Managing Projects with openSE

Part 4 focusing on Project Risk Management

CERN | EN ENGINEERING DEPARTMENT

Pierre Bonnal

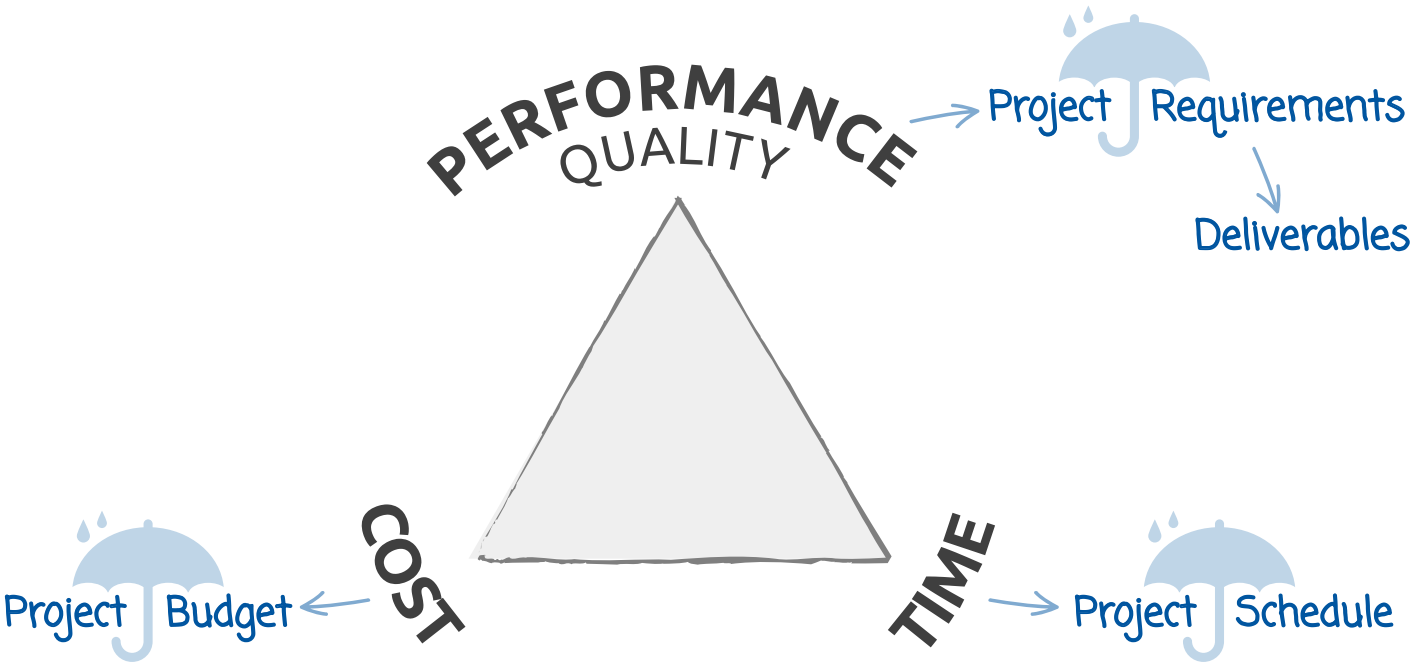
version **1.0**

Why?

1. to set a reference 
2. to assess uncertainties
3. to follow up progress

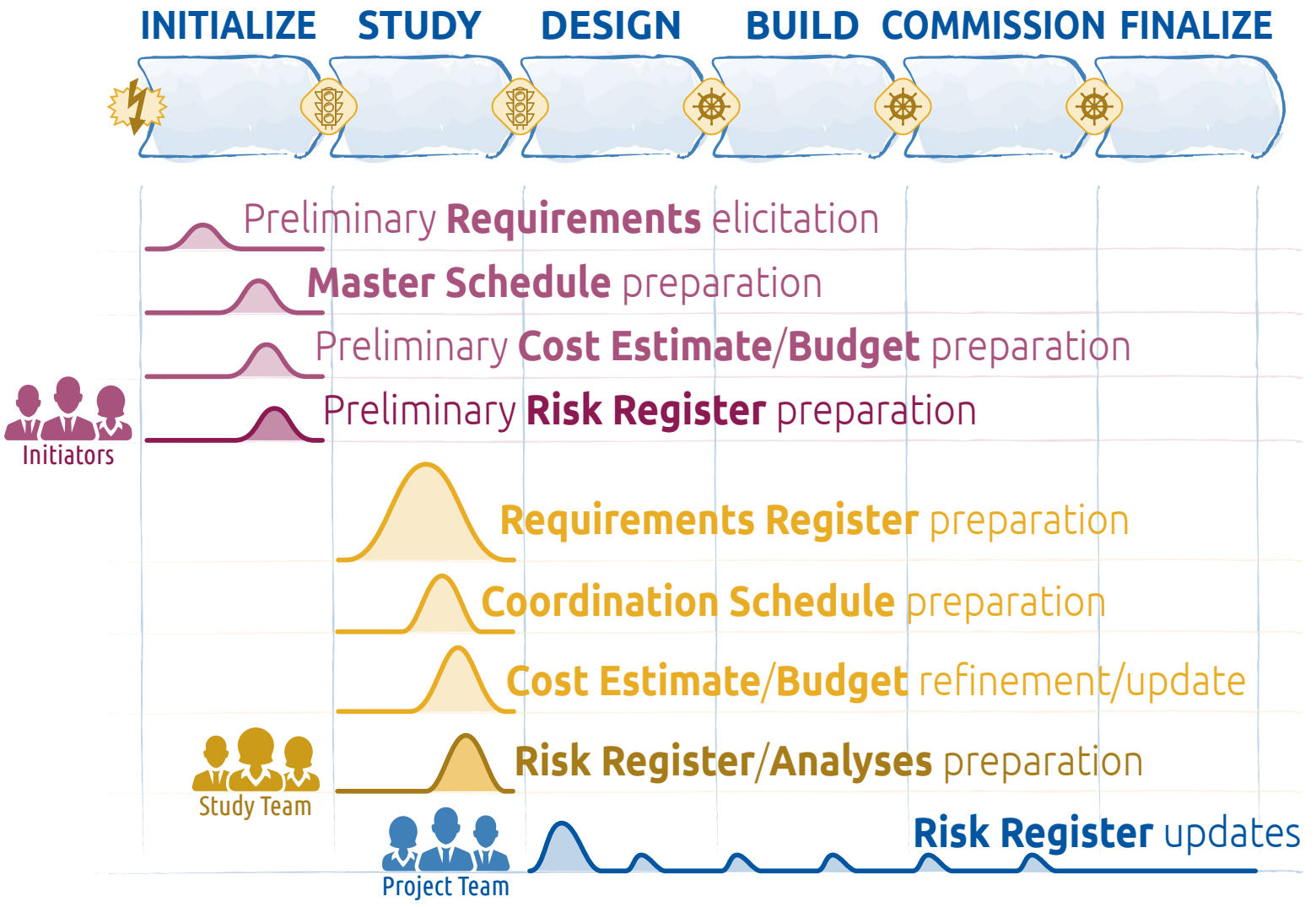
Project Risk Management

"Project triangle"



Project Risk Management

When and which effort?



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: *ριζικόν* = soldier's pay ⇢ ***risk-action***

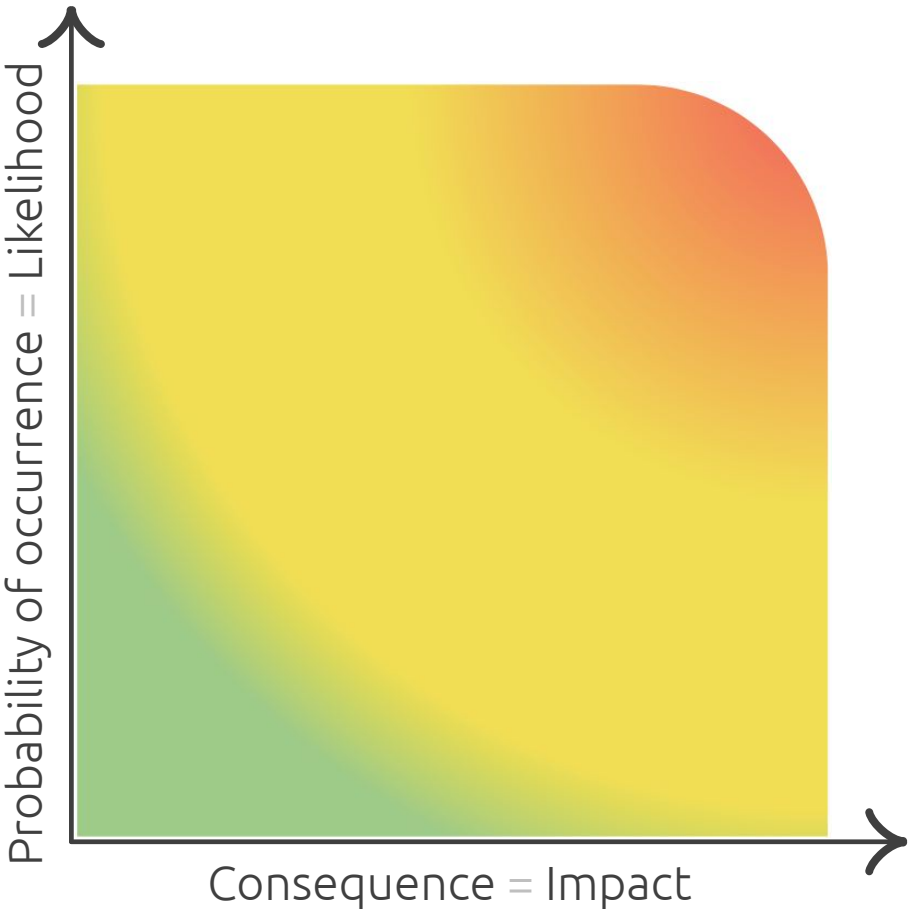
Risiko, Risiken in German

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

Heatmap

Likelihood × Consequences



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** being developed, incl. technical **reqts**.

