
# Risk Management for Engineers

Course No: B02-013
Credit: 2 PDH

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# 1. Introduction

One of the most important tasks of modern engineering personnel is to support, with their technical expertise, various projects they are assigned to. There are many Project Management processes and tasks engineers are involved in, but one of the most important is Risk Management, because it supports two other major processes: Project Estimating and Scheduling in their mission of creating a sufficient budget and a workable schedule, which are the cornerstones of any successful project.

As part of their involvement in Risk Management, engineers are playing a major role in identifying and analyzing project risks, which makes their education in this area extremely important. While engineers should not be Project Management experts, they need to know basic principles, processes and tools in order to become a valuable member of a project team and contribute into a project success. This course is designed to arm engineers with that kind of basic knowledge in Risk Management.

# 2. Definition of Risk. Risk Planning

Every project has a lot of uncertainties. No matter how extensive your planning was, you always run into problems when you start actual work. Some of these problems could be anticipated, some not, but not accounting for them in your Project Budget and Schedule may lead to Project failure. First of all, let's discuss what we can do with anticipated problems, which are called Project risks, starting with their definition.

Each risk may be defined as "The combination of the probability of an uncertain event and its consequences: either positive (opportunity), or negative (threat)"[1]. The main activity in risk management is risk planning, which involves:

- Risk identification
- Risk analysis

[1] URL: w*ww.wsdot.wa.gov/publications/.../**ProjectRiskManagement**.pdf*

- Risk response planning

## 2.1. Risk Identification

Risk identification is the first activity in the risk planning process, and it answers the following main question: "What may go wrong?" The following may be used as sources for answers:

- Historical data

Example: "*During my last backyard party, it rained* "

- Expert interviews

Example: *"My course instructor told me not to use this software for Project Scheduling – it is very confusing"*

- Brainstorming

Example: "*Starting a Project, the Project Manager discussed with the Project Team possible problems leading to delays and cost overruns*"

## 2.2. Risk Analysis

The second step in risk planning is Risk Analysis, which is answering the following main questions:

- How likely is this event to happen? Probability
- If it happens, how bad will it be? Impact

There are two main techniques to perform risk analysis. The first one is a qualitative technique, which is based on the following equation and definitions:

Risk level = F {Probability x Impact}:

- Low probability, low impact – low risk
- High probability, high impact – high risk
- Low probability, high impact or high probability, low impact – medium risk

For a better understanding, let's consider the following real life example:

Description: You are flying to your vacation destination tomorrow from a small local airport which is served by one budget airline, having a history of frequent flight cancellations in the past. What is the level of risk for you not to get to your destination as planned?

Answer: The risk of airline cancelling your flight is high. If it happens, you will be either rebooked to the later flight on the same day if such exists, or stranded at the airport for a day or two. So, you may arrive at your destination later which will cut your vacation short, you may lose a day or two of your prepaid hotel stay, etc., so impact may be high as well. Conclusion: the risk level for you having your vacation spoiled is high.

Results of qualitative risk analysis may be presented as a Risk Matrix, similar to the one shown in the Fig. 1[2].

