Table of Content

Risk Definitions ................................................................. 2
The ‘very basic toolbox’ .......................................................... 6
The ‘intermediate toolbox’ ......................................................... 6
  Step 1 - Risk Management Planning ...................................... 7
  Step 2 - Risk Identification .................................................... 8
  Step 3 - Risk Evaluation ....................................................... 9
  Step 4 - Risk Treatment ....................................................... 12
  Step 5 - Risk Monitoring ....................................................... 14
The ‘advanced toolbox’ ........................................................... 15
  Step 6 - Risk Quantification ................................................... 17
  Step 6’ - Risk Analyses ......................................................... 20

Project Risk Management

"Project triangle"
Project Risk Management

When and which effort?

- **INITIALIZE**
  - Initiators
  - Study Team

- **STUDY**
  - Preliminary Requirements elicitation
  - Master Schedule preparation
  - Preliminary Cost Estimate/Budget preparation
  - Preliminary Risk Register preparation

- **DESIGN**
  - Requirements Register preparation
  - Coordination Schedule preparation
  - Cost Estimate/Budget refinement/update
  - Risk Register/Analyses preparation

- **BUILD**
  - Risk Register updates

- **COMMISSION**

- **FINALIZE**

---

**Risk Definitions**

- **Risk Definition**
  - The effect of uncertainty on objectives.
    - ISO 31000:2009 § 2.1
  - Can be seen as:
    - **Threats**, i.e. with negative impact → common/regular meaning
    - **Opportunities**, i.e. with positive impact → often forgotten!
**Risk**

**Etymology**

- From ancient Latin: *risicare* = reef → *risk-snag*
- From (ancient) Greek: *ρίζα* = root → *risk-snag*
- From (ancient) Latin: *rixa* = quarrel, brawl → *risk-action*
- From ancient Greek: *πίσκον* = soldier’s pay → *risk-action*

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**Risk Heatmap**

Probability of occurrence = Likelihood

Consequence = Impact

Likelihood × Consequences

---

*Fabio Sabelli (mars 1999) Les risques de l’économie, l’économie des risques. Le point de vue de l’anthropologue, présentation donnée lors du 7e Congrès de la Société suisse de management de projet à Lausanne, Suisse*
Risk Management
Enterprise RM vs. Project RM

**ERM**
- Strategic risks
- Operational risks
- Financial risks
- Reputational risks
- Safety risks
- Environmental risks

**PRM**
- Technical risks related to the system/product reqts.
- Programmatic risks related to the project on schedule, on budget
- External risks for which the project team has no real control

Project Risk Management
Concept of lifecycle

- Non completion
- Non compliance
- Non appropriateness

- Project objectives/needs vs. final deliverable(s)
- Product/systems reqts. vs. final deliverable(s)
Project Risk Management
Standards and methodologies

PMBOK ➞ Ch. 11 pp. 309–354 + Practice Standard
PRINCE2 ➞ Ch. 8 (4th theme) pp. 75–88
HERMES 5.1 ➞ Rôle pp. 54–57 + Tâche pp. 104–105
ISO 21500:2012 ➞ §§ 2.13, 4.2.3.8, 4.3.28, —.29, —.30, —.31
INCOSE SEBoK ➞ sebocwiki.org/wiki/Risk_Management
ECSS ➞ ECSS-M-ST-80C July 2008
openSE ➞ § IV.3.5 p. 50

The preferred project risk management approach shall be defined in the Project Management Plan

Project Risk Management with openSE
3 levels of implementation

1. Simple approach
2. Intermediate approach
3. Advanced approach
The ‘very basic toolbox’

Project Risk Management
The ‘basic toolbox’

Simplified Risk Register

- Unsufficient funding, however initial investigations have shown that stakeholders are likely to fund this proposed project
- Unrealistic master schedule, however discussions in conferences and workshops have shown that one year to have an experimental setup in operation is realistic
- Technical problems with instrumentation, however according to a few interviewed experts, the solutions considered are totally feasible
- Enhanced experimental setups by other labs, however our scientific watch shows that this set-up will be very competitive

The ‘intermediate toolbox’