Programmatic risks

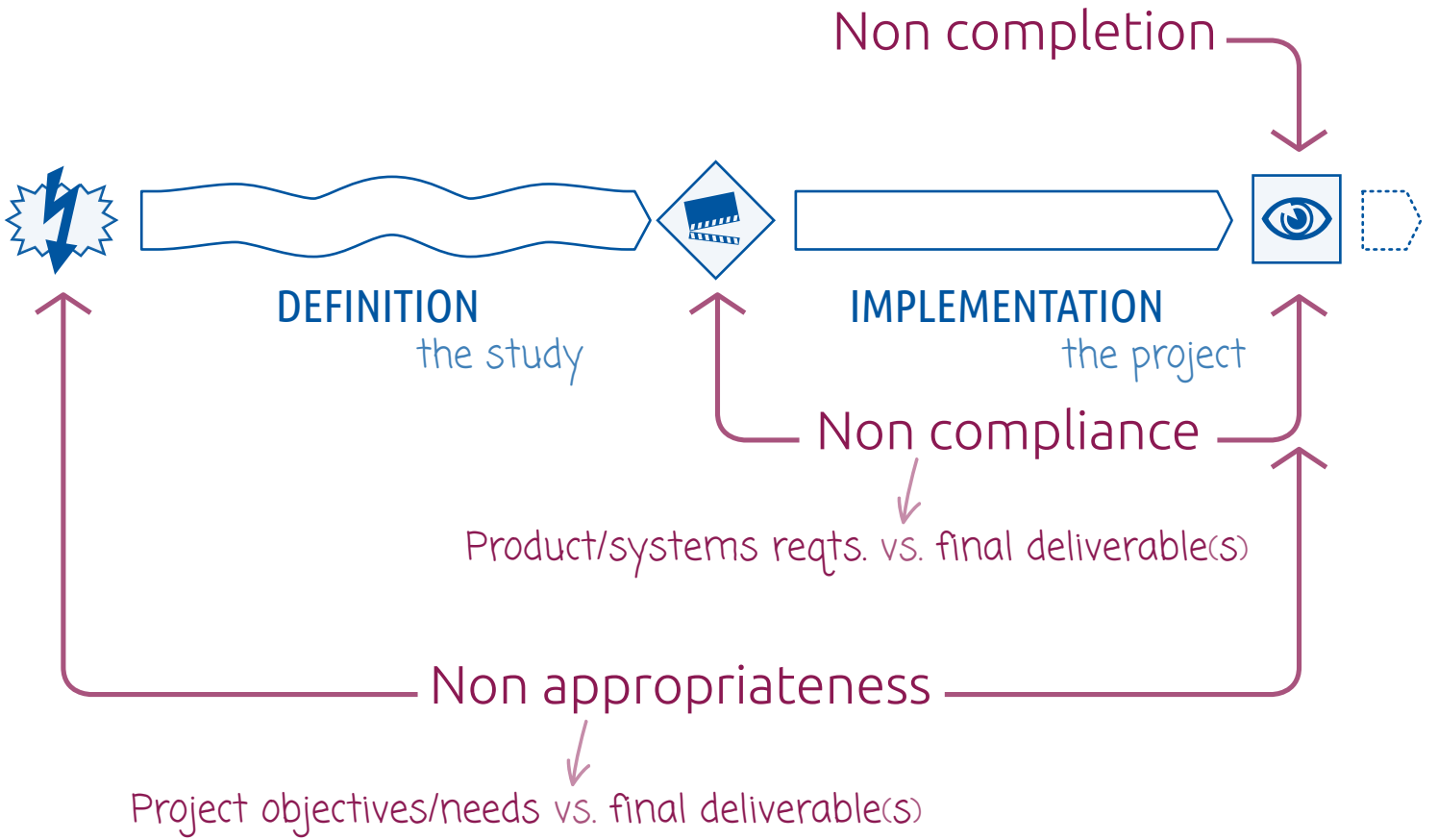
related to the **project**: on schedule, on budget

External risks

for which the project team has no real control

Project Risk Management

Concept of lifecycle



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
NASA Systems Engineering Handbook NASA/SP-2007-6105 Rev1	§ 6.4 pp. 139–150
INCOSE SEBoK	sebocwiki.org/wiki/Risk_Management
Ecss EUROPEAN COORDINATION FOR SPACE STANDARDISATION	ECSS-M-ST-80C July 2008
openSE	§ IV.3.5 p. 50

Project Risk Management with OpenSE

3 levels of implementation

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

Project Risk Management

The ‘basic toolbox’

SIMPLE approach

Simplified
Risk Register

→

Bullet list consisting of **risk statements**:

- ⟨risk⟩, *however* ⟨response⟩

examples

- 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

Project Risk Management

The 'intermediate toolbox'

INTERMEDIATE approach

Regular
Risk Register

Spreadsheet table consisting of **risk scenarios**:

RISK SCENARIO	RISK MAGNITUDE	RISK RESPONSE

Project Risk Management

A 5-step process

INTERMEDIATE approach

1. Agreeing a risk management approach for the project ✓
   - risk management planning
2. Identifying risk scenarios
   - risk searching
3. Evaluating their magnitude
   - risk sorting
4. Defining responses to these risk scenarios
   - risk treatment or risk planning
5. Following up the risks as the project progresses
   - risk monitoring

8.1

Risk Management Planning

1

openSE

Project Risk Management

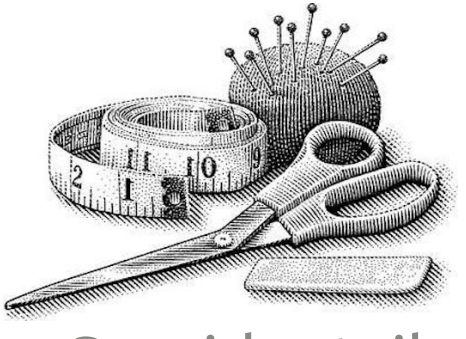
1 Risk Management Planning

INTERMEDIATE approach

Shall be discussed with Project Board

§ 3.6 of the **Project Management Plan**

Risk aversion
vs.
Risk appetite



Consider tailoring

Risk Identification

Project Risk Management

2 Risk Identification

INTERMEDIATE approach

How to identify all appropriate risk scenarios **?**

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.

Risk scenario column of the **Risk Register**

Project Risk Management

INTERMEDIATE
approach

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"

8.3

Risk Evaluation

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Project Risk Management

3 Risk Evaluation

INTERMEDIATE approach

Project Roadmap

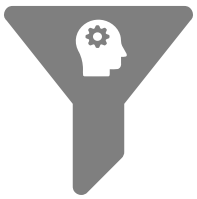
Project Mngt. Plan

Subject matter experts

Risk scenarios from the **Risk Register**

Risk Level Matrix

FMAC Analysis, etc.



Risk Register with magnitude columns populated

Risk Level Matrix

Probability	***P***
Very unlikely	.1
Rather unlikely	.3
Possible, plausible	.5
Rather likely	.7
Very likely, quite certain	.9

Consequences	***C***
Negligible	.05
Marginal	.1
Significant	.2
Major, critical	.4
Catastrophic, crisis	.8

Risk Level Matrix

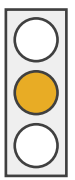
Consequences	c	on budget	on schedule
Negligible	.05	$\Delta C \approx 0$	$\Delta D \approx 0$
Marginal	.1	$1\% < \Delta C \leq 5\%$	$1\% < \Delta D \leq 5\%$
Significant	.2	$5\% < \Delta C \leq 10\%$	$5\% < \Delta D \leq 10\%$
Major, critical	.4	$10\% < \Delta C \leq 20\%$	$10\% < \Delta D \leq 20\%$
Catastrophic, crisis	.8	$\Delta C > 20\%$	$\Delta D > 20\%$

Risk Level Matrix

Consequences	***C***	on the project performance
Negligible	.05	Minimal or no consequence
Marginal	.1	Small reduction of the performance
Significant	.2	Significant degradation of the performance
Major, critical	.4	Technical goals cannot be achieved
Catastrophic, crisis	.8	Project cannot be completed

Risk Level Matrix

$$S = P \times C$$

$S < 0.05$		low risk
$0.05 \leq S < 0.20$		medium risk
$S \geq 0.20$		high risk

Risk Level Matrix

P \ C	.05	.1	.2	.4	.8
.9	.05	.09	.18	.36	.72
.7	.04	.07	.14	.28	.56
.5	.03	.05	.10	.20	.40
.3	.02	.03	.06	.12	.24
.1	.01	.01	.02	.04	.08

The CanNet project risk register

- Some statements from the **Project Roadmap**
- The **Master Schedule** of the project
- A description of the **process**, and the **layout** (pilot project)
- The Product Breakdown Structure (**PBS**)
- The Work Breakdown Structure (**WBS**)
- The Organizational Breakdown Structure (**OBS**)
- The Resource Breakdown Structure (**RBS**)
- The **Coordination Schedule** of the pilot project

Your task, as groups of 2 (or 3) participants :

- Identifying 6 (or 9) **risk scenarios** of the 3 types
- Evaluating their **risk magnitude**

The CanNet project risk register

RISK SCENARIO	TYPE	P	C_P	C_C	C_D	S	

One risk scenario per card

Tech.
Progr.
Ext.

