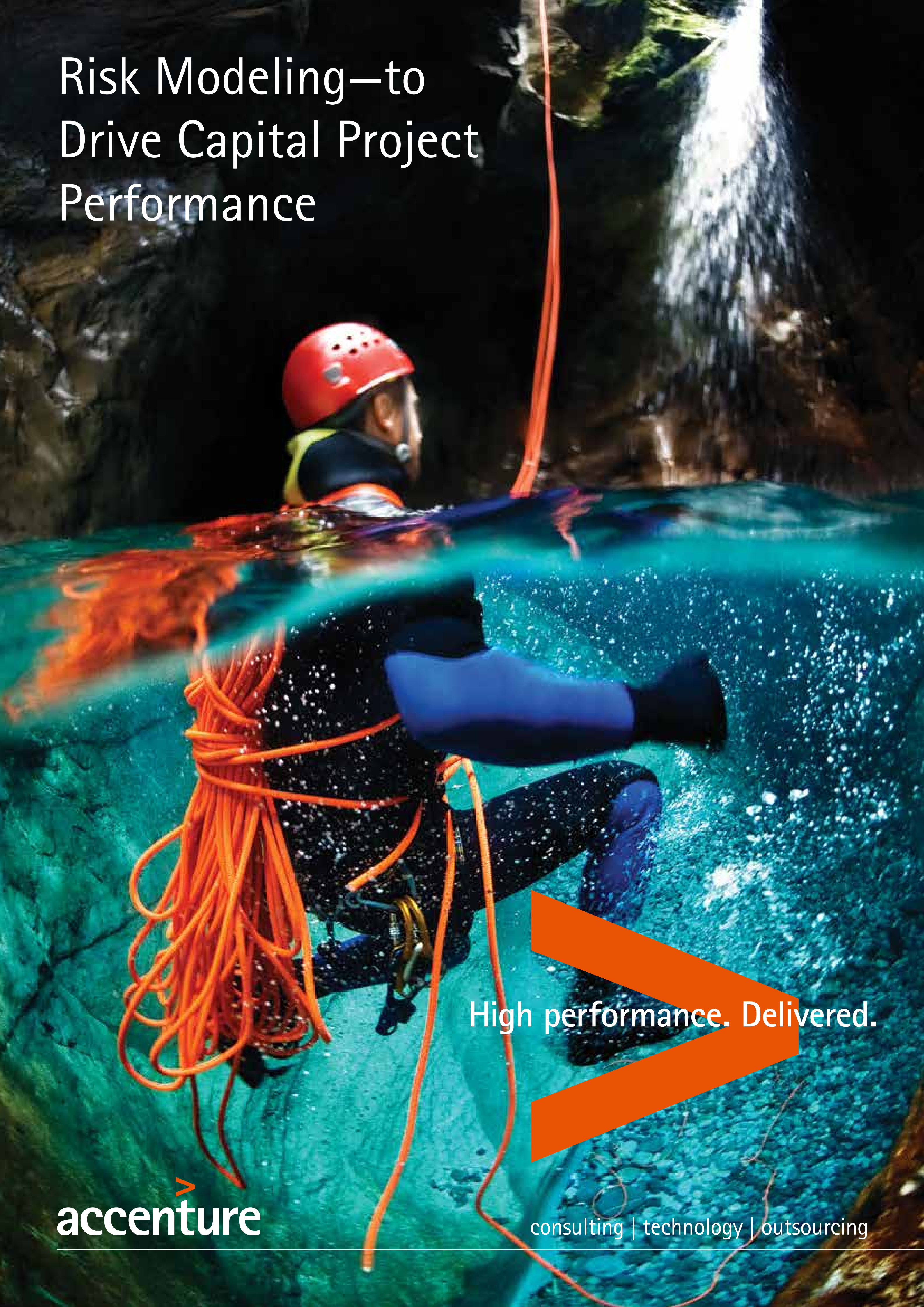
Risk Modeling—to Drive Capital Project Performance



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Debt, liquidity constraints and access to financing are major issues for public and private participants in major capital projects. Banks, investment funds, sponsors, industries or estates are less willing than ever to invest their money in projects without a strict analysis of the return on investment. While such analysis provides a precise financial estimation of the project, financial evaluation of the most probable scenarios is not enough to protect against capital project risk.

