

Nolberto Munier

# Risk Management for Engineering Projects

Procedures, Methods and Tools

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Nolberto Munier  
Associate Researcher INGENIO (CSIC-UPV)  
Polytechnic University of Valencia, Spain

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# Chapter 1

## Principles and Elements of Risk Management – Data and Initial Conditions

**Abstract** This chapter is devoted to furnishing background information on Risk Management, explaining the string of steps that comprise it, and the use of techniques within it, as well as their relationships. The chapter follows the widely accepted sequence for risk identification, assessment, execution, remediation and control; it starts with some basic definitions and, in its first topic, analyzes the sources for risks, considering internal and external risks and opportunities. It follows with a guide for identifying and managing risks in different areas of a project and suggests appropriate tools and techniques for each one. Completion of sequence sensitivity analysis, a subject developed in full in Chap. 6, is commented upon briefly just to give the reader an idea of its use and potential, the sequence finishes with steps for closing and reporting. Establishing a procedure that is a norm in this book, a real life example is proposed using SWOT analysis (This is a planning technique for assessing a firm capability for executing a project considering Strength, Weakness, Opportunities and Threats) to illustrate a firm self-evaluation regarding risks for a particular project. The chapter concludes with the definition of a project strategy, a fundamental step, since it will determine the road to follow for a successful project to be finished on time, under budget and with the required quality.

**Keywords** Risk • Identification, assessment and remediation • Sensitivity analysis • SWOT analysis • Project strategy

### 1.1 Background Information on Risk Management

**Risk:** Its most general definition is “*Probability Distribution of Loss*” (Paulos 2001).

**Risk Management (RM) procedure:** Its more general definition is “*the set of techniques for controlling the uncertainty in a project*” (Merritt and Smith 2004). It is necessary to take into account that risk management is not an exact science and is subject to the particular conditions of a project, conditions that will most likely be

different even from those of very similar projects. To this point, Kutsch (2008) asserts, “..... *this study offers evidence to counter argue the “self-evident” correctness of deterministic and rational risk management processed successfully by the PMI (2004), OGC or the APM (2005) and highlights the need to include behavioral aspects into the management of risk*”.

However, according to Kwak and Dixon (2008), it appears that high-technology industries face many of the same challenges regarding uncertainty, complexity and risk as those faced by the pharmaceutical industry. It would thus be convenient, if possible, to have some sort of tabular information concerning these facts for different industrial sectors, which, if the facts really exist, will help in identifying risk and decreasing uncertainty.

Uncertainty has been mentioned, but what does it mean? The Dictionary gives different definitions for this word; however, for our purpose, we find that ‘uncertainty’, at least in the context of Project Management, is better expressed as a number of different values that can exist for a quantity, with ‘risk’ meaning the possibility of loss or gain as the result of uncertainties (Rodger and Petch 1999). It is generally accepted that uncertainty has two sources:

1. The uncertainty or randomness inherent to a process,
2. The uncertainty resulting from lack of information about that process, that is, the relationship between human knowledge and the process.

Once the project scope is established, project planning and scheduling begin, through definition and sequencing of the different tasks or activities with their corresponding durations, and assignment of resources along the project duration (Project horizon). This allows for computing the Budget Cost of Work Scheduled curve (BCWS), which includes direct and indirect costs and project reserves. The BCWS is used as a reference for checking construction advance and expenditures during construction, and should be in line with the Control Account Plan (CAP).

Normally, once the project is underway, it is periodically updated, with information about progress registered (by Monitoring) and assessed (by Project Control), and then exerted using Earned Value (EV), also in line with CAP. The work actually done, valued at actual costs, prices and time spent, gives a monetary value. These values, through successive updates, constitute the Actual Cost of Work Performed (ACWP) curve. Similarly, the amount of work done valued at budget cost gives the successive points that allow for drawing the Budget Cost of Work Performed (BCWP) curve. These three curves permit for associating the amount of work done with the money actually spent.

Thus, we have three curves, each one expressing a different concept of the work and allowing the computation of important metrics such as Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), and Estimate at Completion Cost (EAC).

Thus, Earned Value Management (EVM)

- (a) Measures performance and
- (b) Forecasts how much the project will ultimately cost.

However, neither Planning, which in reality looks at a not-so-distant future, nor EV, which analyzes past performance, usually take into account uncertainty existing in all projects, and this is where RM enters into the picture. RM can look further into the future, although it is sometimes used as a prevention tool in certain activities, but is not usually considered at the same level of usage compared with the other two, perhaps because of its probabilistic nature, with which not everybody is comfortable. This book proposes approaching Project Management in a different way and taking into account two features.

Firstly, because of uncertainty, there is no project without risk, and this uncertainty may be due to different causes, such as an indefinite result or lack of sufficient information on a subject.

