.

Without a governance structure, an organization runs the risk of conflicts and inconsistencies between the various means of achieving organizational goals, such as processes and resources, thereby causing costly inefficiencies that negatively impact both smooth running and bottom line profitability.

Approaches to governance vary by the particularities of organizations. Some organizations are more shareholder oriented than others, thus aim mainly for Return on Invest-

“...This article introduces project governance, a major area of interest in organizations...”

Author

Ralf Müller, PhD, is Professor of Business Administration at Umeå University, Sweden, and Professor of Project Management at BI Norwegian Business School, Norway. He lectures and researches in governance and management of projects, as well as in research methodologies. He is the (co)author of more than 100 publications and received, among others, the Project Management Journal’s 2009 Paper of the Year, 2009 IRNOP’s best conference paper award, and several Emerald Literati Network Awards for outstanding journal papers and referee work. He holds an MBA degree from Heriot Watt University and a DBA degree from Henley Management College, Brunel University, U.K. Before joining academia he spent 30 years in the industry consulting large enterprises and governments in 47 different countries for their project management and governance. He also held related line management positions, such as the Worldwide Director of Project Management at NCR Teradata. <pmconcepts.ab@gmail.com>

1 This article was previously published online in the "Advances in Project Management" column of PM World Today (Vol. XII Issue III - March 2010), <http://www.pmworldtoday.net/>. It is republished with all permissions.
Risk Management

Figure 1: Four Project Governance Paradigms.

Governance provides a framework to guide managers in their daily work of decision making and action taking.

digm must be skilled, experienced and flexible and often work autonomously to optimize shareholder returns through professional management of their projects. The *Versatile Artist* paradigm maximizes benefits by balancing the diverse set of requirements arising from a number of different stakeholders and their particular needs and desires. These project managers are also very skilled, experienced and work autonomously, but are expected to develop new or tailor existing methodologies, processes or tools to economically balance the diversity of requirements. Organizations using this governance paradigm possess a very heterogeneous set of projects in high technology or high risk environments. The *Agile Pragmatist* paradigm is found when maximization of technical usability is needed, often through a time-phased approach to the development and product release of functionality over a period of time. Products developed in projects under this paradigm grow from a core functionality, which is developed first, to ever increasing features, which although of a lesser and lesser importance to the core functionality, enhance the product in flexibility, sophistication and ease-of-use. These projects often use Agile/Scrum methods, with the sponsor prioritising deliverables by business value over a given timeframe.

Larger enterprises often apply different paradigms to different parts of their organization. Maintenance organizations are often governed using the conformist or economist paradigms, while R&D organizations often use the versatile artist or agile pragmatist approach to project governance.

Governance is executed at all layers of the organizational hierarchy or in hierarchical relationships in organizational networks. It starts with the *Board of Directors*, which defines the objectives of the company and the role of projects in achieving these objectives. This implies decisions about the establishment of steering groups and Project Management Offices (PMOs) as additional governance institutions. The former often being responsible for the achievement of the project’s business case through direct governance of the project, by setting goals, providing resources (mainly financial) and controlling progress. The latter (the PMOs) are set up in a variety of structures and mandates, in order to solve particular project related issues within the organization. Some PMOs focus on more tactical tasks, like ensuring compliance of project managers with existing methodologies and standards. That supports gov-

Figure 2: Framework for Governance of Project, Program and Portfolio Management.

<table>
<thead>
<tr>
<th>Step</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>What can be done</td>
<td>Education</td>
<td>Methodology use and basic training</td>
<td>Certification</td>
</tr>
<tr>
<td>What should be done</td>
<td>Management demand</td>
<td>Steering Committees</td>
<td>Project Management Office (PMO / PSO / PO)</td>
</tr>
<tr>
<td>What is done</td>
<td>Audits / reviews</td>
<td>Mentor programs</td>
<td>Maturity Model</td>
</tr>
</tbody>
</table>
Risk Management

Governance along the behaviour control paradigms. Other PMOs are more strategic in nature and perform stewardship roles in project portfolio management and foster project management within the organization thereby supporting governance along the outcome control paradigms. A further governance task of the Board of Directors is the decision to adopt programme and/or portfolio management as a way to manage the many projects simultaneously going on in an organization. Programme management is the governing body of the projects within its programme, and portfolio management the governing body of the groups of projects and programmes that make up the organization. They select and prioritize the projects and programmes and with it their staffing.