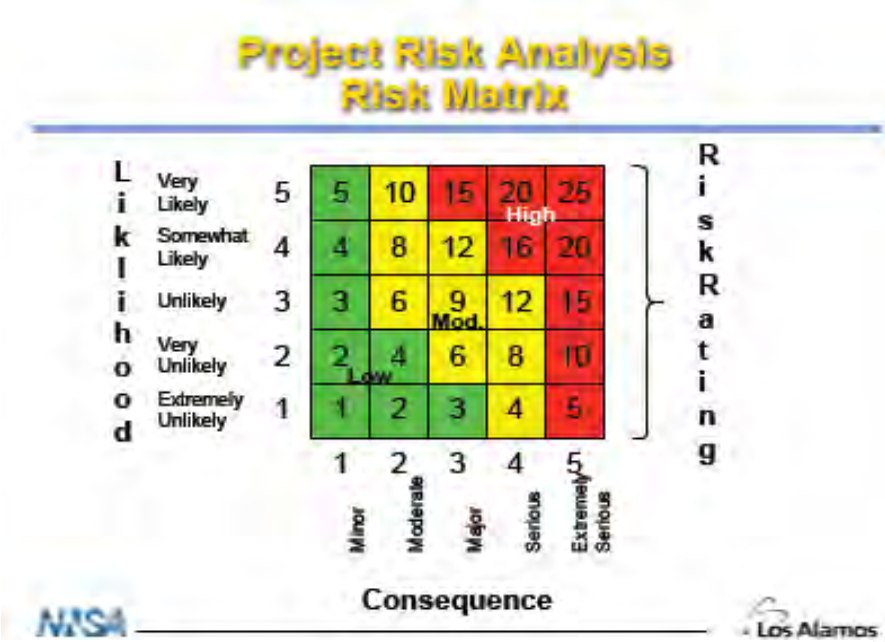


*Figure 1 - Example of a Risk Matrix*

[2] URL: www.lanl.gov/orgs/d/d5/documents/case.pdf

The second technique for risk analysis is a quantitative technique, which is based on the following equation:

Cost of risk = probability x impact

Example:

A meat processing plant's transformer substations are fed by two 26 kV cable lines. Probability of both of them failing and being out of service at the same time is 0.1% for any given year. If it happens, the loss of revenue for the plant is $500M. What is the annual cost of risk?

**Answer:** Cost of risk = 0.001 x $500,000,000 = $500,000

As we can see, the quantitative technique provides a much more definitive answer than the qualitative one does. Unfortunately, the exact information about probability and the impact of every risk event is rarely available. That's why a qualitative technique is used much more often than a quantitative one.

Usually both risk identification, and qualitative risk analyses are performed during a brainstorming session, where all project team members and invited experts generate all possible risk events (identification) and assign risk levels to each of them (analysis). The outcome of this brain storm should be a Project Risk Matrix, similar to the one shown in Fig. 1.

## 2.3. Risk Response

After risk matrix is created, the main question becomes: what to do about the risks?

The following are the standard responses to risk events:

- *Avoid the risk* – take another path

  In the vacation example, risk avoidance may involve flying from the closest major airport which is served by several airlines, so if your flight is cancelled you have better chances to rebook it with your original airline or even a different one.

- *Mitigate the risk* – take steps to reduce either probability of risk, or impact, or both

In the vacation example, risk mitigation may be:

- Leaving one day earlier
- Having a flexible cancellation policy with your hotel

- *Transfer the risk* – transfer or share the risk with another party

  In the vacation example, risk transfer may involve buying a travel insurance.

- *Accept the risk* – take no action to reduce probability or impact of the risk

  In the vacation example, risk acceptance may involve flying from the airport of your original choice and hoping for the best.

As a rule of thumb, low risk events may be accepted, while high risk events always require an action. Medium risks are handled on case by case basis.

## 3. Risk Breakdown Structure (RBS)

Another effective way to streamline risk identification and its qualitative analysis is by the application of a Risk Breakdown Structure (RBS). RBS is similar to a Work Breakdown Structure (WBS), which in a nutshell is a "family tree" of all the tasks to be performed in the course of the project, except that on the lowest level instead of tasks, RBS has risks.

To illustrate this statement, both WBS and RBS for the same construction component of the Project are shown in Fig. 2 and 3 respectively.