A complete assessment of the project leading to a decision on the investment should include a thorough risk evaluation. A $100 million project with a high degree of risk is not the same as a $100 million project with low risk. Probabilistic risk modeling can help companies estimate this risk, providing powerful insights into what different levels of risk mean in terms of capital project performance.

Continuous risk management during project delivery

Once the project is launched, risks should be monitored during the entire project's life in order to make sure that anticipated value is ultimately delivered to investors. The overall risk management process—including risk modeling—is not a one-time activity but continues throughout the entire project lifecycle (Figure 1).

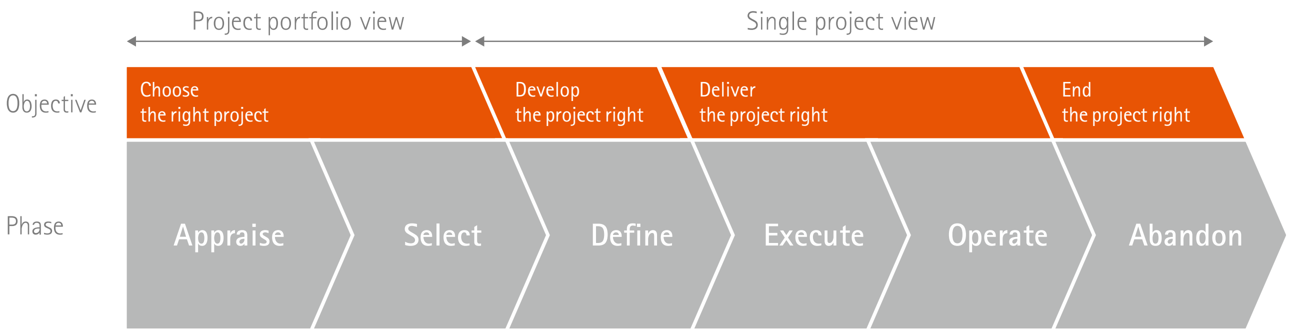
Through ongoing risk management and modeling, investors and project managers can effectively answer key questions such as:

- In which projects are we willing to invest?
- What are the key threats that can potentially undermine the project execution?
- How can such threats be avoided or mitigated during the definition and design of the project?
- Will the project be delivered on schedule and within budget?
- Which events may lead to deviation from the initial project plan?
- How can risks be mitigated during project delivery and ongoing operations, balancing effectiveness against efficiency?
- How can the benefits of risk mitigation actions be measured against their costs?
- How can the right behaviors be incentivized on the project, balancing risk and reward?
- How can the project be abandoned or decommissioned without compromising the future development or utilization of the area—or exposing the project to additional costs?

As illustrated in Figure 2, the project risk management process consists of six successive major phases. Risk modeling is part of the risk analysis phase, which follows the risk identification phase. Risk modeling is a crucial activity that allows project investors and management to determine on an ongoing basis—through a quantitative approach using deterministic or probabilistic methods—the levels of risk to which the project is exposed.

Quantitative risk analysis enables both decision makers and project managers to include the risk dimension in the financial model of the project and in the overall project monitoring process. It is the basis for choosing cost-effective risk responses and supports the allocation of available (and limited) resources to where they matter most.

Figure 1: Typical capital project lifecycle and objective of risk management



Source: Accenture

Figure 2: Overall project risk management process

WBS: Work Breakdown Structure
CBS: Cost Breakdown Structure

Source: Accenture

I. Tools for measuring uncertainty

Traditionally, the financial evaluation of projects has been based on a deterministic quantitative model. Such models generate a single deterministic output, such as gross margin or required capital expenditure, given a set of deterministic input including revenue streams or expenditures. Project risk evaluation has often been performed with a qualitative (High - Medium - Low) or quantitative deterministic (xM$) approach, based on the evaluation of the likelihood and impact of the risks identified.

For example, a project might be valued at $100 million, when in fact the real value might be $102 million, $114 million, $89 million, or even (although less likely) $70 million. Rarely, if ever, is such a project going to cost exactly $100 million. Factoring potential risk events into the financial analysis supports a more realistic and robust estimate of the true cost of delivering the project. When risk events are factored in, the original, non-risk adjusted estimate seems unlikely to be accurate.