How Much Project Management is enough for my Organization?

This is addressed through governance of project management. Research showed that project-oriented companies balance investments and returns in project management through careful implementation of measures that address the three forces that make them successful. These forces are (see also Figure 2):

a) educated project managers. This determines what can be done;

b) higher management demanding professionalism in project management. This determines what should be done; and,

c) control of project management execution. This shows what is done in an organization in terms of project management.

Companies economize the investments in project management by using a three step process to migrate from process orientation to project orientation. Depending on their particular needs they stop migration at step 1, 2 or 3 when they have found the balance between investments in project management (and improved project results) in relation to the percentage of their business that is based on projects. Organizations with only a small portion of their business based on projects should invest less, and project-based organizations invest more in order to gain higher returns from their investments. The three steps are (see also Figure 2):

Step 1: Basic training in project management, use of steering groups, and audits of troubled projects. This relatively small investment yields small returns and is appropriate for businesses with very little activities in projects.

Step 2: all of step 1 plus project manager certification, establishment of PMO, and mentor programs for project managers. This medium level of investment yields higher returns in terms of better project results and is appropriate for organizations with a reasonable amount of their business being dependent on projects.

“Approaches to governance vary by the particularities of organizations”
Step 3: All of step 1 and 2 plus advanced training and certification, benchmarking of project management capabilities, and use of project management maturity models. This highest level of investment yields the highest returns through better project results and is appropriate for project-based organizations, or organizations whose results are significantly determined by their projects.

The same concept applies for programme and portfolio management. This allows the tailoring of efforts for governance of project, program, and portfolio management to the needs of the organization. By achieving a balance of return and investment through the establishment of the three elements of each step, organizations can become mindful of their project management needs. Organizations can stop at each step, after they have reached the appropriate amount of project management for their business.

**How does All that link together in an Organization?**

The project governance hierarchy from the board of directors, via portfolio and program management, down to steering groups is linked with governance of project management through the project governance paradigm (see Figure 3).

A paradigm such as the Conformist paradigm supports project management approaches as described above in Step 1 of the three step governance model for project management, that is, methodology compliance, audits and steering group observation. A Versatile Artist paradigm, on the other hand, will foster autonomy and trust in the project manager, and align the organization towards a ‘project-way-of-working’, where skilled and flexible project managers work autonomously on their projects.

The paradigm is set by management and the nature of the business the company is in. The project governance paradigm influences the extent to which an organization implements steps 1 to 3 of the governance model for project management. It then synchronizes these project management capabilities with the level of control and autonomy needed for projects throughout the organization. This then becomes the tool for linking capabilities with requirements in accordance with the wider corporate governance approach.
Five Steps to Enterprise Risk Management

Val Jonas

With the changing business environment brought on by events such as the global financial crisis, gone are the days of focussing only on operational and tactical risk management. Enterprise Risk Management (ERM), a framework for a business to assess its overall exposure to risk (both threats and opportunities), and hence its ability to make timely and well informed decisions, is now increasingly becoming the norm. Ratings agencies, such as Standard & Poors, are reinforcing this shift towards ERM by rating the effectiveness of a company’s ERM strategy as part of their overall credit assessment. This means that, aside from being best practice, not having an efficient ERM strategy in place will have a detrimental effect on a company’s credit rating. Not only do large companies need to respond to this new focus, but also the public sector needs to demonstrate efficiency going forward, by ensuring ERM is embedded not only vertically but also horizontally across their organisations. This whitepaper provides help, in the form of five basic steps to implementing a simple and effective ERM solution.