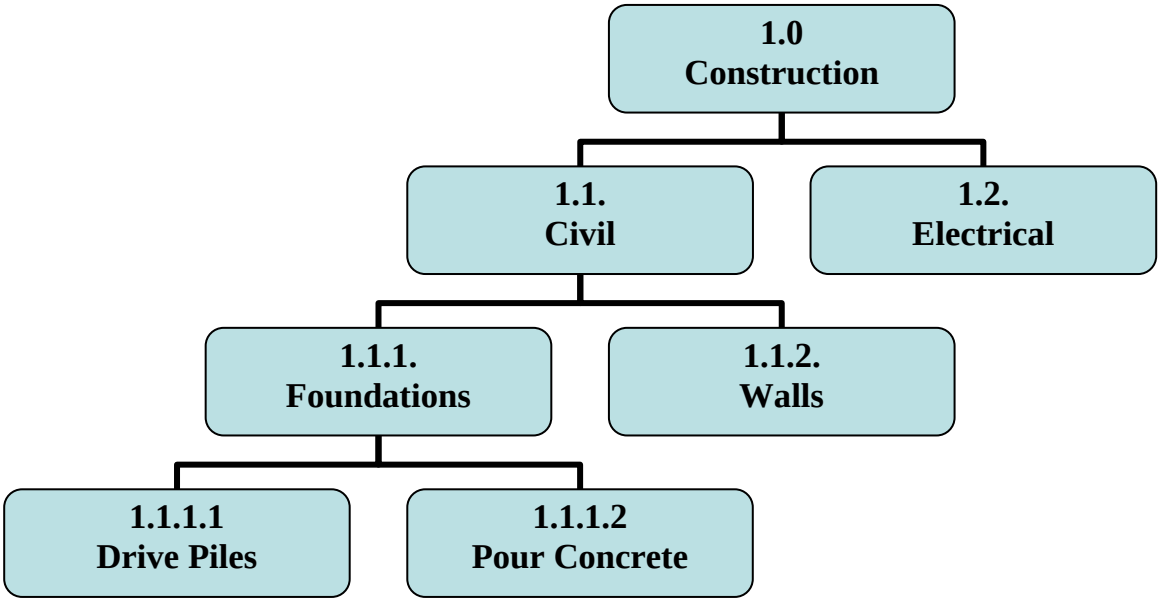


*Figure 2 - Example of Work Breakdown Structure (WBS)*

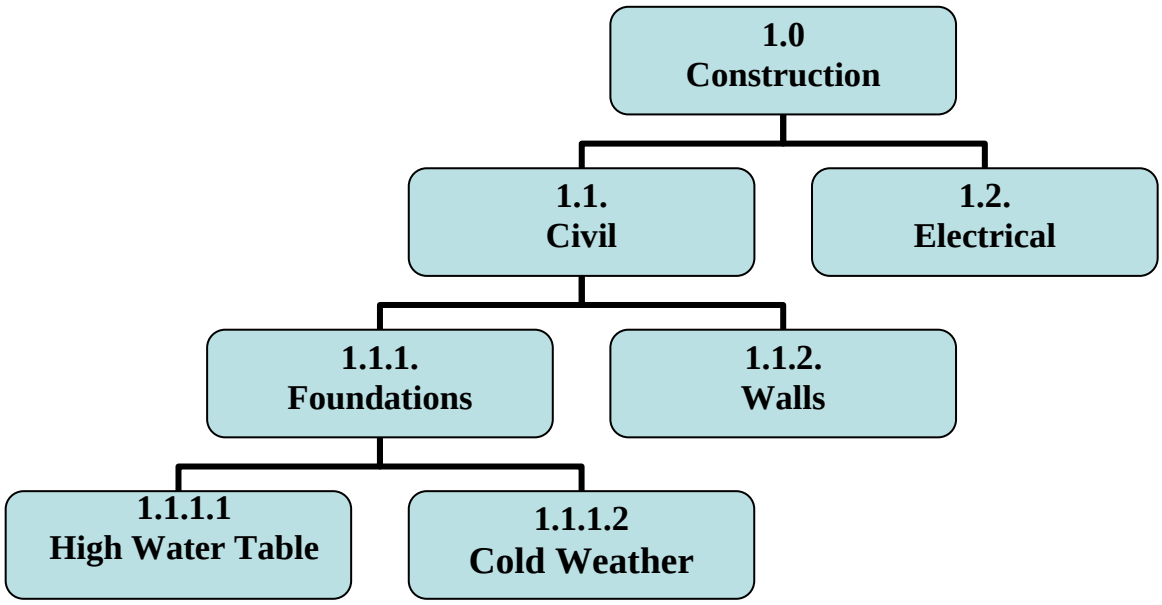


*Figure 3 - Example of Risk Breakdown Structure (RBS)*

Both WBS and RBS may be presented in either graphical (Examples – Figures 2 and 3) or tabular formats. The latter may work better for Risk Management purposes if there are a significant number of risks that need to be identified and analyzed. We'll use a tabular RBS format later in a case study.

## 4. Dealing with Risks at a Project Level

Let's discuss how risks may be handled at a Project level:

- For *budget risks*:
  - Create extra funds to cover the risk impacts
  - Review adequacy of initial extra funds at key points in the Project Life Cycle and initiate a change if needed
- For *schedule risks*:
  - Add time buffers to the Project schedule
  - Review adequacy of initial time buffers at key points in the Project Life Cycle and initiate change if needed

As we mentioned before, risks are the anticipated problems ("known unknowns"), but there are events which may be not even foreseen, that are called contingencies ("unknown unknowns"). For example, for a vacation trip a contingency may be an airport shutdown because of power failure which will prevent our flight from leaving on time. Should we do anything about contingencies? It is a Project Manager's call, but usually it is a good practice to include in the budget some extra contingency funds (5% - 10% of the total) to cover events which we can't even imagine. It is difficult to include extra float in the schedule to cover contingencies (not only we do not know what they are, we have no idea what kind of delay they can cause). Hopefully, having extra money in the budget will help Project Manager to accelerate the Project if needed.

# 5. Risks Specific to Electrical Utility Companies

Speaking of risks, we need to remember that there are always events typical for specific industries. For example, for electrical utility companies the following main sources of risks may be noted:

- *Licensing and Permitting*:
  - Local residents' resistance to the project