$S = P \times \max (C_P, C_C, C_D)$

8.4

Risk Treatment

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Generic Response Types

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

Stephen Ward, Chris Chapman (2011) How to Manage Project Opportunity and Risk: Why Uncertainty Management can be a Much Better Approach than Risk Management (3 ed). Wiley

Generic Response Types

In practice

INTERMEDIATE
approach

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

↓

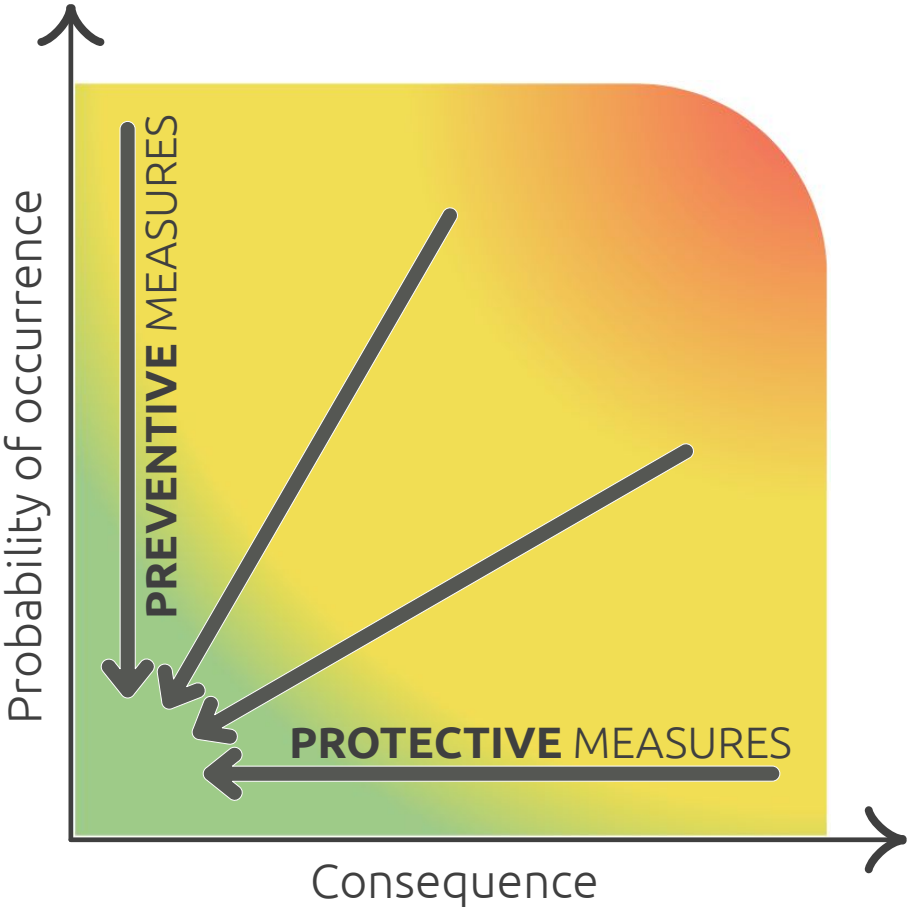
provision
insurance

~~Ignorance~~

Risk

Heatmap

Prevention vs. Protection



Project Risk Management

4 Risk Treatment

INTERMEDIATE approach

Project Roadmap

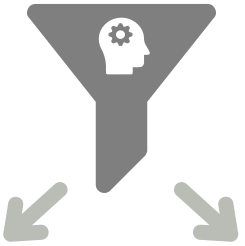
Project Mngt. Plan

Subject matter experts

Lessons learned

Risk Register

Doc. screening
Interviews



Delphi panels
Six-hats, etc.

Risk Register with response columns populated

Continuity Plan(s)

The CanNet project risk register

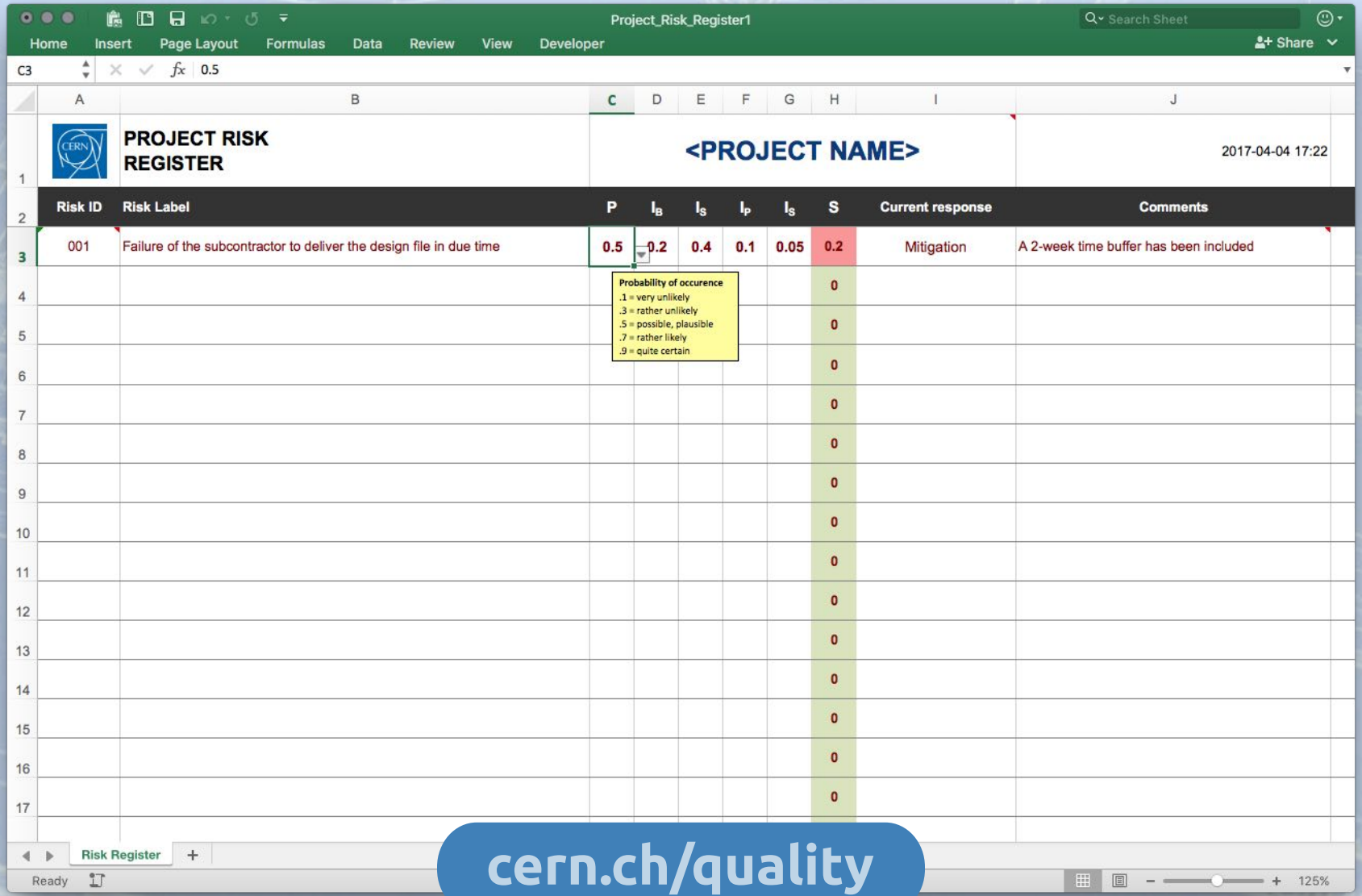
Your task, per group of 2 (or 3) participants :

- Identifying 6 (or 9) **risk scenarios** of the 3 types ✓
- Evaluating their **risk magnitude** ✓

Together :

- Defining **risk responses** to some of these risk scenarios

At **CERN** (in the A&T Sector)



Project_Risk_Register1

Home Insert Page Layout Formulas Data Review View Developer

C3 0.5

PROJECT RISK REGISTER

<PROJECT NAME>

2017-04-04 17:22

Risk ID	Risk Label	P	I_B	I_S	I_P	I_S	S	Current response	Comments
001	Failure of the subcontractor to deliver the design file in due time	0.5	0.2	0.4	0.1	0.05	0.2	Mitigation	A 2-week time buffer has been included
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		
							0		

Probability of occurence
.1 = very unlikely
.3 = rather unlikely
.5 = possible, plausible
.7 = rather likely
.9 = quite certain

Risk Register

Ready

125%

cern.ch/quality

8.5

Risk Monitoring

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Project Risk Management

5 Risk Monitoring

INTERMEDIATE approach

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

Project Risk Management

The 'advanced PRM toolbox'

ADVANCED approach

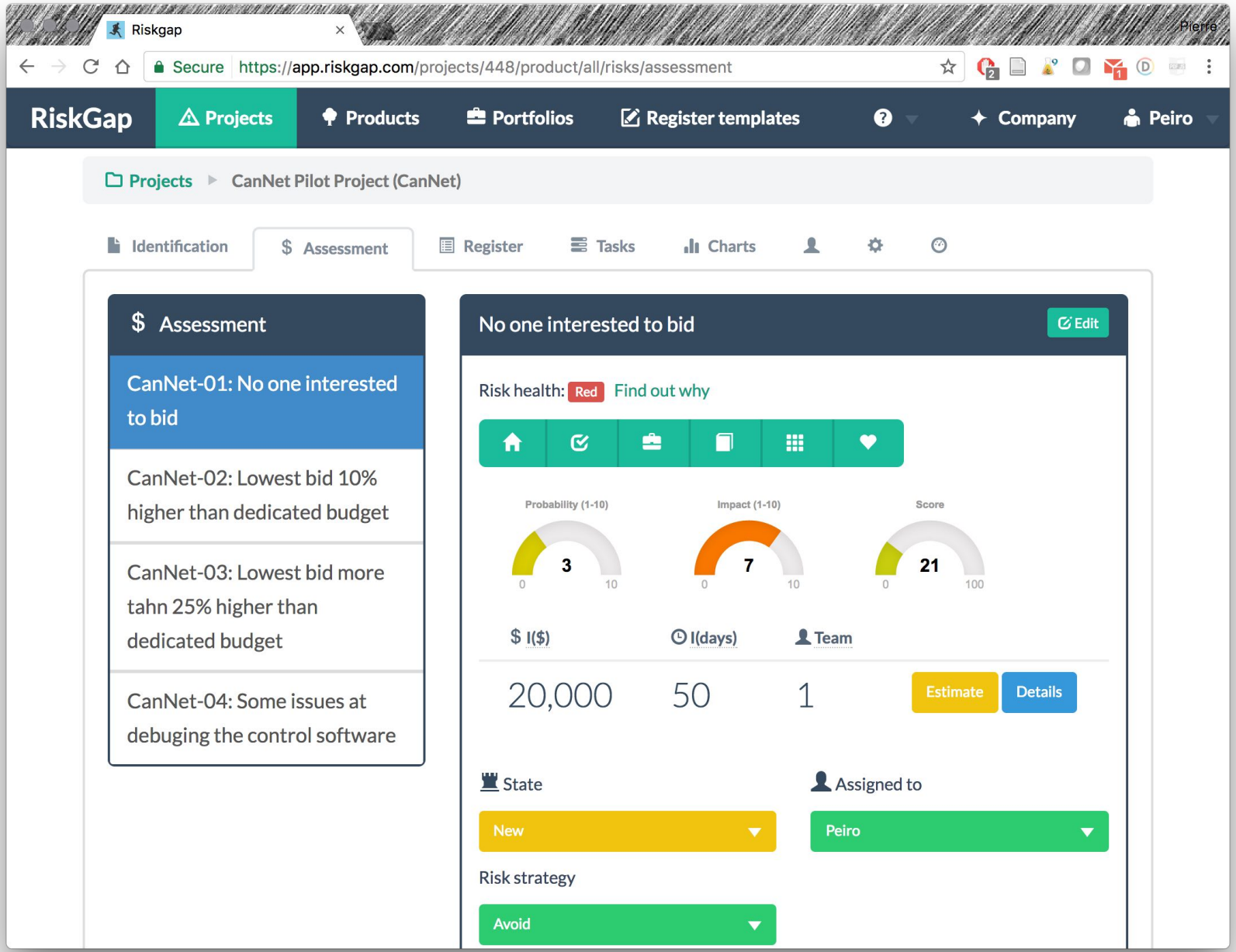
e.g. coordination schedule
Monte Carlo simulations