1 Introduction

With the changing business environment brought on by events such as the global financial crisis, gone are the days of focussing only on operational and tactical risk management. Enterprise Risk Management (ERM), a framework for a business to assess its overall exposure to risk (both threats and opportunities), and hence its ability to make timely and well informed decisions, is now the norm.

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Not only do large companies need to respond to this new focus, but also the public sector needs to demonstrate efficiency going forward, by ensuring ERM is embedded not only vertically but also horizontally across their organisations (Figure 1). This whitepaper provides help, in the form of five basic steps to implementing a simple and effective ERM solution.

2 Five Steps to implementing a Simple and Effective ERM Solution

The five steps to implementing a simple and effective ERM solution are explained in this section.

Author

Val Jonas is a highly experienced risk management expert, with extensive experience of training, facilitating and implementing project, programme and strategic risk management systems for companies in a wide range of industries in the UK, Europe, USA and Australia. With more than 18 years experience in risk management and analysis, working with large organisations, Val has a wealth of practical experience and vision on how organisations can improve project and business performance through their risk management strategic framework and good practice. Val played a major part in the design and development of the leading Risk Management and Analysis software product Predict! More recently, she has pioneered Governance and Risk Management Master Class sessions for senior management in industry and government and has been a keen and active participant in forging the interfacing of Risk and Earned Value Management, including speaking at international conferences on these topics. She has a joint honors BA in Mathematics and Computing from Oxford University. <val.jonas@riskdecisions.com>.

About Risk Decisions

Risk Decisions Limited is part of Risk Decisions Group, a pioneering global risk management solutions company, with offices in the UK, USA and Australia. The company specialises in the development and delivery of enterprise solutions and services that enable risk to be managed more effectively on large capital projects as well as helping users to meet strategic business objectives and achieve compliance with corporate governance obligations. Clients include Lend Lease, Mott MacDonald, National Grid, Eversholt Rail, BAE Systems, Selex Galileo, Raytheon, Navantia, UK MoD, Australian Defence Materiel Organisation and New Zealand Air Force.

1 This is first of a series of whitepapers on Enterprise Risk Management. Future papers will expand on each of the steps in this white paper as well as continuing to cover Governance and Compliance.
Enterprise Risk Management (ERM), is a framework for a business to assess its overall exposure to risk (both threats and opportunities).

![Figure 1: Vertical and Horizontal ERM.](image)

![Figure 2: Enterprise Risk Structure in the Predict! Hierarchy Tree.](image)
Step 1 – Establish an Enterprise Risk Structure

ERM requires the whole organisation to identify, communicate and proactively manage risk, regardless of position or perspective. Everyone needs to follow a common approach, which includes a consistent policy and process, a single repository for their risks and a common reporting format. However, it is also important to retain existing working practices based on localised risk management perspectives as these reflect the focus of operational risk management.

The corporate risk register will look different from the operational risk register, with a more strategic emphasis on risks to business strategy, reputation and so on, rather than more tactical product, contract and project focused risks. The health and safety manager will identify different kinds of risks from the finance manager, while asset risk management and business continuity are disciplines in their own right. ERM brings together risk registers from different disciplines, allowing visibility, communication and central reporting, while maintaining distributed responsibility.

In addition to the usual vertical risk registers, such as corporate, business units, departments, programmes and projects, the enterprise also needs horizontal, or functional risk registers. These registers allow function and business managers, who are responsible for identifying risks to their own objectives, to identify risks arising from other areas of the organisation.

The enterprise risk structure (Figure 2) should match the organisation’s structure: the hierarchy represents vertical (executive) as well as horizontal (functional and business) aspects of the organisation. This challenges the conventional assumption that risks can be rolled up automatically.

"Aside from being best practice, not having an efficient ERM strategy in place will have a detrimental effect on a company’s credit rating."
Also the public sector needs to demonstrate efficiency going forward, by ensuring ERM is embedded vertically and also horizontally across their organisations.

Figure 5: Scoring by Cluster Maps from Local to Enterprise Level.