  - Site restrictions: wetlands, height, noise, etc.
- *Site conditions*:
  - Presence of underground obstructions
  - High water table
- *Technical problems*:
  - Problems discovered by detail design, which were not foreseen in the course of feasibility studies
- *Equipment issues*:
  - Vendors' delays with delivery of equipment
  - Equipment quality issues
- *Contractor performance*:
  - Contractor's deviation from specifications
  - Production delays
  - Workmanship quality issues
- *Personnel issues*:
  - Lack of qualified resources

We will identify similar types of risks and analyze them for a case study below.

# 6. Case Study - Renovation of Main Street Substation

## 6.1. Description

Electrical Utility company ABC Energy needs to renovate 13/4 kV Main Street Substation, consisting of 50-year old 13/4 kV transformers and 13 kV and 4 kV switchyards, shown in Fig. 4. New Substation will have new 13/4 kV transformers, new 13 kV switching equipment installed on steel structures (see Fig. 5) and a new metal enclosed 4 kV switchyard (see Fig. 6 and 7). All equipment will be installed on new concrete foundations. All design and engineering will be outsourced to the CED consulting company. Procurement of equipment and materials will be done by utility company personnel. Construction will be performed by FGI civil and electrical contractors under ABC Energy supervision. Work may start on October 1st of 2020 and needs to be finished by July 1st of 2021 before the start of a summer load maximum.

On November 1st, 2019, ABC Energy assigned a Project Team for the Main Street Substation renovation project led by a Project Manager John Smith. Approved Project Budget is $5,000,000 including extra funds to cover risks and contingencies. John Smith spent 2 months verifying the sufficiency of the approved budget and prepared a preliminary project schedule. Now, on January 10th, 2020 he called for a meeting with his team to create a Risk Breakdown Structure (RBS) for the Project, discuss possible risk mitigation strategies and make a final verification of adequacy of project budget and schedule.