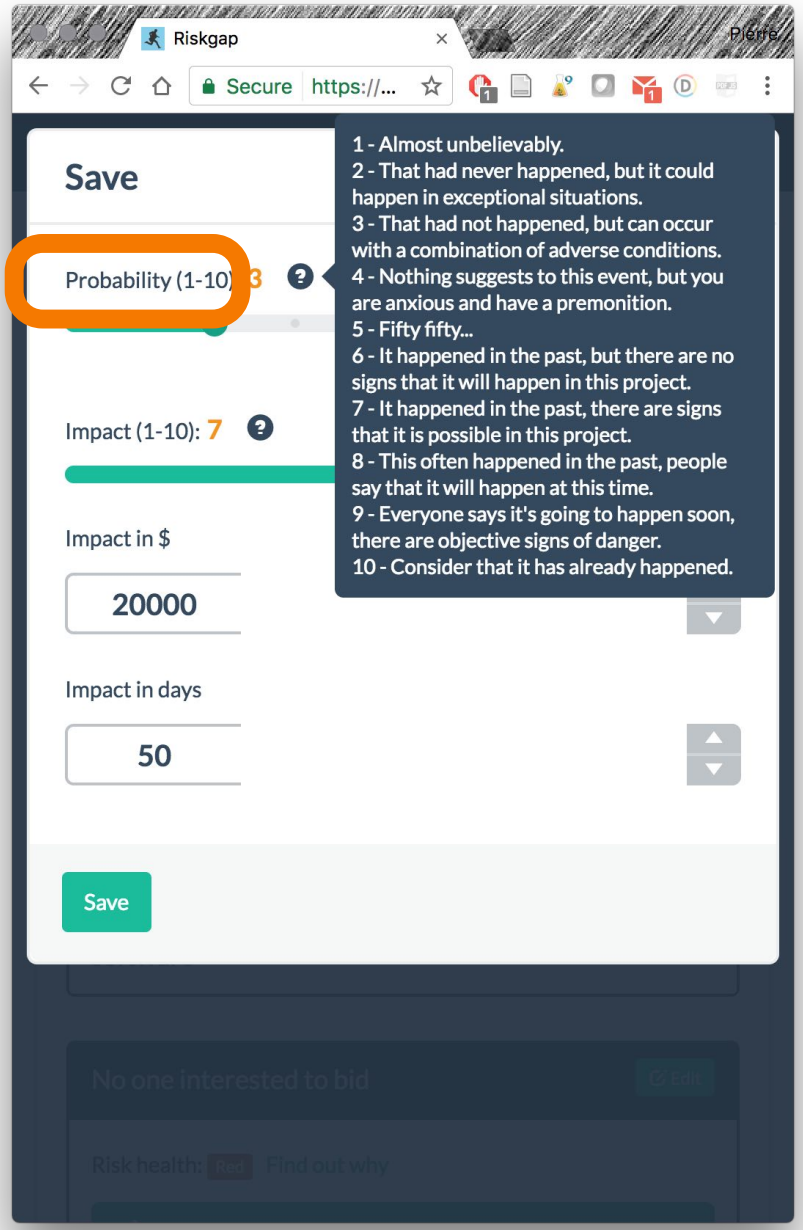
Various simulations and analyses

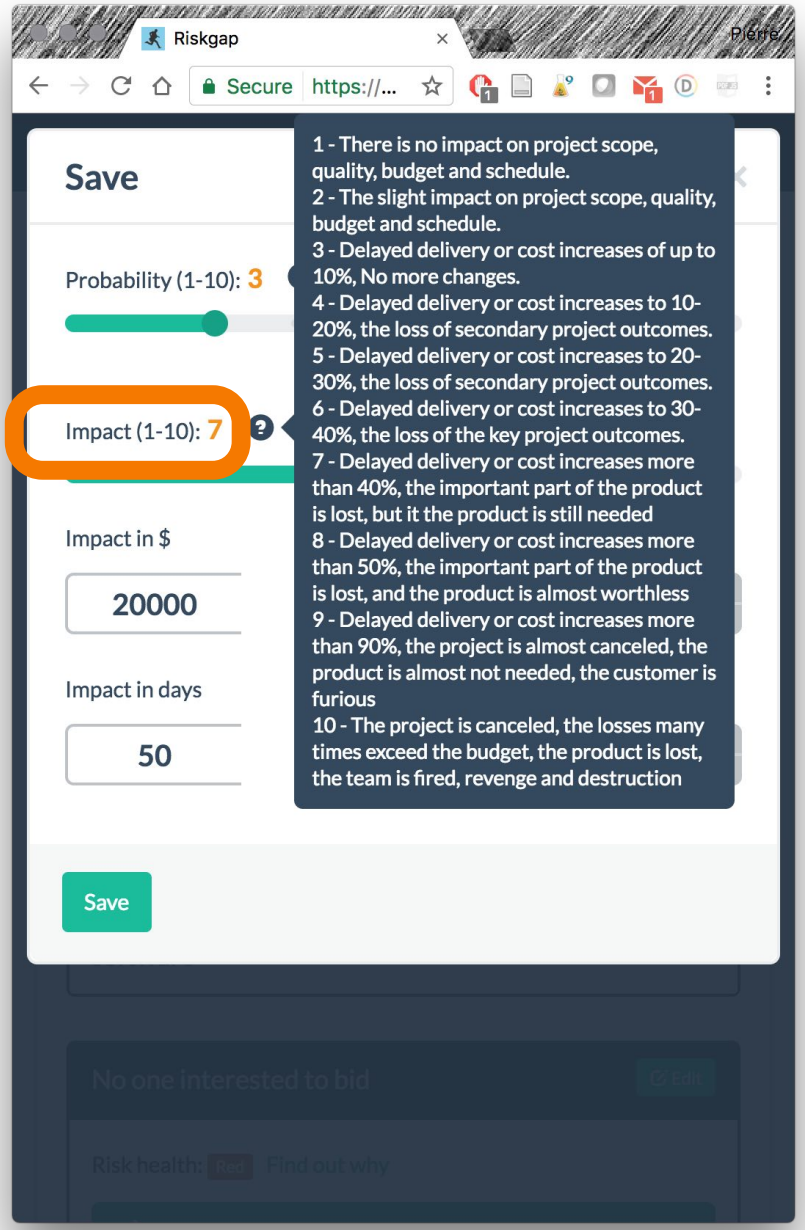
DB-based **Risk Register**

Enhanced **Risk Register**

RISK SCENARIO	RISK MAGNITUDE **BEFORE**	RISK RESPONSE	RISK MAGNITUDE **AFTER**


Riskgap
Pierre
Secure
https://app.riskgap.com/projects/448/product/all/risks/assessment
RiskGap
Projects
Products
Portfolios
Register templates
Company
Peiro
Projects
CanNet Pilot Project (CanNet)
Identification
Assessment
Register
Tasks
Charts
$ Assessment
CanNet-01: No one interested to bid
CanNet-02: Lowest bid 10% higher than dedicated budget
CanNet-03: Lowest bid more tahn 25% higher than dedicated budget
CanNet-04: Some issues at debuging the control software
No one interested to bid
Edit
Risk health: Red Find out why
Probability (1-10)
3
0
10
Impact (1-10)
7
0
10
Score
21
0
100
$ I($)
I(days)
Team
20,000
50
1
Estimate
Details
State
New
Assigned to
Peiro
Risk strategy
Avoid


Riskgap
Pierre
Secure https://...
Save
Probability (1-10): 3
1 - Almost unbelievably.
2 - That had never happened, but it could happen in exceptional situations.
3 - That had not happened, but can occur with a combination of adverse conditions.
4 - Nothing suggests to this event, but you are anxious and have a premonition.
5 - Fifty fifty...
6 - It happened in the past, but there are no signs that it will happen in this project.
7 - It happened in the past, there are signs that it is possible in this project.
8 - This often happened in the past, people say that it will happen at this time.
9 - Everyone says it's going to happen soon, there are objective signs of danger.
10 - Consider that it has already happened.
Impact (1-10): 7
Impact in $
20000
Impact in days
50
Save
No one interested to bid
Edit
Risk health: Red Find out why


Riskgap
Pierre
Secure https://...
Save
Probability (1-10): 3
Impact (1-10): 7
1 - There is no impact on project scope, quality, budget and schedule.
2 - The slight impact on project scope, quality, budget and schedule.
3 - Delayed delivery or cost increases of up to 10%, No more changes.
4 - Delayed delivery or cost increases to 10-20%, the loss of secondary project outcomes.
5 - Delayed delivery or cost increases to 20-30%, the loss of secondary project outcomes.
6 - Delayed delivery or cost increases to 30-40%, the loss of the key project outcomes.
7 - Delayed delivery or cost increases more than 40%, the important part of the product is lost, but it the product is still needed
8 - Delayed delivery or cost increases more than 50%, the important part of the product is lost, and the product is almost worthless
9 - Delayed delivery or cost increases more than 90%, the project is almost canceled, the product is almost not needed, the customer is furious
10 - The project is canceled, the losses many times exceed the budget, the product is lost, the team is fired, revenge and destruction
Impact in $
20000
Impact in days
50
Save
No one interested to bid
Edit
Risk health: Red Find out why

Project Risk Management

A 7-step process

ADVANCED approach

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**

   ↖ risk quantification
7. Following up the risks as the project progresses
   Running additional risk simulations
   and conducting additional risk analysis ✓

Risk Quantification

6

Risk quantification

Four approaches for dealing with probabilities:

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

Risk quantification

Four approaches for dealing with probabilities:

- **Classical** approach:

The probability P(*A*) of an event *A* is the property that determines its frequency of occurrence.

