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Melbourne Cricket Ground, Melbourne

Calculating project risk contingency – Expected Monetary Value (EMV) vs Monte Carlo Analysis

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Part 1
Contemporary Risk Management (Debra - 10 min)

Part 2
Calculating Risk Contingency: EMV vs. Monte Carlo (Kazi - 20 min)

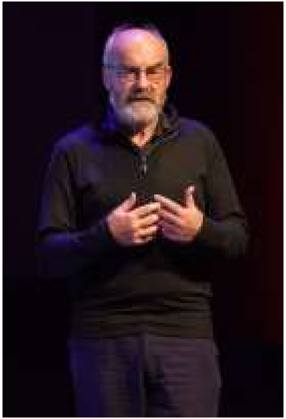
Part 3
Project Continuity Management & Summary (Debra - 10 min)

Part 1: Contemporary Risk Management

Contemporary Projects

- Pace of **change** accelerating
- Project **size** increasing
- Project **complexity** multiplying

Contemporary thinkers

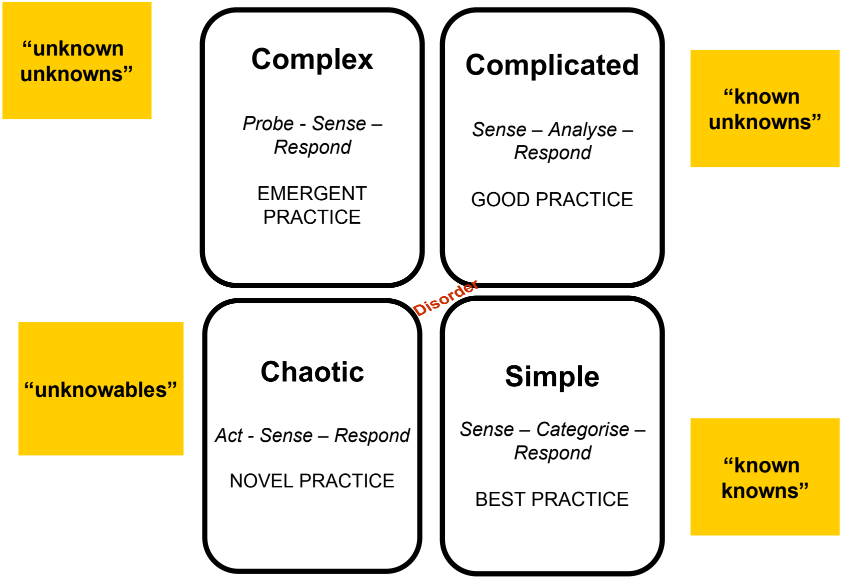


David Snowden
Management Consultant & Researcher

Craig Rispin
Business Futurist

Dr David Hillson
Risk Doctor

David Snowden, 2002



“unknown unknowns”
Complex
Probe - Sense – Respond
EMERGENT PRACTICE
Complicated
Sense – Analyse – Respond
GOOD PRACTICE
“known unknowns”
Disorder
“unknowables”
Chaotic
Act - Sense – Respond
NOVEL PRACTICE
Simple
Sense – Categorise – Respond
BEST PRACTICE
“known knowns”

It makes no sense to work on risks one at a time.

In order to achieve the best possible outcomes, we need to understand the dynamics of the inter-relationships between risks.

I'm Craig and I'm a Futurist ...

Craig Rispin, Business Futurist

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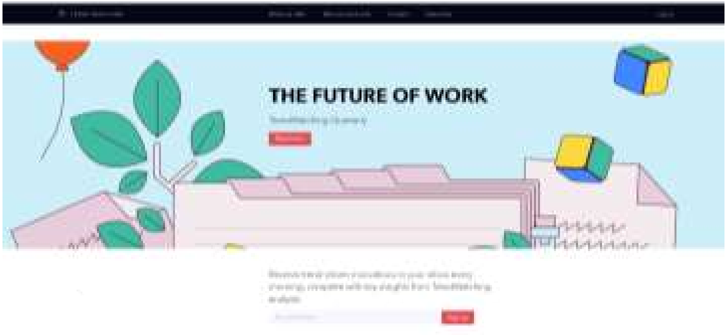
Futurist Tools & Techniques