Most projects deal with uncertainties, and many projects depend, to a certain measure, on unforeseen circumstances that are beyond the control of the owners, stakeholders, project managers (PM), contractors and suppliers. In conclusion, a project of any kind is a risky endeavour and, as such, this paper suggests the use of RM in managing a project, because risk is present in practically all activities and estimates of every kind, from task duration to profit, from relationships with stakeholders, contractors and suppliers to exogenous factors.

What does this mean?

It means that risk should be routinely considered from the very beginning in all aspects of the project, including its development (to update risks, incorporate new ones or eliminate those already identified), and that **a project should be oriented toward managed risk.**

It is interesting to consider that, in its origins, Project Management, other than the initial utilization of **GANTT** Charts (after Henry Gantt, 1915), a **scheduling method**, began using **PERT** in 1957 (developed by Booze Allen Hamilton and the U.S. Navy) for very complex and uncertain projects, such as the Polaris nuclear submarine and the Ballistic Missile Program.

PERT is essentially a **planning and risk method**, since it considers estimates of not one, but three points for every task, that is, it considers some flexibility in recognizing that only one estimate, either in duration or cost, is not enough.

A little later, in 1958, du Pont de Nemours developed the Critical Path Method (**CPM**), the other great management-planning tool, which complements the Gantt chart for scheduling. Both PERT and CPM are project modelling techniques and have most elements in common, as well as procedure; however, the first takes into account uncertainty in task duration while the second considers deterministic estimates for task duration, or, in other words, considers that those durations are reliable values, which unfortunately is not the case.

Earned Value Management (EVM) is not used for planning and scheduling, but as a project control tool for measuring performance based on past performance, allowing for corrective actions if necessary.

At present, it is true that Project Management has begun using some risk concepts in projects, but it is believed that there is incomplete acknowledgment and conviction about the need to include risk in every project and at each stage.

The second point in this work proposes using Planning and RM from the very beginning and throughout the project, as well as EVM starting with the first update. Thus, it is proposed that, in the initial listing of activities, a column should be added to compute risk for each activity or task. After each update, rescheduling the work will very often be required due to scope changes, or because there is better information on task duration, additions, etc. At the same time, past risks and their occurrence (or not) should be examined to take advantage of the information they can provide. For instance, it may be that, at the beginning of planning, the project team considered it necessary to add days to the duration of a task owing to a threat of risk involved. However, if during the update, it is confirmed that the task was completed and without any risk present, then excess duration in days can be transferred to the end of the project to be used in future tasks, if the need arises. At the same time, lessons are learnt about this type of task for better assessment in future projects or its forthcoming replication in the same project.

The above procedure keeps some similitude with **Critical Chain Project Management (CCPM)**, developed by Elijah Goldratt in 1997, a **resource-oriented planning tool** which establishes buffers in the planning stage for all activities or tasks, many of which are accumulated at the end of the project to be used whenever necessary.

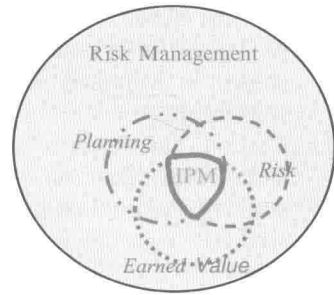
As a summary, Fig. 1.1 depicts the superposition of the three methods and identifies an Integrated Project Management (IPM) common area indicating that the three methods participate, but under the Risk Management umbrella. In reality, RM is aimed at managing uncertainty, and then incorporating data into the other methods.

RM is concerned with the whole project from beginning to end; however, in this approach, the project is broken-down into areas and tasks, with RM affecting each of them. This is a way to make sure that the method is applied to everything and not just to the overlapping areas.

There is a path within a project from start to finish that leads to the attainment of the project objective; many factors act along this path, making it jagged and tortuous owing to deviations; with RM, we try to avoid or at least to minimize these deviations. Subsequently, RM must be embedded in a project, although, if there is certainty that something will not happen, it is not considered a risk.

As mentioned, this book suggests that a project should be oriented toward managed risk, with risk covering the following aspects: (1) Costs, (2) Economics and Finance, (3) Time, (4) Environment, (5) Societal Opinion, (6) Safety, (7) Quality, (8) Legal, (9) Communications, (10) External Factors, and (11) Closing. What now follows is a description, with brief comments, of diverse procedures proposed for dealing with risk in each aspect. It is necessary to take into account that these measures must be applied at the beginning of the project in the initial planning stage. In successive updates, the procedure is repeated, perhaps correcting pessimistic and optimistic prior estimates, saving buffers when forecasted durations did not materialize, recovering dedicated funds when costs did not increase, etc., and computing new values for risks up to the end of the project.

**Fig. 1.1** Integrated Project Management (IPM) including the three main methods, enveloped by Risk Management



1. Cost. This refers to potential or actual threats related to the project not meeting the established project budget. Cost contractor's performance index (CPI) normally replicates in the future. According to some researchers, the CPI does not change by more than 10 % once 20 % of the project has been completed. The research found that, in most cases, it worsens as the project advances to its completion, and that the EAC tends to get larger when computed using the CPI in short periods (6 months).