Figure 6: Metrics Reports by Business Objective, Cluster and Supplier.
Risk Management

cally, by placing horizontal structures side by side with vertical executive structures. Risks should be aggregated using a combination of vertical structure and horizontal intelligence. This is a key factor in establishing ERM.

**Step 2 – Assign Responsibility**
Once an appropriate enterprise risk structure is established, assigning responsibility and ownership should be straightforward. Selected nodes in the structure will have specified objectives; each will have an associated manager (executive, functional or business), who will be responsible for achieving those objectives and managing the associated risks. Each node containing a set of risks, along with its owner and leader, is a Risk Management Cluster. (See Figure 3.)

Vertical managers take executive responsibility not only for their cluster risk register, but also overall leadership responsibility for the Risk Management Clusters below. Responsibility takes two forms: ownership at the higher level and leadership at the lower level. For example, a programme manager will manage his programme risks, but also have responsibility for overseeing risk within each of the programme’s projects.

Budgetary authority (setting and using Management Reserve), approval of risk response actions, communication of risk appetite, management reporting and risk performance measures are defined as part of the Owner and Leader roles as illustrated in Figure 3. This structure is also used to escalate and delegate risks.

Horizontal managers take responsibility for their own functional or business Risk Management Clusters, but also for gathering risks from other areas of the Enterprise Risk Structure related to their discipline. For example, the HR functional manager will be responsible for identifying common skills shortfall risks to bring them under central management. Similarly, the business continuity manager will identify all local risks relating to use of a test facility and manage them under one site management plan. To assist in this, we use an enterprise risk map – see Step 3.

**Step 3 – Create an Enterprise Risk Map**
Risk budgeting and common sense dictates that risks should reside at their local point of impact, because this is where attention is naturally focused. However, the risk cause, mitigation or exploitation strategy may come from elsewhere in the organisation and often common causes and actions can be identified. In this case, we take a systemic approach, where risks are managed more efficiently when brought together at a higher level. To achieve this, we need to be able to map risks to different parts of the risk management structure.

Figure 7: Robust Risk Information for Decision-making.

ERM requires the whole organisation to identify, communicate and proactively manage risk.

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2 Risk Management Clusters® are unique to the Predict! risk management software.
To create an enterprise risk map, you need:

- a set of global categories to communicate information to the right place
- the facility to define the relationships between risks (parent, child, sibling etc)
- scoring systems with consistent common impact types

**Global Categories**

Functional and business managers should use these global categories to map risks to common themes, such as strategic or business objectives, functional areas and so on. These categories then provide ways to search and filter on these themes and to bring common risks together under a parent risk. (See Figure 4).

**Risk Relationships**

For example, if skills shortage risks are associated with HR, the HR manager can easily call up a register of all the HR risks, regardless of project, contract, asset, etc. across the organisation and manage them collectively.

Similarly, the impact of a supplier failing on any one contract may be manageable. But across many contracts could be a major business risk. In which case, the supply chain function needs to bring the risks against this supplier together and to manage the problem centrally.

Each Risk Management Cluster will include both global and local categories in a Predict! Group, so that each area of the organisation needs only to review relevant information.

**Scoring systems** are also applied by Risk Management Cluster, with locally meaningful High, Medium and Low thresholds which map automatically when rolled up (Figure 5). For example, a High impact of £150k at project or contract level will appear as Low at corporate level. Whereas a £5m risk at a project or contract level may appear as High at the corporate level.

Typically, financial and reputation impacts will be common to all clusters, whereas local impacts, such as project schedule, will not be visible higher up.

**Step 4 – Decision Making through Enterprise Risk Reporting**

The most important aspect of risk management is carrying out appropriate actions to manage the risks. However, you cannot manage every identified risk, so you need to prioritise and make decisions on where to focus management attention and resources. The decision making process is underpinned by establishing risk appetite against objectives and setting a baseline, both of which should be recorded against each Risk Management Cluster®.

Enterprise-wide reporting allows senior managers to review risk exposure and trends across the organisation. This is best achieved through metrics reports, such as the risk histogram (see Figure 6). For example, you might want to review the risk to key business objectives by cluster. Or how exposed different contracts and projects are to various suppliers.