Project Risk Management
The ‘intermediate toolbox’

Regular Risk Register

Spreadsheet table consisting of risk scenarios:

<table>
<thead>
<tr>
<th>RISK SCENARIO</th>
<th>RISK MAGNITUDE</th>
<th>RISK RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project Risk Management

A 5-step process

1. Agreeing a risk management approach for the project
2. Identifying risk scenarios
3. Evaluating their magnitude
4. Defining responses to these risk scenarios
5. Following up the risks as the project progresses

INTERMEDIATE approach

Step 1 - Risk Management Planning

Project Risk Management

Risk Management Planning

Shall be discussed with Project Board

Risk aversion vs. Risk appetite

§ 3 of the Project Management Plan

Consider tailoring
Step 2 - Risk Identification

Project Risk Management

How to identify all appropriate risk scenarios?

- Risk scenario column of the Risk Register
- Project Roadmap
- Project Management Plan
- Requirements Register
- PBS, WBS, RACI Matrix
- Project Coord. Schedule
- Project Budget Document
- Risk Checklists, Vademecums
- Subject matter experts
- Doc. screening
- Interviews
- Delphi panels
- Six-hats, etc.

Project Risk Management

3 project risk categories

- Technical risks
  - risks related to the systems/product being developed: appropriateness and compliance
- Programmatic risks
  - risks related to the project itself: completion on schedule and on budget
- External risks
  - "project strategic risks": macro-economic risks
  - natural hazards
  - regulatory risks
  - "PESTLE-risks"
Step 3 - Risk Evaluation

Project Risk Management

Risk Evaluation

Risk Level Matrix

FMAC Analysis, etc.

Risk scenarios from the Risk Register

Risk Register with magnitude columns populated

Risk Level Matrix

<table>
<thead>
<tr>
<th>Probability</th>
<th>Probability</th>
<th>Consequences</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very unlikely</td>
<td>.1</td>
<td>Negligible</td>
<td>.05</td>
</tr>
<tr>
<td>Rather unlikely</td>
<td>.3</td>
<td>Marginal</td>
<td>.1</td>
</tr>
<tr>
<td>Possible, plausible</td>
<td>.5</td>
<td>Significant</td>
<td>.2</td>
</tr>
<tr>
<td>Rather likely</td>
<td>.7</td>
<td>Major, critical</td>
<td>.4</td>
</tr>
<tr>
<td>Very likely, quite certain</td>
<td>.9</td>
<td>Catastrophic, crisis</td>
<td>.8</td>
</tr>
</tbody>
</table>
### Risk Level Matrix

<table>
<thead>
<tr>
<th>Consequences</th>
<th>C</th>
<th>on budget</th>
<th>on schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>.05</td>
<td>(\Delta C \approx 0)</td>
<td>(\Delta D \approx 0)</td>
</tr>
<tr>
<td>Marginal</td>
<td>.1</td>
<td>1% &lt; (\Delta C \leq 5%)</td>
<td>1% &lt; (\Delta D \leq 5%)</td>
</tr>
<tr>
<td>Significant</td>
<td>.2</td>
<td>5% &lt; (\Delta C \leq 10%)</td>
<td>5% &lt; (\Delta D \leq 10%)</td>
</tr>
<tr>
<td>Major, critical</td>
<td>.4</td>
<td>10% &lt; (\Delta C \leq 20%)</td>
<td>10% &lt; (\Delta D \leq 20%)</td>
</tr>
<tr>
<td>Catastrophic, crisis</td>
<td>.8</td>
<td>(\Delta C &gt; 20%)</td>
<td>(\Delta D &gt; 20%)</td>
</tr>
</tbody>
</table>

### Risk Level Matrix

<table>
<thead>
<tr>
<th>Consequences</th>
<th>C</th>
<th>on the project performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>.05</td>
<td>Minimal or no consequence</td>
</tr>
<tr>
<td>Marginal</td>
<td>.1</td>
<td>Small reduction of the performance</td>
</tr>
<tr>
<td>Significant</td>
<td>.2</td>
<td>Significant degradation of the performance</td>
</tr>
<tr>
<td>Major, critical</td>
<td>.4</td>
<td>Technical goals cannot be achieved</td>
</tr>
<tr>
<td>Catastrophic, crisis</td>
<td>.8</td>
<td>Project cannot be completed</td>
</tr>
</tbody>
</table>
Risk Level Matrix

\[ S = P \times C \]