E.g.:
P(head) = P(tail) = 1/2
P(⚀) = P(⚁) = 1/6
P(⚅ and ⚅) = 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:

$0 \leq P(A) \leq 1$
$P(A \vee B) = P(A) + P(B)$
$\sum P(A_i) = 1$
…

Risk quantification

Four approaches for dealing with probabilities:

- **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

Project Risk Management

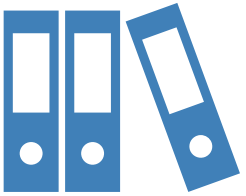
6 Risk Quantification

ADVANCED approach

Risk Register

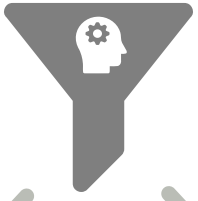
Subject matter experts

Lessons learned



Eventually all project docs.

Mathematics toolbox
(probabilities, combinatorics)



Monte Carlo simulations
Decision trees, etc.

Risk Simulation(s)

Risk Analysis(-es)

Probabilistic Project Scheduling

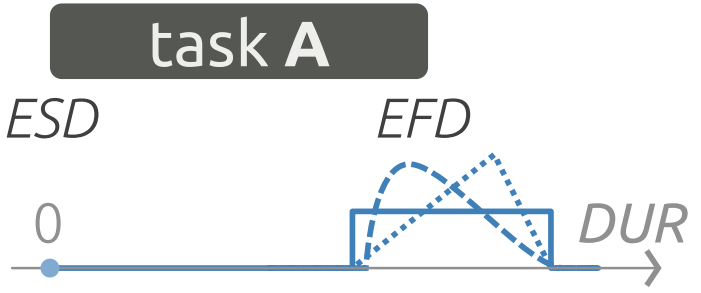
Monte Carlo-based schedule assessment

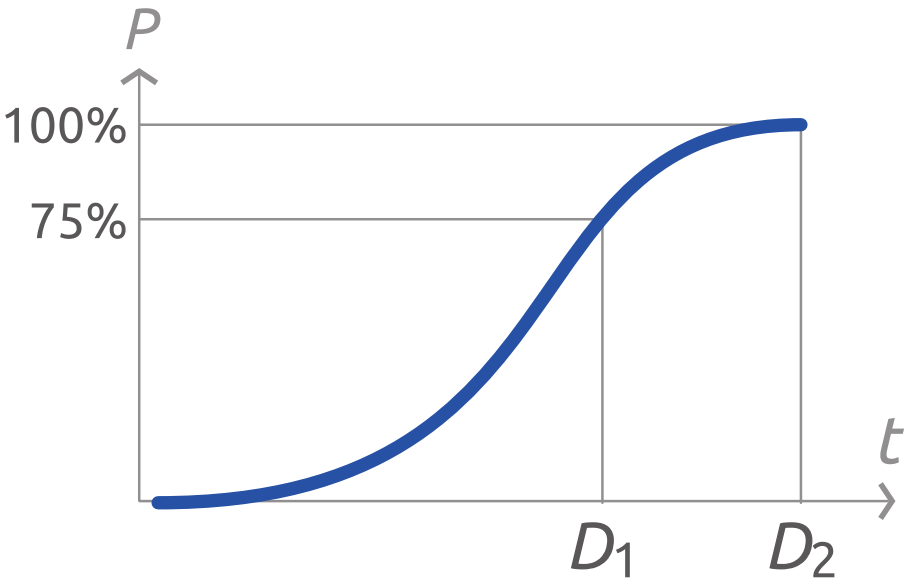
ADVANCED approach

1. Identifing 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**

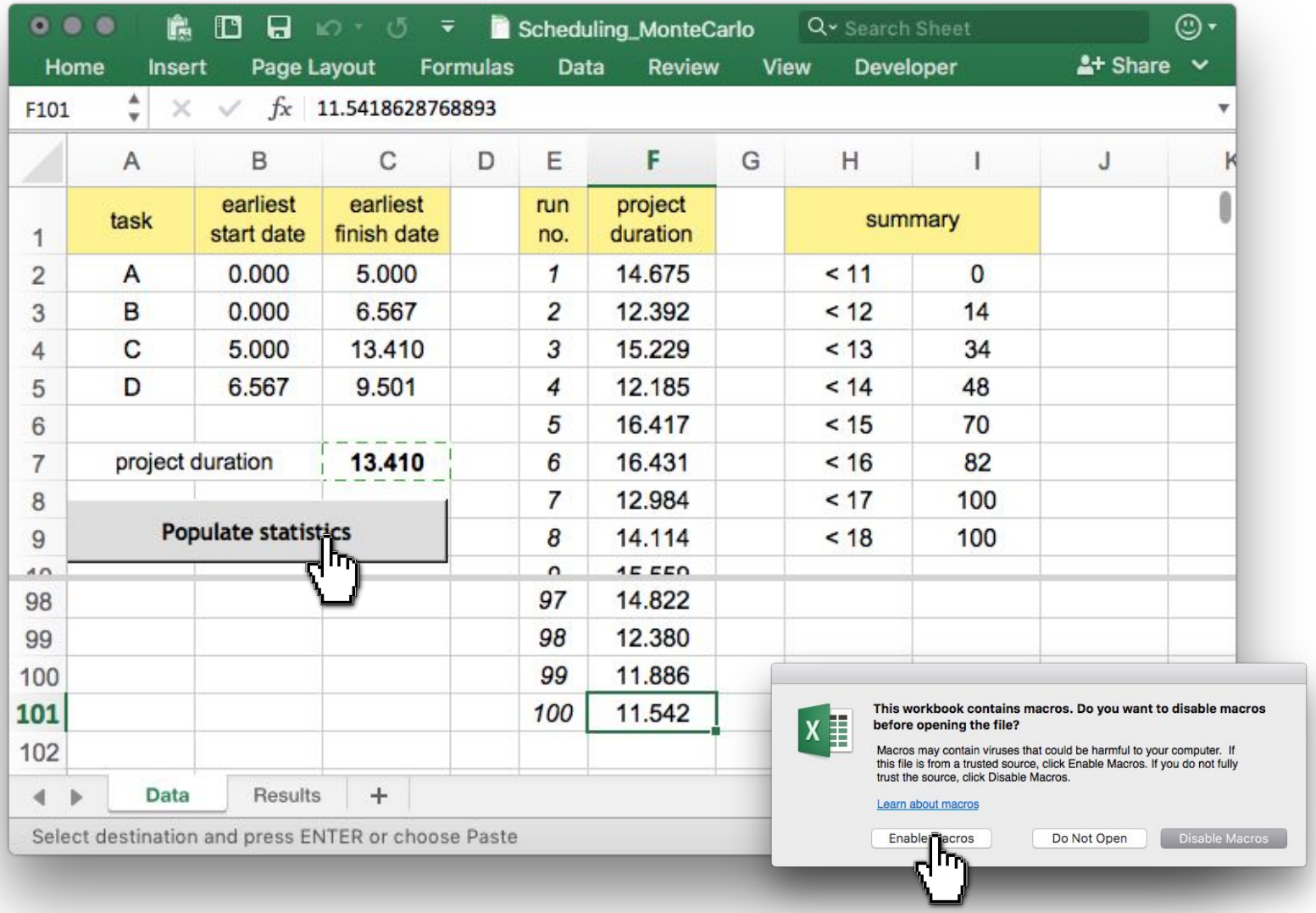




Probabilistic Project Scheduling

Monte Carlo-based schedule assessment

ADVANCED approach

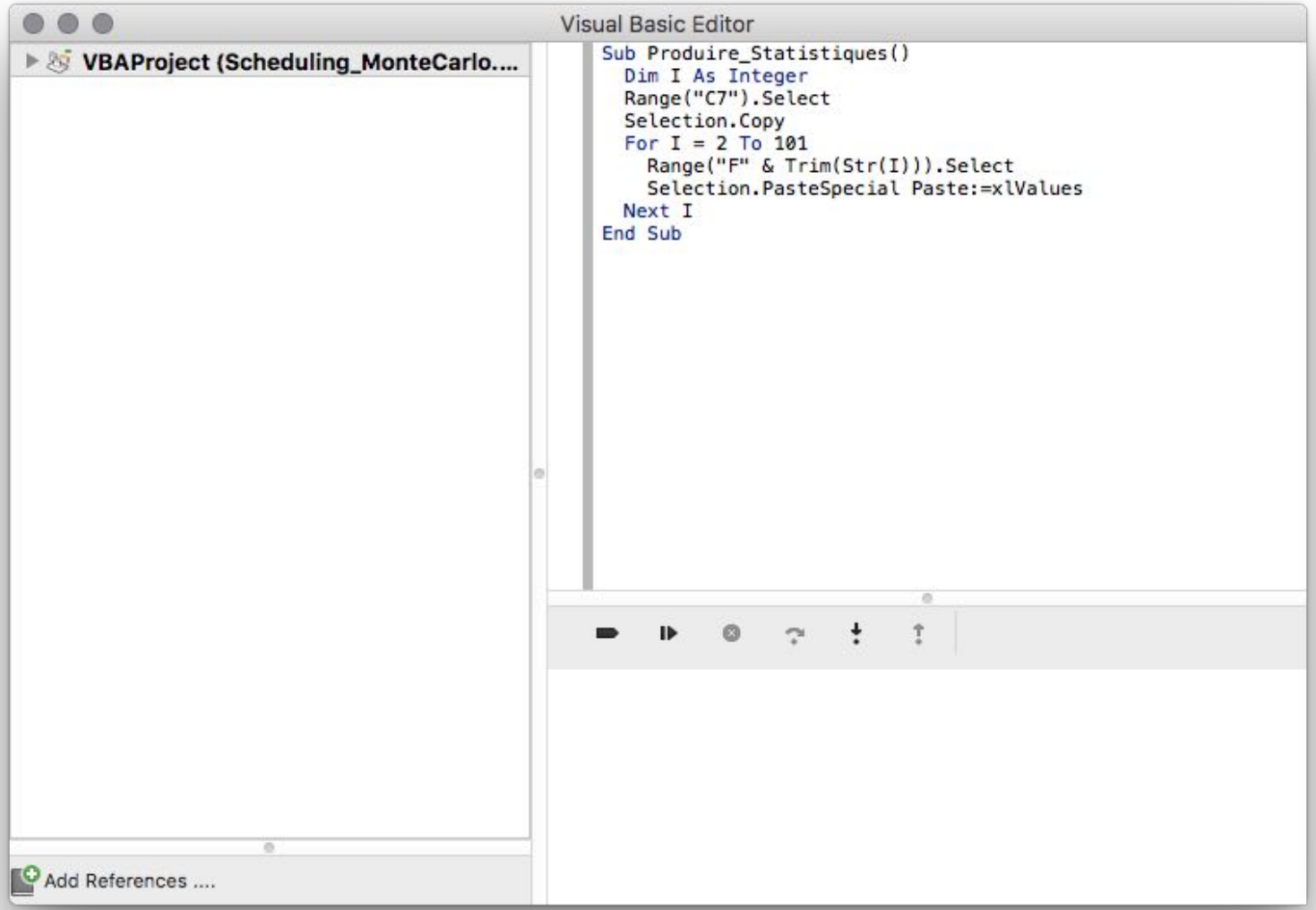


	A	B	C	D	E	F	G	H	I	J
1	task	earliest start date	earliest finish date		run no.	project duration		summary		
2	A	0.000	5.000		1	14.675		< 11	0	
3	B	0.000	6.567		2	12.392		< 12	14	
4	C	5.000	13.410		3	15.229		< 13	34	
5	D	6.567	9.501		4	12.185		< 14	48	
6					5	16.417		< 15	70	
7	project duration		13.410		6	16.431		< 16	82	
8					7	12.984		< 17	100	
9					8	14.114		< 18	100	
98					97	14.822				
99					98	12.380				
100					99	11.886				
101					100	11.542				
102										