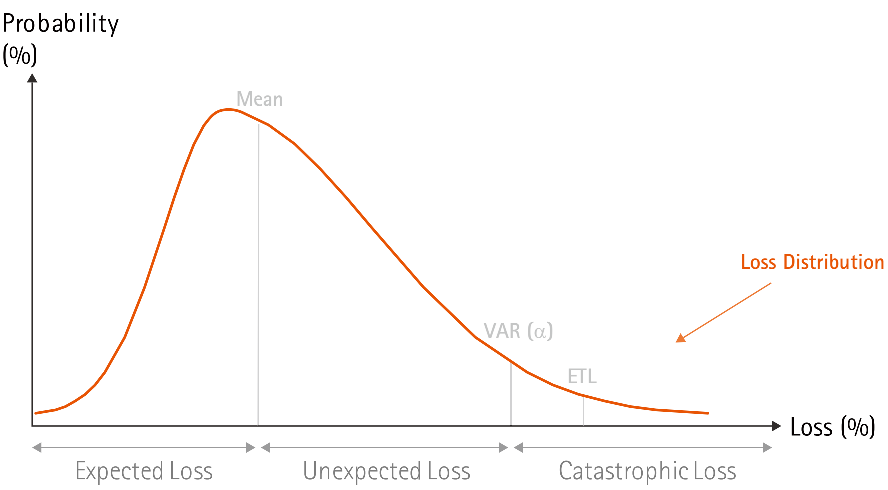
To properly evaluate the project, investors need to know—before the project is launched—what is the risk that the value of the project is over- or underestimated. After the project is launched, investors should be aware of the risks involved in the delivery of a project, in terms of cost, delay, revenues and other factors, at each stage of its life cycle.

Both the qualitative and quantitative deterministic approaches are based on a simple measurement of the Expected Loss (the average loss, or the probability-weighted mean of a loss distribution) without taking into consideration the Unexpected Loss (the difference between the total exposure at the target risk tolerance level) or even the Expected Tail Loss, which provides a more suitable measure of the level of uncertainty (Figure 3).

Estimates of cost and completion dates or any other variable used to describe project performance—such as power plant reliability—should be associated with confidence levels. They should be viewed as distributions, with each value corresponding to a given probability of occurrence.

Indeed, in today's increasingly complex and interconnected global operating environment, growing drivers of risk such as the scarcity of commodity resources, shortages of talented human capital, environmental responsibility, geo-political instability and technology dependence are significantly increasing the level of uncertainty in the development and delivery of capital projects. Investors who need a thorough financial analysis to decide whether to invest in a project, and project managers who need to implement robust on-going project control, agree on the need for extensive risk modeling. A qualitative or deterministic approach, however, is no longer suitable to

Figure 3: Expected, Unexpected and Catastrophic Losses



VAR (α): Value at Risk at a specified confidence level α
ETL: Expected Tail Loss

Source: Accenture

effectively support the decision making process. A probabilistic approach is needed to deal with such uncertainties.

Probabilistic risk modeling is a way of numerically estimating the probability that a project will meet its target performance criteria in areas such as cost and schedule at each stage of its lifecycle. It is based on a simultaneous evaluation of the effect of all identified and quantified risks on the project. Monte Carlo simulation, one type of risk modeling, is a powerful technique to analyze project risk and the associated level of uncertainty.

Risk analysis based on probabilistic risk modeling should be conducted throughout the whole capital project lifecycle and be fully integrated in the project management process, following the same "stage and gate" approach. The risk profile of a project evolves and changes as the project is developed. Knowledge gained and mitigation actions performed may reduce some risks, while new risks can emerge at any time; due to changes in external market conditions, the occurrence of natural events or simply because the project enters a new stage of the lifecycle.

While it is clear that probabilistic risk modeling cannot prevent the occurrence of risk events or project failure, it allows investors to complete a financial valuation of the project, taking into account all the risks and uncertainties which could prevent the project from reaching such performance targets as internal rate of return (IRR), return on capital (ROC), return on investment (ROI) and net present value (NPV) of the project's cash flow, margin and earnings. It allows a more comprehensive and more accurate overall evaluation of the project. Risk modeling also allows project managers to understand how different types of risk can affect the overall cost of the project, as well as the target schedule for completion of activities, during the definition and execution stages of the project life cycle.

This type of risk modeling can therefore support decision makers and managers in defining cost-effective measures to reduce the overall project risk profile as well as increasing the level of confidence in reaching target performance.