<table>
<thead>
<tr>
<th>( S )</th>
<th>low risk</th>
<th>medium risk</th>
<th>high risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S &lt; 0.05 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0.05 \leq S &lt; 0.20 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( S \geq 0.20 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Risk Level Matrix

<table>
<thead>
<tr>
<th>( P \times C )</th>
<th>.05</th>
<th>.1</th>
<th>.2</th>
<th>.4</th>
<th>.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>.9</td>
<td>.05</td>
<td>.09</td>
<td>.18</td>
<td>.36</td>
<td>.72</td>
</tr>
<tr>
<td>.7</td>
<td>.04</td>
<td>.07</td>
<td>.14</td>
<td>.28</td>
<td>.56</td>
</tr>
<tr>
<td>.5</td>
<td>.03</td>
<td>.05</td>
<td>.10</td>
<td>.20</td>
<td>.40</td>
</tr>
<tr>
<td>.3</td>
<td>.02</td>
<td>.03</td>
<td>.06</td>
<td>.12</td>
<td>.24</td>
</tr>
<tr>
<td>.1</td>
<td>.01</td>
<td>.01</td>
<td>.02</td>
<td>.04</td>
<td>.08</td>
</tr>
</tbody>
</table>
## Step 4 - Risk Treatment

### Generic Response Types

<table>
<thead>
<tr>
<th>Type of response</th>
<th>Method of handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modify objectives</td>
<td>Reduce or raise performance targets; change tradeoffs between objectives</td>
</tr>
<tr>
<td>Avoid</td>
<td>Plan to avoid specified sources of risk/uncertainty</td>
</tr>
<tr>
<td>Influence probability</td>
<td>Change the probability of potential variations, i.e. prevent</td>
</tr>
<tr>
<td>Modify consequences</td>
<td>Modify the possible consequences of variations, i.e. protect</td>
</tr>
<tr>
<td>Transfer consequences</td>
<td>Transfer consequences to another party, e.g. contract provision, insurance</td>
</tr>
<tr>
<td>Develop continuity plans</td>
<td>Set aside means or make other plans to provide a reactive ability to cope</td>
</tr>
<tr>
<td>Keep options open</td>
<td>Delay choices and commitments, choosing versatile options</td>
</tr>
<tr>
<td>Monitor</td>
<td>Collect and update data about sources of uncertainty</td>
</tr>
<tr>
<td>Accept</td>
<td>Acknowledge and accept uncertainty</td>
</tr>
<tr>
<td>Remain unaware</td>
<td>Ignore uncertainty, take no action to identify, evaluate or handle it</td>
</tr>
<tr>
<td>Optimize all the above</td>
<td>Explicitly recognise the value of selecting an optimal combination</td>
</tr>
</tbody>
</table>

---

### Generic Response Types

#### In practice

4 types of **responses** to risks

- **Mitigation**
  - Preventive and protective measures
- **Avoidance**
  - Bare suppression of the source of risk (precautionary principle)
- **Acceptance**
  - No action except documentation of the risk
- **Transfer**
  - Provision
  - Ignorance (INTERMEDIATE approach)

---

Risk Heatmap

**Prevention vs. Protection**

![](Risk-Heatmap.png)

---

**Project Risk Management**

- **Risk Treatment**
  - Project Roadmap
  - Project Mngt. Plan
  - Subject matter experts
  - Lessons learned
  - Risk Register

![Delphi panels](Delphi-panel.png)

**INTERMEDIATE approach**

- Doc. screening
- Interviews
- Delphi panels
- Six-hats, etc.