Therefore, this is something that should be considered in successive updates.

2. Economics and Finance. These refer to potential risks related to the project not meeting economic and financial expectations.
3. Time. This refers to potential or actual threats that can risk the established completion date of the project.
4. Environment. This refers to potential or actual threats related to the project not meeting standard environmental contamination limits or affecting the environment (soil, water, air, land use, wildlife, forests, and aquatic life) in various ways.
5. Societal Opinion. This refers to potential or actual threats related to public opinion on the project, which can even risk its very existence.
6. Safety. This refers to potential or actual threats that can risk the safety of personnel and structures or even the project itself, and to the safeguards that may require implementation.
7. Quality. This refers to the existing chances of a contractor or manufacturer not doing quality work.
8. Legal. This refers to potential or actual threats related to assorted legal issues that can not only endanger the project, but also paralyse it.
9. Communications. This refers to threats originated by a lack of proper communication between the contractor and stakeholders, owners, suppliers, vendors, etc. It is also related to the owner's organization, contracting, or consulting firm developing the project. In reference to this issue, De Bakker et al. (2011) mention that "*Analysis demonstrates stakeholders deliberately use risk management to convey messages to others, with the aim of influencing their behaviour, synchronizing their perception, and making them aware of the context and their responsibilities. Stakeholders perceive these effects as contributing to project success*".

10. External factors. This refers to threats linked to risks produced by the occurrence of factors and events that the owner, stakeholders or contractors cannot control or accurately predict, such as acts of nature, government regulations, weather, etc.
11. Closing. This refers to potential or actual threats that can risk well-ordered and efficient handover of the project to the owner or stakeholders, since the possibility exists that they may not be satisfied with the closing procedures, especially regarding project documentation and further contractor's obligations, if any.

## **1.2 Project Scope**

The scope of the project must be thoroughly studied from the contractual point of view, owing to risk of the owner claiming that something that should have been done, as set down in the contract, was not. For instance, landscaping or improvement of certain municipal services (common in many cities that allow for some violation of city bylaw in exchange for execution of certain work, such as a roundabout, a water fountain, or opening of a new street).

## **1.3 Sources That Can Trigger Risk for a Project**

It is almost impossible, because of the large variety of projects, to establish sources of risk; for that reason, it is proposed here that the following aspects should be considered in looking for these sources (U.S. Department of Transportation 2013).

- Performance, scope, quality, and technology issues.
- Environmental, safety, and health concerns.
- Scope, cost, and schedule uncertainty.
- Political concerns.

## **1.4 Internal and External Risks**

Internal risks are an important concept, being those inherent to the project or the firm developing it and subsequently capable of being managed. There are many examples of internal risks, such as:

1. The scope of the project is not very well defined; it is not clear where it finishes, and responsibilities between owner and contractor/consultant are not clearly established,



2. The contractor does not have enough equipment to do the job and has to rent it (and this is internal, because this information must be included in the contractor's proposal, and the owner, therefore, knows about it),
3. There are uncertainties concerning the data or more data is needed (the owner is responsible for collecting reliable data),
4. The project incorporates new technology which has not been sufficiently tested, or, if it is well known, the contractor/consultant does not have the expertise necessary to use it,
5. There are many vendors from overseas, making their integration difficult (information known to the owner).
6. The contractor/consultant does not have the adequate structure for the project (information known to the owner).
7. Potential cash flow problem during construction owing to known and documented delays by the owner in paying work certificates (responsibility of owner's financial department),
8. Relationship with the owner is considered problematic, because of owner's reluctance to attend meetings with the contractor/consultant to iron out problems, believing that those must be solved entirely by the contractor/consultant (the main contractor or consultant must make an appraisal concerning the nature or difficulties of this relationship),
9. The project jobsite is in an isolated area, which will complicate logistics and personnel movement (owner's/consultant's responsibility, and a fact that must be clearly stated when tendering),
10. There will be a close watch from the environmental impact office, which will have a permanent representative at the jobsite, meaning special care must be taken to avoid problems or even closure due to infractions (owner/contractor/consultant's responsibility),
11. There is a necessity of sending very experienced staff to the job site, because decisions have to be made promptly and without the support of the contractor/consultant's head office, meaning the project manager must be carefully selected (owner/consultant's responsibility).

External risks can be very difficult or even impossible to manage. Examples include:

1. Government policies affecting the project, for instance, wages and salaries, inflation, etc. (there could be hints as to these policies, for instance, cost of life index, negotiations with trades and unions, etc.),
2. Weather, which, if severe enough, can delay or even stop the work (statistics have to be used here),
3. Supplier and vendor delays (this is a big unknown, unless the owner and consultant know about them),
4. Volume of sales of the product to be manufactured by the project, as well as prices (another big unknown, although examination of market trends for the product or similar products can be helpful, as can examination of the competition's prices and quality),