Probabilistic Project Scheduling

Monte Carlo-based schedule assessment

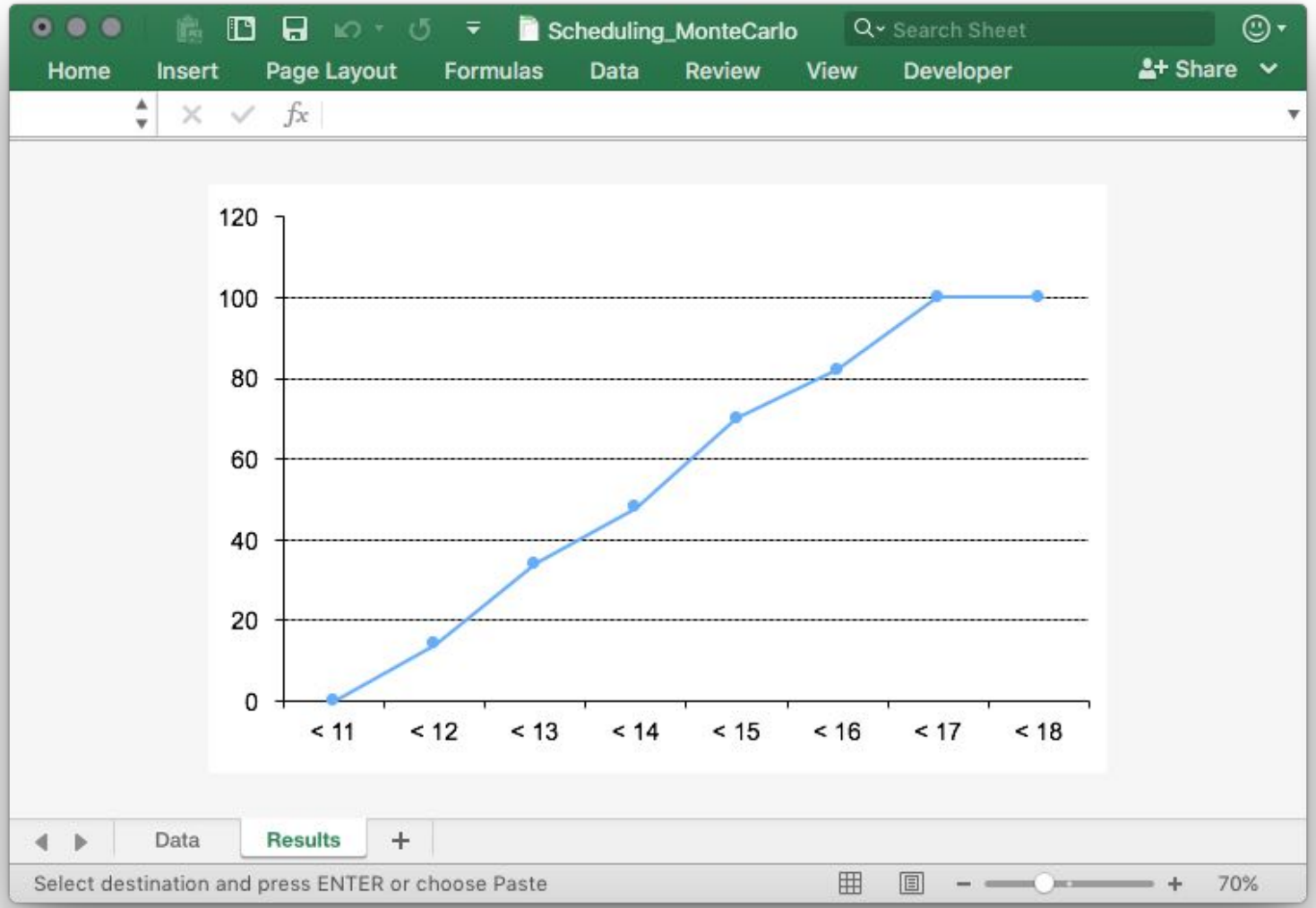
ADVANCED approach



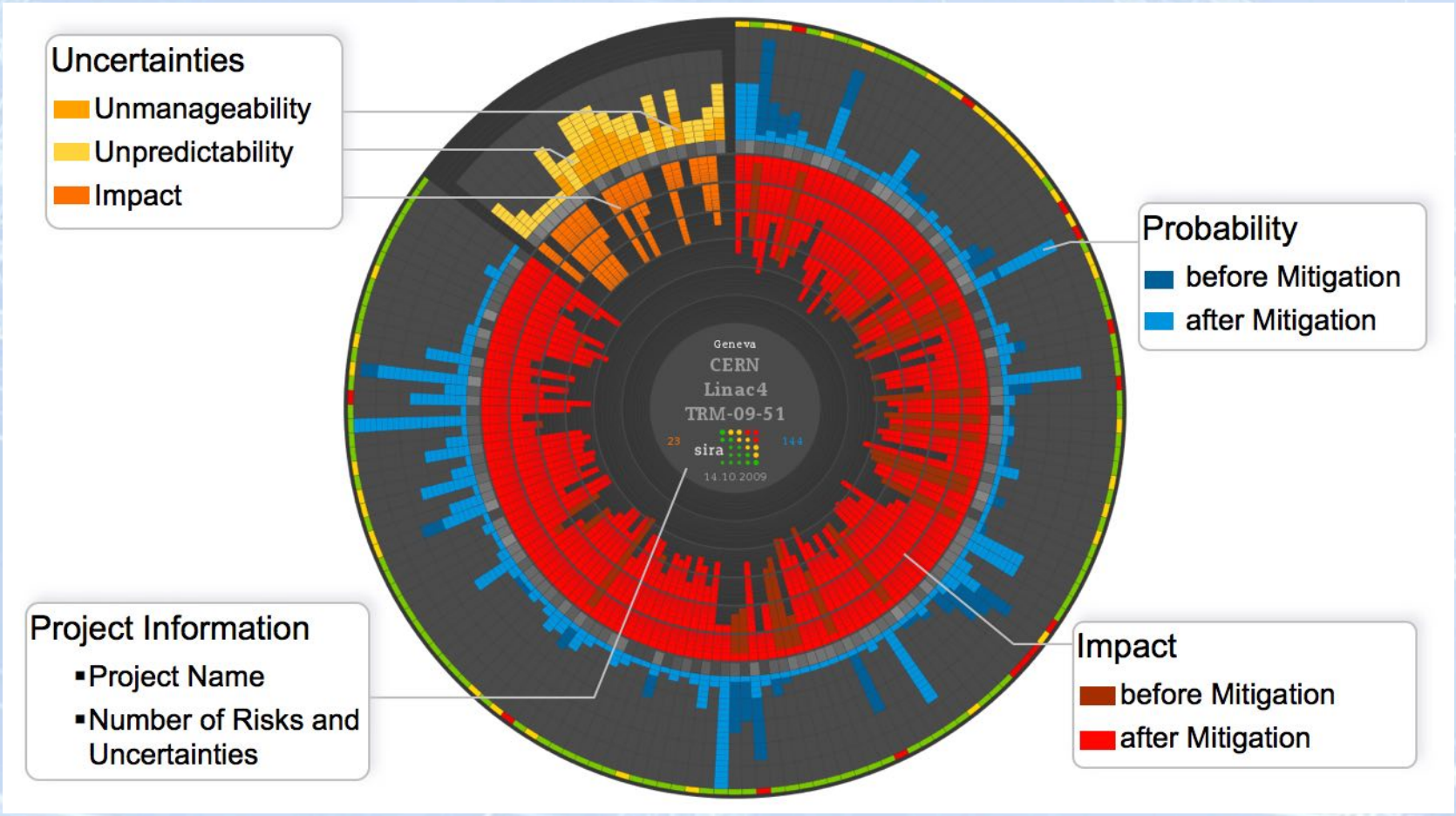
Probabilistic Project Scheduling

Monte Carlo-based schedule assessment

