UNCERTAINTY MANAGEMENT IN COST AND TIME ESTIMATES FOR CHALLENGING PROJECTS

Francesca Nava - consultant at kwantis, a company dedicated to supporting decision makers in identifying, evaluating and controlling future uncertainties in their investments.

When we talk about non-standard and challenging projects, Project CAPEX (Capital Expenditure) and time estimates become a difficult exercise because of the high number of external factors that can influence project success and moreover because of the variety of situations and design alternatives still to be considered. All these factors can cause cost overruns and delays in Projects from many industries, especially Construction, which encompasses both strategic infrastructure and building with high technological content.

A good way to tackle this issue is avoiding simply reacting at the events, and to ground Project estimates on a consolidated process encompassing the following steps:

1. **Identification** of all Project uncertainties related to:
   - Performance and quantities variability;
   - Lack of information;
   - Unexpected events (Threats or and Opportunities) generally called “Risks”;
2. **Evaluation** of the uncertainties identified, through a qualitative & quantitative probabilistic approach;
3. **Control & Monitoring** of Project uncertainties;
4. **Consolidation** of the risks feedback (Lessons Learned) at the end of the Project execution, in support to future projects.

This methodology is now widely used for large projects such as power plants, railways, tunnels and other challenging civil engineering works.

The aim of this article is, firstly, to present the characteristic of Non-Standard projects, then to describe in an intuitive way the workflow applicable to increase confidence on Project targets (cost, time and quality) and manage uncertainties in a pro-active rather than merely reactive way.

Project targets in terms of Project Risk Management are regarding cost, time and quality, since other fundamental targets such as health, safety and environment are treated by complementary HSE processes.

**Non – Standard Projects**

Large private and public organisations are facing non-standard investments to support their development. These investments are considered non-standard because they are subject to various challenges such as:

- **Technical Complexity:**
  - Multiple subsystems;
  - Continuous innovations;
  - High reliability requirements;
- **Cost & Time Constraints:**
  - Large CAPEX and limited margin for overruns;
  - Tight schedules;
- **Project Organisation:**
  - Numerous contractors to be coordinated;
Logistical constraints;
- Challenging legal framework;
- Highly uncertainties regarding permits/authorisations;
- Lack of historical feedback;
- Different cultures, perspectives and objectives of the participants;

Market Conditions:
- Highly uncertain conditions of commodities, services cost, etc;
- Payment in different currencies;

Estimating CAPEX in these problematical conditions represents a real challenge for Project management. To improve estimate accuracy, it is necessary to rationalise the methods and the analysis in estimating activities.

Project Risk Management (PRM) Workflow

To tackle this issue, Project cost and time estimates can be grounded on a four-step process as presented in the figure below:

![Figure 1: PRM Workflow](image)

Identification - Following Project data collection and benchmark analysis of similar past Project experiences, the potential uncertainties that may affect Project objectives are identified by all required experts during a dedicated brainstorm session. Then these uncertainties are listed in a Risk Register in the most exhaustive possible manner, including a risk description and categorisation by risk’s area.

Evaluation - The impact of these risks on Project objectives is addressed directly with the relevant experts. This step encompasses two complementary analyses:

- **Qualitative Risk Evaluation** to assess each individual risk in a descriptive and graphical way, allowing to focus on the most important key risks. In particular, any specific risk is evaluated through two parameters, both scaled on Project objectives:
  - **Probability** of the risk occurrence (based on different levels, for instance from 1-Very Low to 5- Very High);
  - **Impact** (based on a scale of different levels, such as from 1-Minor to 5-Catastrophic) on the main Project objectives: schedule, budget, quality.

By cross plotting the probability and the highest level of impact gives a unique localisation of the risks in the matrix which is the base instrument for qualitative evaluation, because it summarizes Probability, Impact and Criticality Levels as shown in the example below:
In this way, risks can be divided in groups having different criticalities and requiring different response strategies as shown in Figure 2: Risk Matrix. Below.