Based on a critical review and judgment of the modeling output, a number of risk transfer or reduction measures can be implemented, including:

- Reducing risk — by applying targeted prevention and mitigation measures such as reinforcing control processes, investing in additional protection, or upgrading workers' technical skills.
- Sharing risks — with partners through techniques such as public-private project negotiations between partners, including a stage in which risks are assigned to each partner.
- Insuring risks — by transferring risks outside the organization to another party—typically an insurer—who will bear the liability of the risk, should it occur. Insurance involves payment of a premium and the cost-effectiveness of this is a consideration when deciding whether to adopt a transfer strategy to finance risk.
- Selling the risks — when two partners have two different valuation of a risk, one can sell it to the other by negotiating its price.

The specific risk response strategy for each project strongly depends on the nature of the risk to be treated, the overall exposure the project or organization is subject to and the current stage of the project lifecycle. In any case, project risk response should be discussed periodically to reassess existing risks, verify the adequacy and effectiveness of planned and implemented mitigation actions, and eventually to define additional measures. The identification and assessment of emerging risk is not a one-time exercise. It should be performed continuously. At all stages of the project lifecycle those discussions should occur—in particular, during regular management meetings—thus allowing executives to gain a better understanding of current risk and its potential impact on the project.

A structured approach to risk modeling

Probabilistic risk modeling performed with Monte Carlo techniques involves analyzing a large output of data generated by solving a "problem" many times over, with each solution or "iteration" representing a possible scenario.

The more transparent the input and the hypothesis are to key stakeholders, the higher the credibility of the output, as well as the confidence in such models.

Monte Carlo techniques can be applied through a straightforward process involving three key steps as seen in Figure 4.

The three steps are:

A. Define and model single risk distribution. Analyze distributions of severity and frequency for each identified risk, instead of fixed inputs. These distributions allow modeling of the uncertainty on the estimated values (such as cost, barrels of production, inflation rate and others) and of risk events (such as technical failures, natural hazards, or legal constraints or proceedings). Adequate modeling of the distribution of each single risk is therefore crucial as it affects all subsequent steps.

   As a general starting point it is possible to distinguish at least three types of risk, each of them requiring an ad hoc approach to modeling.

   The first type of risk includes those linked to uncertainties in the estimates. These would include, for example, risk of additional costs to develop a new processor in the aerospace industry or the cost of a long-lead time item such as a turbine in a power plant. A normal distribution is often used as a first approximation to describe real-valued random variables that cluster around a single mean value.

   When there is reason to suspect the presence of a large number of small effects acting additively and independently, it is reasonable to assume that observations will be normal. Effects can also act as multiplicative (rather than additive) modifications. In that case, the assumption of normality is not justified, and it is the logarithm of the variable of interest that is normally distributed. This is often the case for financial variables such as interest rates or exchange rates. The distribution of the directly observed variable is then called log-normal.

   The second type of risk is linked to the occurrence of specific identified events. These risks are commonly identified by the project initiators. The difference from the first type of risk is that this risk can happen once, twice or never. There is a difference between binary specific risks, (when risk, by its nature, can occur only once during a certain stage of the project, or at certain time intervals,) and recurring specific risks, which can occur many times during the project lifecycle. An example of binary specific risk would be the risk of additional costs to receive a concession or authorization, due to the ratification of a new regulation; recurring specific risks would include labor unrest or strikes.

   The last type of risk is linked to very rare, unpredicted "Black Swan" events with a high potential impact on the project. The best way to deal with such risks is to evaluate their effect on project performance with particular types of analysis such as stress tests, and by applying particular at-risk measures such as Conditional Value-at-Risk which will be described shortly.

B. Evaluate risks correlation and dependencies. It is important to consider dependencies among different risks when modeling ("when event A occurs there is a greater/lesser chance that event B occurs as well"). Indeed, the overall risk of the project is not equal to the sum of each single risk.

C. Aggregate risks. Risk is aggregated through the model (such as a financial model for project evaluation, or a project cost model) allowing the generation of an overall project risk profile. This output can be further analyzed in depth, applying additional techniques.

Today, risk modeling is applied across a range of industries. In addition, there is a wide array of IT solutions in the market that may assist in running Monte Carlo simulations. These tools are typically not expensive and are often quite intuitive to use. In selecting tools, a key feature is whether the financial model can be run within an acceptable timeframe by users; with Monte Carlo simulation, for example, it will be run more than a thousand times to reach a stable result or convergence.