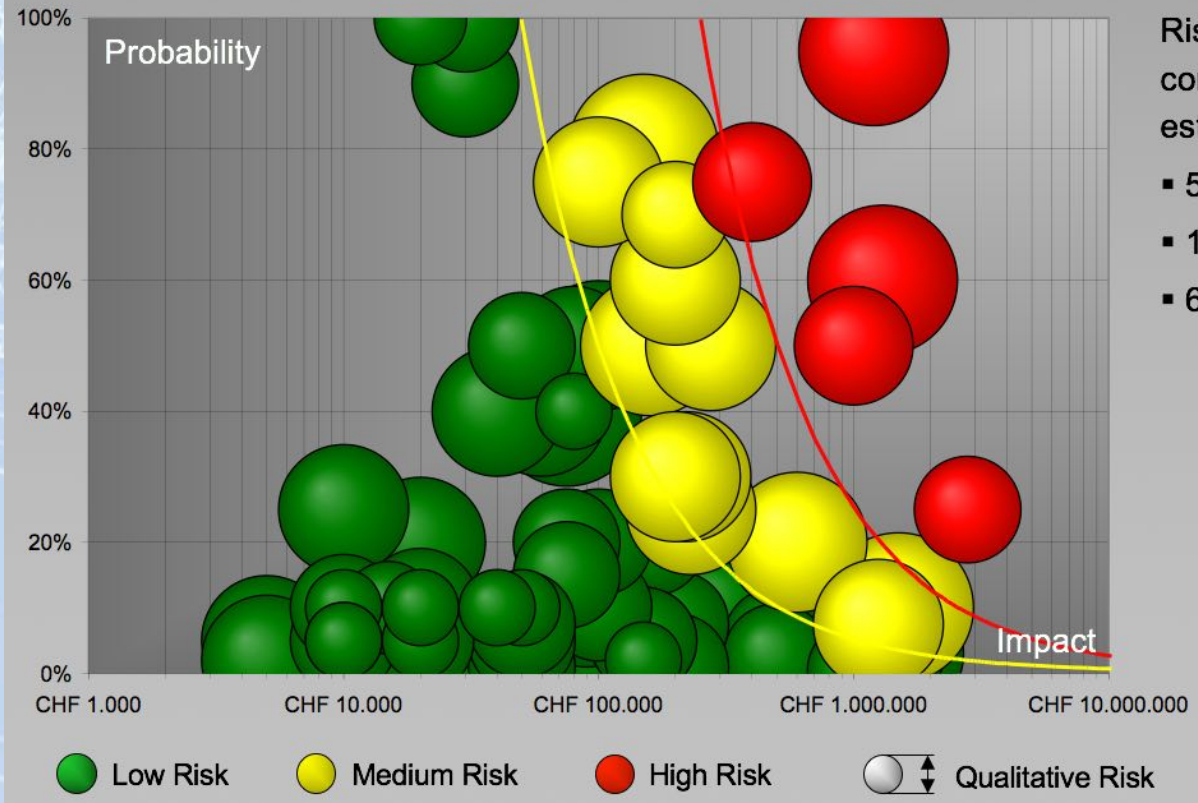
ADVANCED approach



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



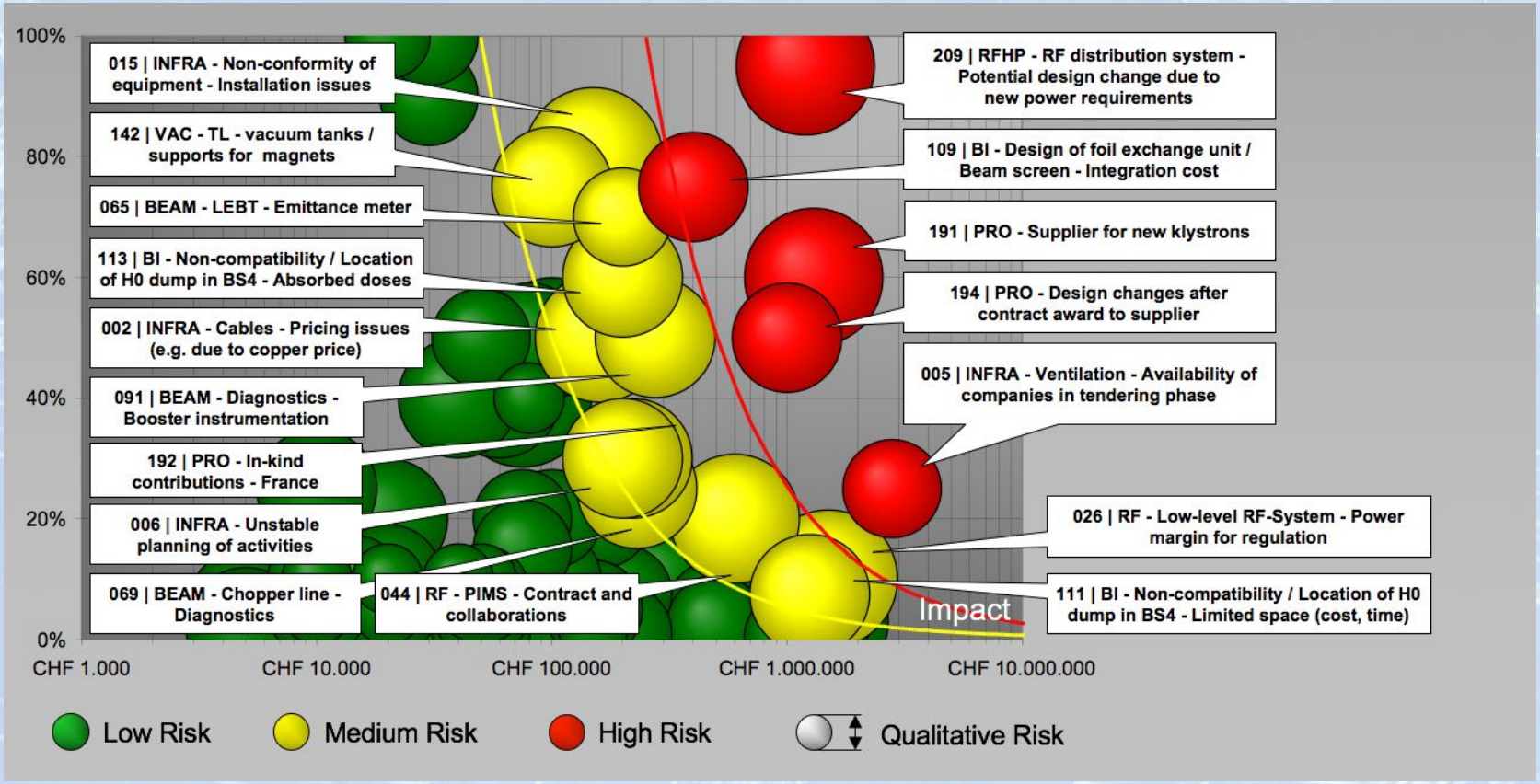
At **CERN** (in the A&T Sector)
Linac4 Project Risk Analysis
Overview of cost impact before mitigation