**Risk Register with response columns populated**

**Continuity Plan(s)**
Step 5 - Risk Monitoring

Project Risk Management

Risk Monitoring

Consists of:

- Following up the identified risk scenarios
- Detecting the emergence of **residual risks** and engaging the appropriate actions or Continuity Plans
- Following up the implementation of Continuity Plans, appraising their efficiency
- Scrutinizing the emergence of **new risks** (i.e. these risks that were not identified during the Study Phase or the early Design Phase of the project), evaluating them, integrating them in the Risk Register, and deciding relevant responses
The ‘advanced toolbox’

Project Risk Management
The ‘advanced PRM toolbox’

- e.g. coordination schedule
- Monte Carlo simulations
- Various simulations and analyses
- DB-based Risk Register

http://app.riskgap.com

Enhanced Risk Register

<table>
<thead>
<tr>
<th>RISK SCENARIO</th>
<th>RISK MAGNITUDE BEFORE</th>
<th>RISK RESPONSE</th>
<th>RISK MAGNITUDE AFTER</th>
</tr>
</thead>
</table>

No one interested to bid

Risk score: 2

Risk: 21

Estimate: 0

Risk level: 2

Cost: 20,000

Days: 50

Teams: 1

State: Assigned to

Risk strategy: Await

Project Risk Management with openSE --- Part 4

Pierre Bonnal
Project Risk Management

A 7-step process

1. Agreeing a risk management approach for the project
2. Identifying risk scenarios
3. Evaluating their magnitude (before)
4. Defining responses to these risk scenarios
5. Re-evaluating their magnitude (after)
6. Running relevant simulations and conducting risk analyses
7. Following up the risks as the project progresses
   Running additional risk simulations and conducting additional risk analysis
Step 6 - Risk Quantification

Risk quantification

Four approaches for dealing with probabilities:

- Classical approach
- Mathematical approach
- Frequentist approach
- Bayesian approach

Classical approach:
The probability $P(A)$ of an event $A$ is the property that determines its frequency of occurrence.

E.g.:
- $P(\text{head}) = P(\text{tail}) = 1/2$
- $P(\text{}) = P(\text{}) = 1/6$
- $P(\text{and} \text{ }) = 1/36$
Risk quantification

Four approaches for dealing with probabilities:

- **Mathematical** approach:
  
  P(A) is a number that obeys the many axioms of the theory built up by A. Kolmogorov in the ’30s:

  \[
  0 \leq P(A) \leq 1 \\
  P(A \cup B) = P(A) + P(B) \\
  \sum P(A_i) = 1 \\
  \ldots
  \]

- **Frequentist** approach:
  
  P(A) is a limit over a set, when the number of elements of this set tends to ∞
Risk quantification

Four approaches for dealing with probabilities:

- **Bayesian** approach:
  
  $P(A)$ is the degree of belief in the occurrence of an event
Step 6’ - Risk Analyses

Probabilistic Project Scheduling
Monte Carlo-based schedule assessment

1. Identifying a probability distribution function for each activity duration

2. Using a random number generator for setting activity duration based on their PDF, then computing the activity network several thousand times

3. S-curves (cumulated PDFs) can be generated from the computed data for a few relevant milestones
Probabilistic Project Scheduling
Monte Carlo-based schedule assessment

ADVANCED approach
At CERN (in the A&T Sector)
Linac4 Project Risk Analysis
Conducted in 2009 using the Siemens’ SIRA methodology

Overview of cost impact before mitigation

Risks of budget overrun compared to overall project cost estimate (baseline 2009):
- 5 high risks
- 12 medium risks
- 63 low risks

Project Risk Management with openSE -- Part 4

Pierre Bonnal
At CERN (in the A&T Sector)
Linac4 Project Risk Analysis
Overview of cost impact before mitigation

At CERN (in the A&T Sector)
Linac4 Project Risk Analysis
Overview of cost impact after mitigation
At CERN (in the A&T Sector)
Linac4 Project Risk Analysis
Monte Carlo simulation on cost impact

With 80% confidence, the impact value is:
- below 8.1 m CHF (before mitigation)
- below 4.4 m CHF (after mitigation)

Note: One opportunity is included.
Project Uncertainties are not considered in the Monte-Carlo-Simulation as they are non-monetary assessable risks.

At CERN (in the A&T Sector)
Linac4 Project Risk Analysis
Uncertainties

Project Risk Management with openSE --- Part 4  Pierre Bonnal