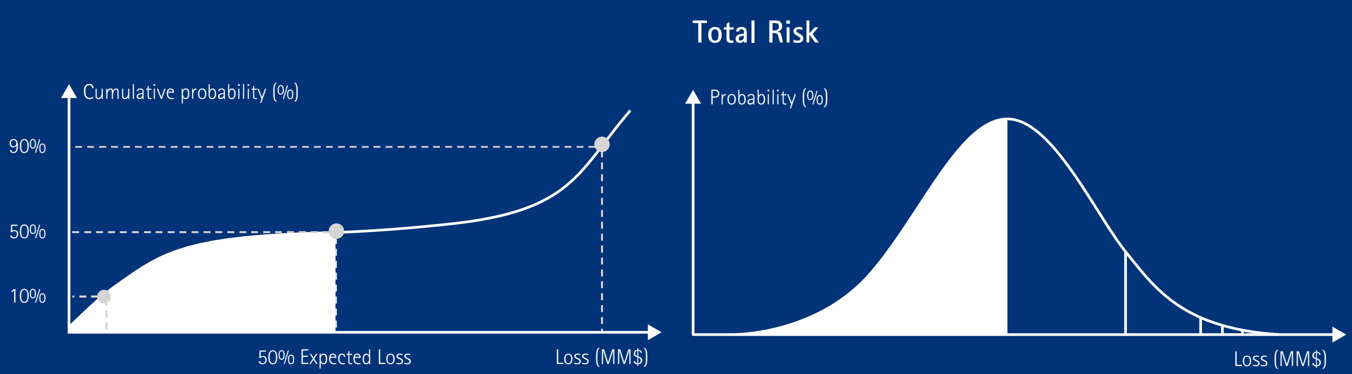
Figure 4: Key steps to risk modeling

A Define and Model Single Risk Distribution

B Evaluate Risk Correlation / Dependencies

Correlation matrix	Risk 1	Risk 2	Risk 3
Risk 1	1	-0.755	0.981
Risk 2	-0.755	1	-0.866
Risk 3	0.981	-0.866	1

C Aggregate Risks



Source: Accenture

II. How the output from risk modeling can be used to support decision making and risk monitoring

Using risk modeling to support decision making and risk monitoring

Probabilistic modeling produces many outcomes such as S-curves or probabilistic distribution of overall financial results. The key question is how these outcomes can be used effectively in the decision making process. Do such outcomes provide all the information managers need to make decisions?

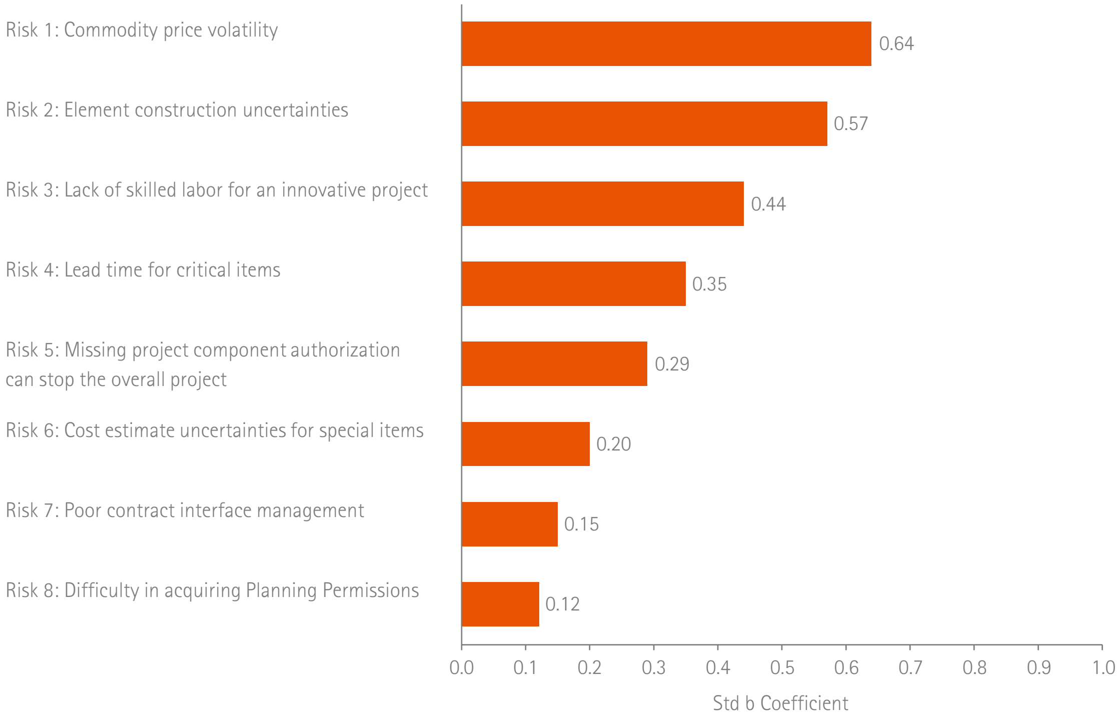
In fact, information derived from the output of the risk modeling described above is not sufficient to support managers in making decisions. Additional analysis should be conducted to effectively use the power of the approach. This might include:

- Contribution to variance analysis. This analysis allows comparisons of the influence of each risk on the final result (overall risk). This way risks can be ranked from the most important to the least important, using a chart as illustrated in Figure 5.
- Risk financial valuation. This analysis allows each risk to be priced and sold or transferred, showing its own contribution to the overall risk margin.
- Conditional Value-at-Risk calculation (CVaR). This risk measure indicator—a modified value at risk—takes into account the tails of the distribution, that is, the effect of low-frequency, high-impact risk scenarios.
- Stress testing. The purpose of stress testing is to estimate the potential vulnerability of the company to "exceptional but plausible events" or one-time, low-probability disasters like "Black Swans". Although stress testing is widely used in the banking and financial industries, recent economic calamities have demonstrated that the depth and rigor of existing stress testing processes are often insufficient. To address these shortcomings in the banking industry, new requirements and rules have been issued by authorities such as the Federal Reserve Board in the United States. Lessons learned should be adopted in other industries as well.

Based on these additional analyses, managers will be better able to:

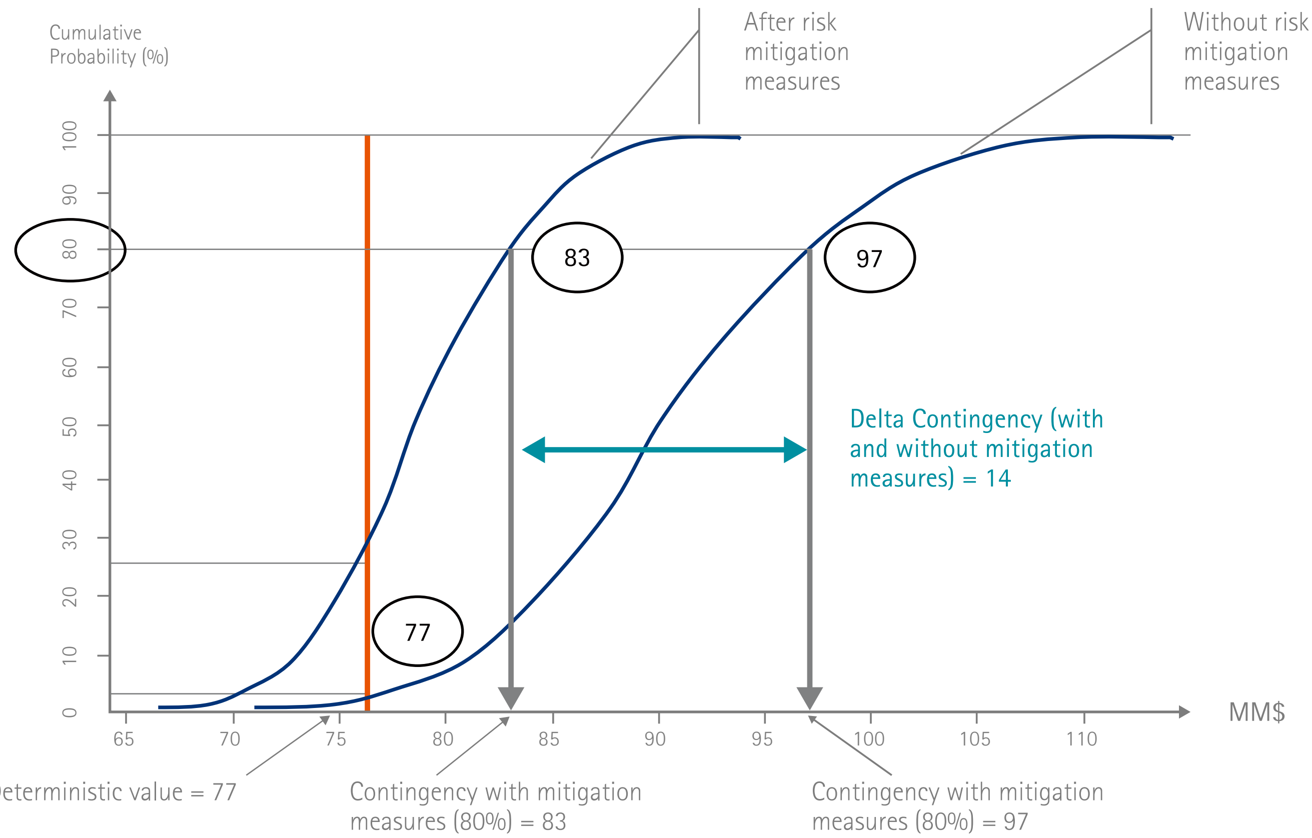
- Analyze the key risks affecting the project performance and their importance to the overall risk.
- Evaluate these risks financially.
- Evaluate the effect of risk control measures on the overall project risk profile, helping to select the most cost-effective risk control strategy and define contingencies to be allocated for the project execution at a given confidence level, as seen in Figure 6.
- Compare risks among different projects.
- Make investment decisions based on quantitative results.