Furthermore, there is a need to use a common set of reports across the organisation, to avoid time wasted interpreting unfamiliar formats (Figure 7). Such common reports ensure the risk is communicated and well understood by all elements of the organisation, and hence provide timely information on the current risk position and trends, initially top-down, then drilling down to the root cause.

**Step 5 – Changing Culture from Local to Enterprise**

At all levels of an organisation, changing the emphasis

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**Figure 8:** Proactive Management of Risks – looking ahead.
from ‘risk management’ to ‘managing risks’ is a challenge; however, across the enterprise it is particularly difficult. It requires people to look ahead and take action to avert (or exploit) risk to the benefit of the organisation. It also requires the organisation to encourage and reward this change in emphasis!

Unfortunately, problem management (fire-fighting) deals with today’s problems at the expense of future ones. This is generally a far more expensive process as the available remedies are limited. However, if potential problems are identified (as risks) before they arise, you have far more options available to affect a ‘Left Shift: from a costly and overly long process to one better matching the original objectives set! (See Figure 8.)

Most organisations have pockets of good risk management, many have a mechanism to report ‘top N’ risks vertically, but very few have started to implement horizontal, functional or business risk management. Both a bottom up and top down approach is required. An ERM initiative should allow good local practices to continue, provided they are in line with enterprise policy and process (establishing each pocket of good risk management as a Risk Management Cluster will provide continuity).

From a top-down perspective, functional and business focused risk management needs to be kick started. A risk steering group comprising functional heads and business managers is a good place to start. The benefits of such a group getting together to understand inter-discipline risk helps break down stove-piped processes. This can trigger increasingly relaxed cross-discipline discussions and focus on aligning business and personal objectives that leads to rapid progress on understanding and managing risk.

Finally, to ensure that an organisational culture shift is affected, the senior management must be engaged. This engagement is not only aimed at encouraging them to see the benefits of managing risk, but to also help the organisation as a whole see that proactive management of risk (the Left Shift principle) is valued by all.

A Risk Management MasterClass for the executive board and senior managers can provide them with the tools necessary to progress an organisation towards effective ERM.

3 The Benefits

ERM delivers confidence, stability, improved performance and profitability. It provides:
- Access to risk information across the organisation in real time
- Faster decision making and less ‘fire fighting’
- Fewer surprises (managed threats and successful opportunities)
- Improved confidence and trust across the stakeholder community
- Reduced cost, better use of resources and improved morale
- Stronger organisations resilient to change, ready to exploit new opportunities
  Over time this will:
  - Increase customer satisfaction, enhance reputation and generate new business
  - Safeguard life, company assets and the environment
  - Achieve best value and maximise profits
  - Maintain credit ratings and lower finance costs

4 Summary

All of the risk management skills and techniques required to implement Enterprise Risk Management can easily be learned and applied. From senior managers to risk practitioners, Masterclasses, training, coaching and process definition can be used to support rollout of Enterprise Risk Management.

Create a practical Enterprise Risk Structure, set clear responsibilities and hold people accountable. Define a simple risk map and provide localised working practices to match perspectives on risk. Be seen to make decisions based on good risk management information.