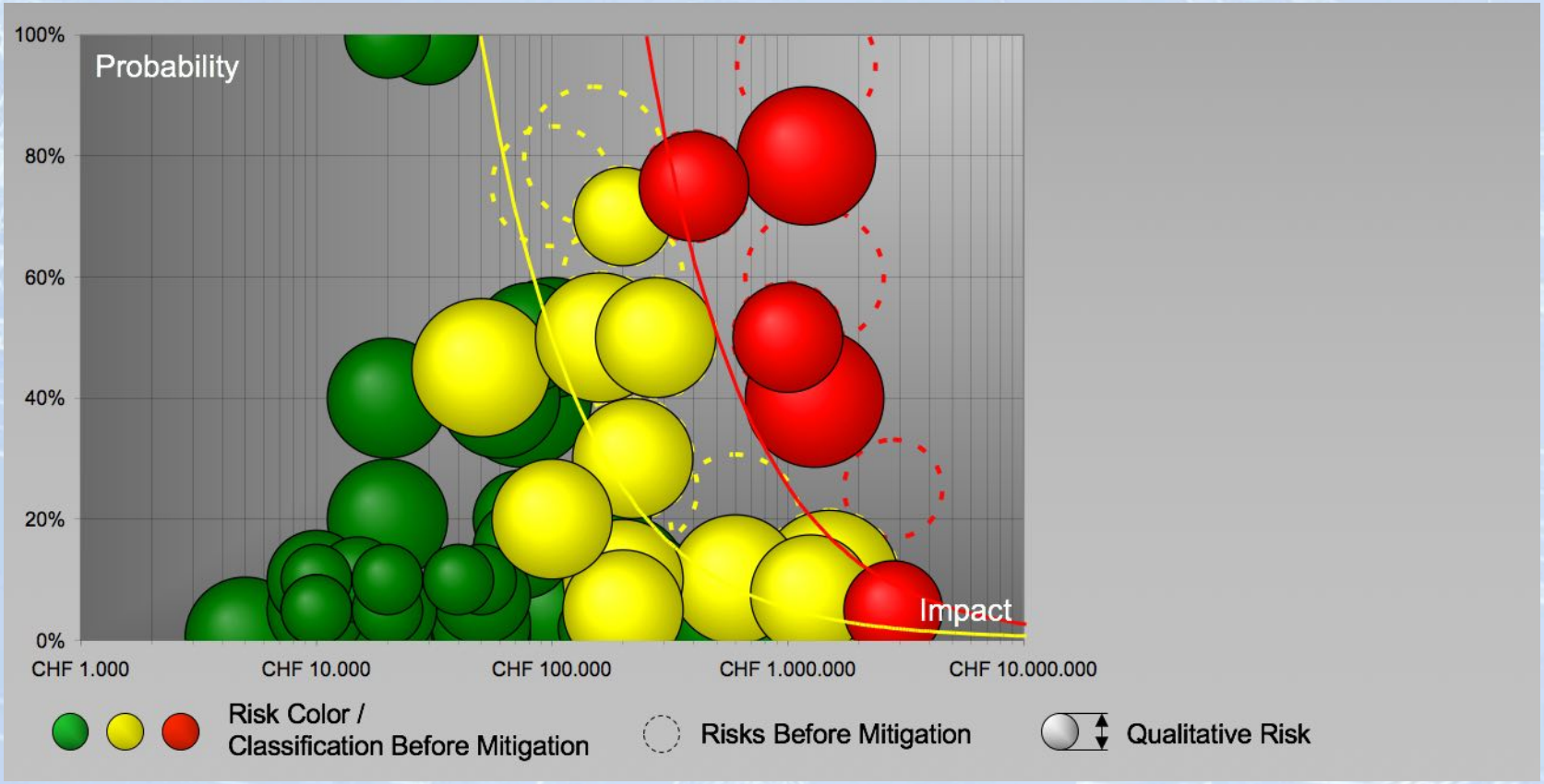
Risks of **budget overrun** compared to overall project cost estimate (baseline 2009):

- 5 high risks
- 12 medium risks
- 63 low risks

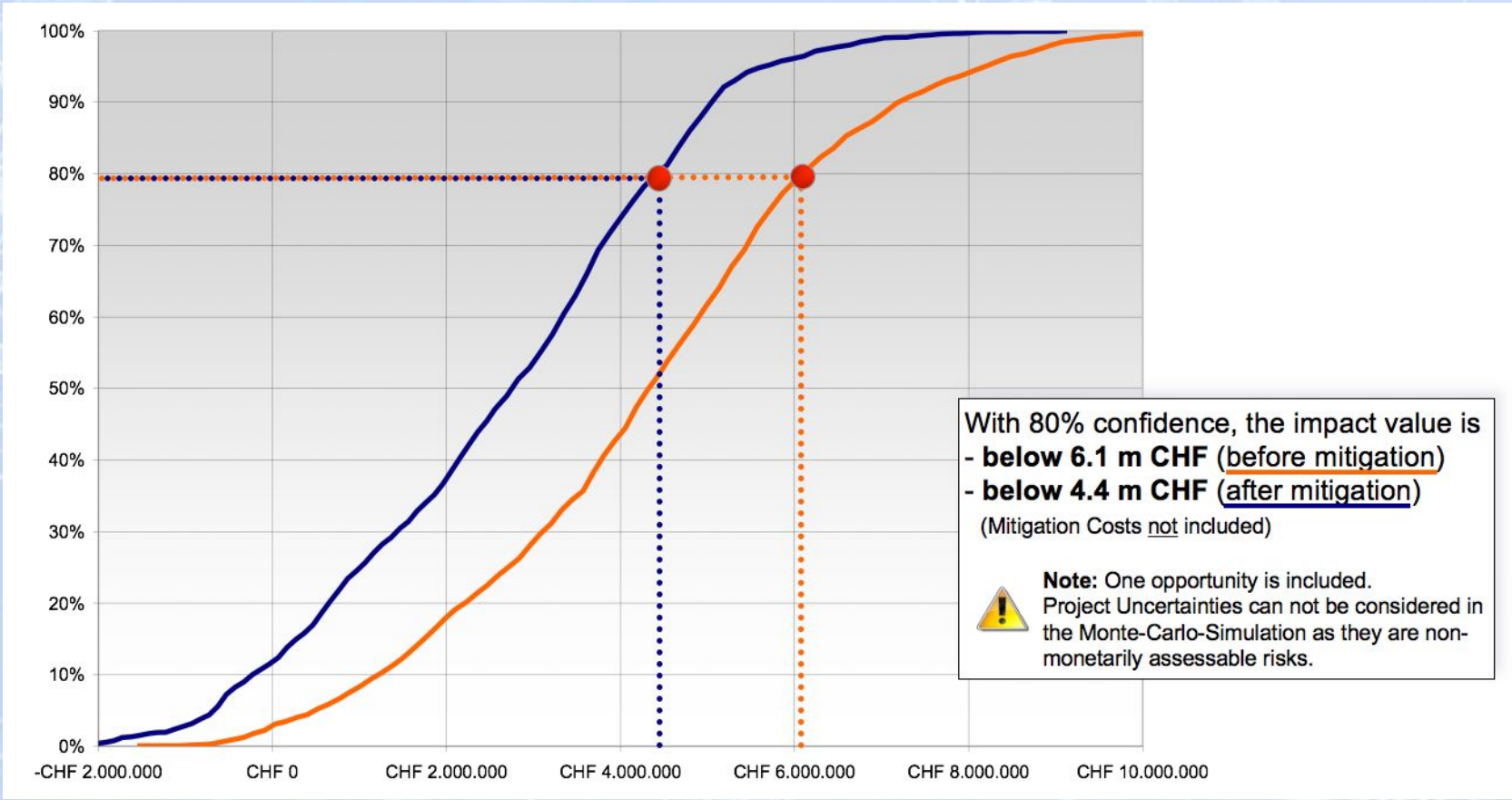
At **CERN** (in the A&T Sector)
Linac4 Project Risk Analysis
Overview of cost impact before mitigation



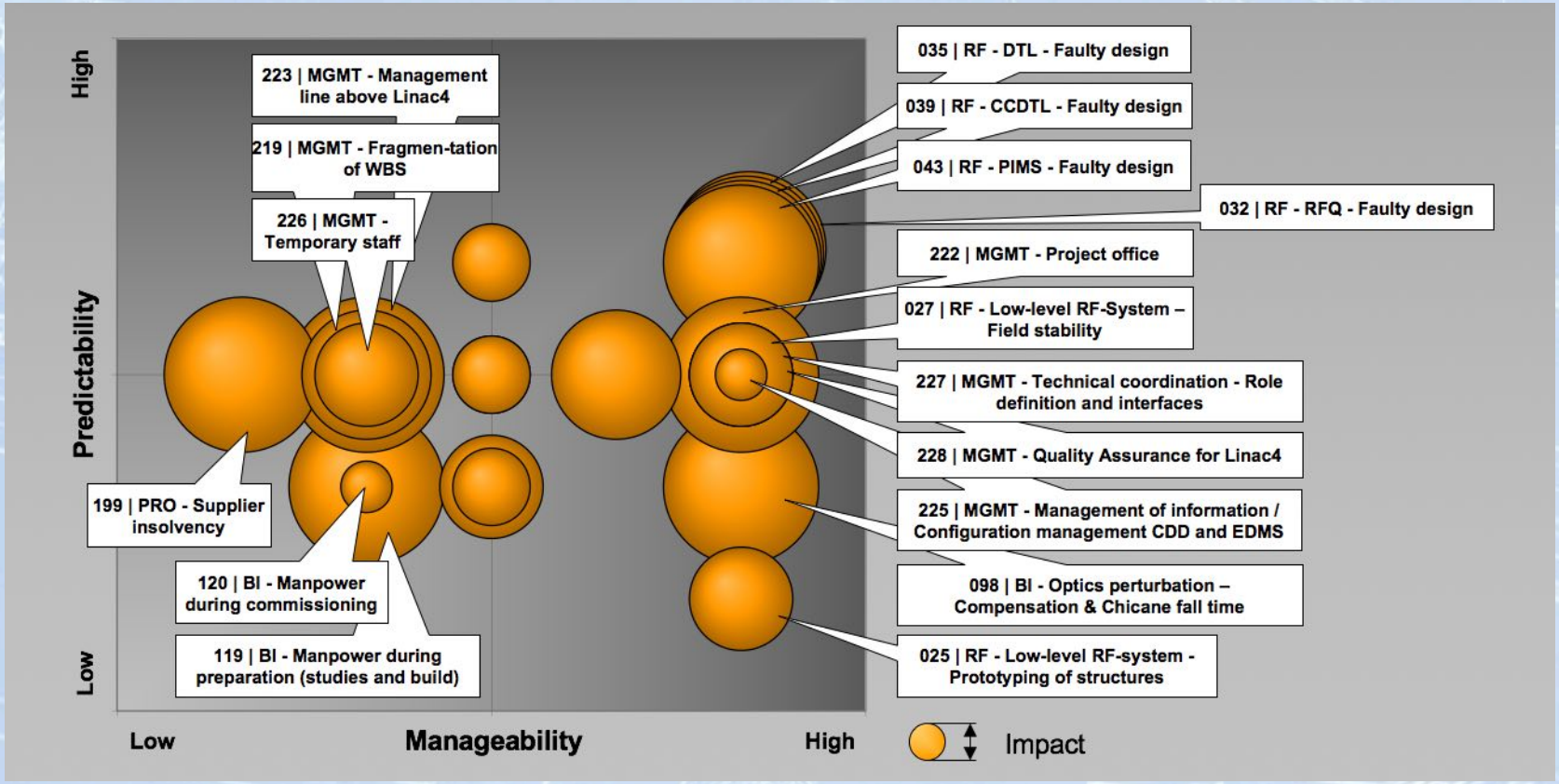
At **CERN** (in the A&T Sector)
Linac4 Project Risk Analysis
Overview of cost impact **after** mitigation



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



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



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