*Figure 4 - Main Street Substation before Renovation*

*Figure 5 - New 13/4 kV Transformers and 13 kV Switchyard*

*Figure 6 - Metal Enclosed 4 kV Switchgear [Outside View]*

*Figure 7 - Metal Enclosed 4 kV Switchgear [Inside View]*

## 6.2. Solution

The Project Team consists of civil and electrical Project Engineers, the Licensing and Permitting expert, Procurement expert, construction manager and Project Support personnel. The goal of their meeting is identification of project risks, their analysis and the selection of risk responses. Before the meeting, John Smith prepared an RBS template to be filled in during the meeting. The result of Project Team brainstorming session is shown in Fig. 8.

| | | | |
|---|---|---|---|
| Project | Technical | Design | Lack of existing substation drawings<br>Change orders from CED Consulting<br>Design quality issues<br>Delays with drawing delivery |
| | | Licensing | Residents resistance to the project<br>Wetlands<br>Delays with getting a permit |
| | Procurement | Equipment | Delays with transformer delivery<br>Poor workmanship<br>Delays with 4 kV switchgear<br>Failed on-site testing<br>Incomplete shipment |
| | | Materials | Delays with delivery<br>Low quality<br>Supplier bankruptcy |
| | Construction | Civil | Underground obstructions<br>High water table<br>Change orders from FGI contractors<br>Cold weather<br>Snowstorms |
| | | Electrical | Cold weather<br>Snowstorms<br>Wrong drawings<br>Change orders from FGI contractors |

*Figure 8 - Risk Breakdown Structure for Main Street Substation Renovation Project*

Now, when risks are identified, the Project Team can analyze them and assign to each risk a rating: low, medium or high based on the probability of a risk event and its impact. After that, a risk response strategy may be selected.

Let's consider several examples:

1. **Design Risks**:

   *1.1. Delays with drawing delivery*
   Probability → medium
   Impact → medium
   Risk rating → medium
   Response: add a one month buffer to the Project Schedule

2. **Licensing Risks:**

   *2.1. Residents' resistance to the project*
   Probability → high
   Impact → high
   Risk rating → high
   Responses:
   - add $50K to the Project Budget to cover multiple public hearings and expert testimonies
   - add a one month buffer to the Project Schedule

3. **Material Procurement Risks:**

   3.1. *Supplier bankruptcy*:
   Probability → low
   Impact → high
   Risk rating → medium
   Response: consider using several suppliers for common materials (control cables for example) to duplicate orders. If surplus materials are left, they may

be used on other projects, with corresponding credit issued to Main Street Substation Project to offset its extra expenses.

4. **Civil Construction Risks**:

*4.1. Cold weather*

Probability → medium

Impact → medium

Risk rating → medium

Cold weather may lead to several problems including slowing down concrete curing which ultimately will lead to delays in foundation work.

Response: include additional $100K in the budget to cover the higher cost of a fast curing concrete.

Results of conducted risk analysis may be brought together into an Excel spreadsheet. As we stated before, the original Project Budget and Schedule included some extra funds and time buffers respectively to address the risks. Now, after risk analysis was done, the Project Manager could get an idea if adjustments are needed to the original Project Budget and Schedule and initiate corresponding changes if needed.

This process needs to be repeated at key points in a Project Life Cycle (for example, after completion of design) to verify if the original risk mitigations strategies are still valid, and identify and analyze additional risks if this is the case.

# 7. Summary Points

This course provided the overview of Risk Management to enable you to:

- Define risk and risk planning
- Understand risk identification
- Perform risk analysis
- Create a risk matrix
- Understand the difference between quantitative and qualitative techniques of risk analysis
- Select an appropriate risk response
- Understand how to use a risk breakdown structure (RBS)
- Deal with risks at a project level
- Understand the difference between risks and contingencies
- List typical risks specific for electrical utility companies