**Enterprise Risk Management should be simple to understand and simple to implement.**

**Keep it simple! Make it effective!**

**Bibliography**

- ISO Guide 73 – Risk management - Vocabulary

**Note:** All of these publications are listed at<http://www.riskdecisions.com>.

**Glossary**

**Note:** Where ‘source’ is in brackets, minor amendments have been incorporated to the original definition.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget</td>
<td>The resource estimate (in £/$s or hours) assigned for the accomplishment of a specific task or group of tasks.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Change Control (Management)</td>
<td>Identifying, documenting, approving or rejecting and controlling change.</td>
<td>(PMBoK)</td>
</tr>
<tr>
<td>Control Account</td>
<td>A management control point at which actual costs can be accumulated and compared to earned value and budgets (resource plans) for management control purposes. A control account is a natural management point for budget/schedule planning and control since it represents the work assigned to one responsible organisational element on one Work Breakdown Structure (WBS) element.</td>
<td>APM EVM guideline</td>
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<tr>
<td>Cost Benefit Analysis</td>
<td>The comparison of costs before and after taking an action, in order to establish the saving achieved by carrying out that action.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Cost Risk Analysis</td>
<td>Assessment and synthesis of the cost risks and/or estimating uncertainties affecting the project to gain an understanding of their individual significance and their combined impact on the project’s objectives, to determine a range of likely outcomes for project cost.</td>
<td>(PRAM)</td>
</tr>
<tr>
<td>Enterprise Risk Map</td>
<td>The structure used to consolidate risk information across the organisation, to identify central responsibility and common response actions, with the aim of improving top down visibility and managing risks more efficiently.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Enterprise Risk Management (ERM)</td>
<td>The application of risk management across all areas of a business, from contracts, projects, programmes, facilities, assets and plant, to functions, financial, business and corporate risk.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Left Shift</td>
<td>The practice by which an organisation takes proactive action to mitigate risks when they are identified rather than when they occur with the aim of reducing cost and increase efficiency.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Management Reserve (MR)</td>
<td>Management Reserve may be subdivided into:</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td></td>
<td>• Specific Risk provision to manage identifiable and specific risks</td>
<td></td>
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<tr>
<td></td>
<td>• Non-Specific Risk Provision to manage emergent risks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Issues provision</td>
<td></td>
</tr>
<tr>
<td>Non-specific Risk Provision</td>
<td>The amount of budget / schedule / resources set aside to cover the impact of emergent risks, should they occur.</td>
<td>APM EV/Risk working group</td>
</tr>
<tr>
<td>Operational Risk</td>
<td>The different types of risks managed across an organisation, typically excluding financial and corporate risks.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Opportunity</td>
<td>An ‘upside’, beneficial Risk Event.</td>
<td>PRAM</td>
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<tr>
<td>Baseline</td>
<td>An approved scope/schedule/budget plan for work, against which execution is compared, to measure and manage performance.</td>
<td>(PMBoK)</td>
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<tr>
<td>Performance Measurement</td>
<td>The objective measurement of progress against the Baseline.</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td>Proactive Risk Response</td>
<td>An action or set of actions to reduce the probability or impact of a threat or increase the probability or impact of an opportunity. If approved they are carried out in advance of the occurrence of the risk. They are funded from the project budget.</td>
<td>(PRAM)</td>
</tr>
<tr>
<td>Reactive Risk Response</td>
<td>An action or set of actions to be taken after a risk has occurred in order to reduce or recover from the effect of the threat or to exploit the opportunity. They are funded from Management Reserve.</td>
<td>(PRAM)</td>
</tr>
<tr>
<td>Risk Appetite</td>
<td>The amount of risk exposure an organisation is willing to accept in connection with delivering a set of objectives.</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td>Risk Event</td>
<td>An uncertain event or set of circumstances, that should it or they occur, would have an effect on the achievement of one or more objectives.</td>
<td>PRAM</td>
</tr>
<tr>
<td>Risk Exposure</td>
<td>The difference between the total impact of risks should they all occur and the Risk Provision.</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td>Risk Management Clusters</td>
<td>Functionality in Risk Decisions’ Predict! risk management software that enables users to organise different groups of risks to form a single, enterprise-wide risk map.</td>
<td>Risk Decisions</td>
</tr>
<tr>
<td>Risk Provision</td>
<td>The amount of budget / schedule / resources set aside to manage the impact of risks Risk provision is a component part of Management Reserve</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td>Risk Response Activities</td>
<td>Activities carried out to implement a Proactive Risk Response.</td>
<td>APM EV/Risk Working Group</td>
</tr>
<tr>
<td>Schedule Risk Analysis</td>
<td>Assessment and synthesis of schedule risks and/or estimating</td>
<td>(PRAM)</td>
</tr>
</tbody>
</table>