<table>
<thead>
<tr>
<th>RISK CRITICALITY</th>
<th>TYPE OF RISK</th>
<th>THREAT</th>
<th>OPPORTUNITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable</td>
<td>Threat</td>
<td>Require urgent attention to reduce the risk to an acceptable level</td>
<td>Requires attention to increase the chances of occurrence</td>
</tr>
<tr>
<td></td>
<td>Opportunity</td>
<td>Need some action (control strategy) to move risk, as far as possible,</td>
<td>Need some action (control strategy) to increase the probability or the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>towards lower probability or impact levels.</td>
<td>impact of the opportunity, as much as possible</td>
</tr>
<tr>
<td>Significant</td>
<td>Threat</td>
<td>Need some action (control strategy) to move risk, as far as possible,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Opportunity</td>
<td>towards lower probability or impact levels.</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>Threat</td>
<td>No action necessary, it should be addressed as normal project activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Opportunity</td>
<td>No action necessary, it should be addressed as normal project activity</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Criticality Levels

This allows to focus the attention on the most critical risk issues to be solved with higher priority and to define different control strategies.

- **Qualitative Risk Evaluation** to numerically analyse through probabilistic models the effects of all identified risks combined together towards Project objectives, thus improving the precision and realism of time and cost estimates, then ultimately supporting investment decision with a greater visibility on uncertainties.

Each risk is integrated in the model choosing the variable distribution to represent its impact with the best realism. Variables distributions can be continuous probability distributions, where there is
a range of continuous outcomes values, or discrete distributions, where there is a limited number of discontinuous possible outcomes. Quantitative estimations are based on the most relevant information available such as lessons learned, databases, expertise.

The Monte Carlo simulation is a mathematical method for combining all these variables: a random value is selected in each variable distribution. The result of the model is recorded and the process is iteratively repeated a number of times. A typical Monte Carlo simulation calculates the model thousands of times, each time using different randomly selected values. At the end of the simulation the outputs are not single values anymore, but probability density curves. These results can be used to:

- Represent all possible results, i.e. ranges between minimum-maximum values, most likely value;
- Calculate the level of confidence for each single value in the distribution, i.e. P50 is the value that has 50% chance to be unreached and 50% chance to be overcome;
- Identify the most sensitive variables driving the output;
- Provide an accurate method to determine the level of contingency for the budget and float for the schedule, according to a defined level of confidence.

The Figure 4 provides an example of a 50% probability confidence level taken as a reference for contingencies calculation.

Contingencies should cover the gap between the target (deterministic) and the requested level of risk acceptance (in this case P50 cumulated probabilities). So the economic value of the contingencies is calculated on the X axis (in our example Contingencies=242-227=15M€).

Above the requested level of risk acceptance (P50 in the graph), the remaining risk exposure is considered as the Value at Risk for the investor (in our example Value at Risk=290-242=48M€).
Control & Monitoring – This step is aiming at assessing specific control actions in order to minimize risks probabilities or impacts to the most reasonable level and continuously monitor all the risks that remain active after the implementation of these control strategies.

- **Risk Control** consists of the revision of the Risk Register, completing it with all the information about risk control strategies to be implemented (including required time and cost) and the relevant new qualitative risk evaluation. Then the probabilistic model should be updated in order to:
  - Estimate control actions resources (cost & time) and their associated benefits;
  - Outline a balanced picture of risks and benefits considering each possible course of action and their relative impact on budget and schedule.

- **Risk Monitoring** provides for a continuous update of the Risk Register in order to monitor if implementation of control actions really work, reducing risk criticality. Furthermore, a revision of the basis of the probabilistic model is performed in order to take into consideration:
  - The use of allocated budget;
  - The progress of the schedule;
  - The new levels of criticality compared to previously identified (before control action implementation).

Consolidation – In order to provide feedback for future Project and to ensure a continuous learning dynamic over the time, experience on the project and related Lessons Learned are formally disseminated within the Company.

Lessons Learned are a powerful way to capitalise information about problems that occurred during the execution of past projects and how to better anticipate and manage them in future projects.

Based on Lessons Learned, statistical analyses on risk categories, probability and impact of a selection of reference projects (from criterions such as location, technical characteristics,...) can be provided in order to:

- Comparing real Project values versus estimates, in order to learn from discrepancies to support accuracy in future estimates;
- Disseminating experience and lessons learned on all projects.

Conclusions

Today, organisations dealing with challenging projects due to several types of constraints, such as technical, environmental conditions, political interferences, can face a dilution or loss of information that could be crucial for Project management. To remedy this situation, the above presented workflow for project risk Management has been successfully implemented in several industries.

A key factor of success to this workflow is the management of the information that has to be organised through an integrated data system, supported by databases and network solutions.

When implemented, such an integrated data system will bring the following benefits:

- Standardisation of the methodologies and results according to industry best practises;
- Acceleration of project studies;
- Support in building probabilistic CAPEX estimates;
- Contribution to a continuous learning within the organisation.