Figure 5: Contribution to variance analysis



Source: Accenture

Figure 6: Impact of risk mitigation on the risk capital expenditure profile



Source: Accenture

Modeling techniques are not enough

As mentioned, Monte Carlo techniques are very simple to apply and yet can be a powerful tool to support investors and project managers in the decision making process.

Accenture has identified four essential elements for making better decisions:

1) Structured data management entails a process that enables the investors and management team to base the modeling of risks on robust input, in order to create sound probability distribution of each risk. For businesses today, the key issue is not the lack of data or information, but the huge amount of information, which results in difficulties in systematically collecting and interpreting data and leads to limited or incorrect use. A sound data management process is crucial to ensure the highest degree of modeling, as well as to achieve credible results.

2) A sound process for risk identification and analysis should be in place to ensure that:

- Every risk is correctly identified in every stage of the project lifecycle.
- Risks are periodically reviewed as the project develops.
- Key expertise is leveraged during risk identification and analysis, involving a group of people with a range of skills including economists, technicians, and managers.
- These experts take responsibility for their estimates.
- An effective "lessons learned" process is in place which creates the basis for continuous improvement.

A key step in the modeling, as mentioned, is the selection of distribution that best describes each single risk factor.

There are two possibilities that can help determine these inputs:

- Historical data. Simple statistical methods allow organizations to determine the probabilistic distribution of risk based upon historical data. However, such data is not always available.
- Expert opinion. Specific techniques exist to convert qualitative opinions into quantitative ones; for example, the Delphi approach applied to derive probability distribution based on expert judgment.

Most of the time historical data and expert opinion should be leveraged together, as historical data alone may not be enough to derive future values of risks given the number of uncertainties which may affect each risk. Future risk profiles are not always like past ones and should be adjusted in the risk models.

The probabilistic approach should also be completed with sound qualitative judgment to cross-check hypotheses and results, leveraging the experience of the risk analysis team as well as past data.

3) An adequate supporting IT system should be implemented in order to provide:

- A systematic and structured collection of data into a "loss database".
- The running of the probabilistic model itself (for large and complex capital projects).
- The production of easy-to-read reports with specific views which can facilitate comprehension of the results even by "non-experts".

4) Clear and effective risk governance must ensure that:

- Clear roles and responsibilities for risk management are defined at every level of the organization, including group/corporate, business unit or division, and at single project levels.
- Prompt communication is established among different stakeholders based on effective top-down and bottom-up flows of information, as well as horizontal flows cross-project and across divisions and business units.
- The risk management process is fully integrated into traditional investment/capital project management processes.

How Accenture can help

Accenture provides a combination of skills and assets that allow a complete and robust implementation of probabilistic risk modeling:

- We can help you strengthen your current risk modeling to achieve higher quality of results.
- Our consultants work side-by-side with you to define and implement adequate supporting tools fully integrated with your financial models to enable a probabilistic risk analysis for large capital projects and investments.
- We support embedding best practices regarding process and governance for capital project risk management into your daily baseline business activities, ensuring full integration with existing investment and capital project management processes.

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About Accenture Risk Management

Accenture Risk Management consulting services work with clients to create and implement integrated risk management capabilities designed to gain higher economic returns, improve shareholder value and increase stakeholder confidence.

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