1. Environmental Scanning

www.trendwatching



2. Scenario Planning

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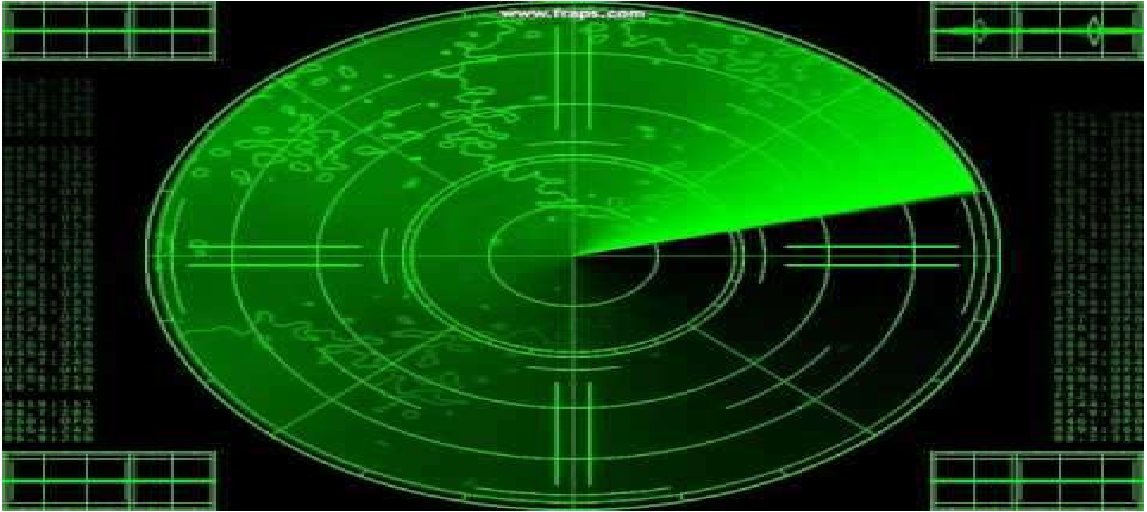
Dr David Hillson
HonFAPM, PMI Fellow, CFIRM

Topic: Managing risks in complex mega projects

APM Risk SIG Annual Conference London,
25 January 2018

Risk Management: Forward looking radar



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Manage the future proactively

Traditional Risk Management

Typical risks

Threats
Avoid / Transfer / Reduce / Accept

Opportunities
Exploit / Share / Enhance / Accept

Project Continuity Management

Emergent risks

Flexibility

Resilience

Dual concept of risks

- **Individual** Risks - the risks in the project
- **Overall** project risks - the risks of the project

- **Individual risks** are specific events or conditions that might affect smaller, individual project objectives.

- **Overall project risk** represents the effect of uncertainty on the project as a whole.

Two levels of question & answer:

Project Manager

Q: What are the risks in my project?

A: Individual risks

Project Sponsor

Q: How risky is this project?

A: Overall project risk

Qualitative Risk Analysis

- Risk-level analysis
- Addresses **individual risks** descriptively
- Assesses the discrete probability of occurrence (**Likelihood**) and impact on objectives if it does occur (**Consequence**)

Risk Register

Project name: Common project risks

ID	Date raised	Risk description	Likelihood of the risk occuring	Impact if the risk occurs	Severity *Rating based on impact & likelihood.*	Owner *Person who will manage the risk.*	Mitigating action *Actions to mitigate the risk e.g. reduce the likelihood.*
1	[enter date]	Project purpose and need is not well-defined.	Medium	High	High	Project Sponsor	Complete a business case if not already provided and ensure purpose is well defined on Project Charter and PID.
2	[enter date]	Project design and deliverable definition is incomplete.	Low	High	High	Project Sponsor	Define the scope in detail via design workshops with input from subject matter experts.
3	[enter date]	Project schedule is not clearly defined or understood	Low	Medium	Medium	Project Manager	Hold scheduling workshops with the project team so they understand the plan and likelihood fo missed tasks is reduced.

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Quantitative Risk Analysis

- Project-level analysis
- Predicts likely project outcomes based on combined effects of risks
- Identifies risks with greatest impact on project

Perform Quantitative Risk Analysis

Tools & Techniques:

- Decision tree
- **Expected monetary value (EMV) analysis**
- Fault tree analysis
- **Monte Carlo Simulation**
- Risk-based earned value analysis
- Sensitivity analysis
- System dynamics

Part 2 - Calculating Risk Contingency

For Major Government Projects

Project Cost Over Run

Conventionally, the following are listed as causes of project underperformance in the literature and in practice:

- project complexity
- scope changes
- technological uncertainty
- demand uncertainty
- unexpected geological features
- negative plurality (i.e. opposing stakeholder voices)
- major projects are prone to what Tale (2007) calls “black swans,” i.e. extreme events with low probability and high impact, but forecasts and risk assessments rarely reflect this.

(Source: Flyvbjerg, Bruzelius, and Rothengatter 2003)

Other Contributing Factors

The root cause of underperformance is the fact that project planners tend to systematically underestimate or even ignore risks of complexity, scope changes, etc. during project development and decision-making. Such ignorance or underestimation of risks is often called optimism.

Optimism Bias: In situations with high political and organisational pressure the underestimation of costs and overestimation of benefits is caused by non-intentional error or optimism bias.

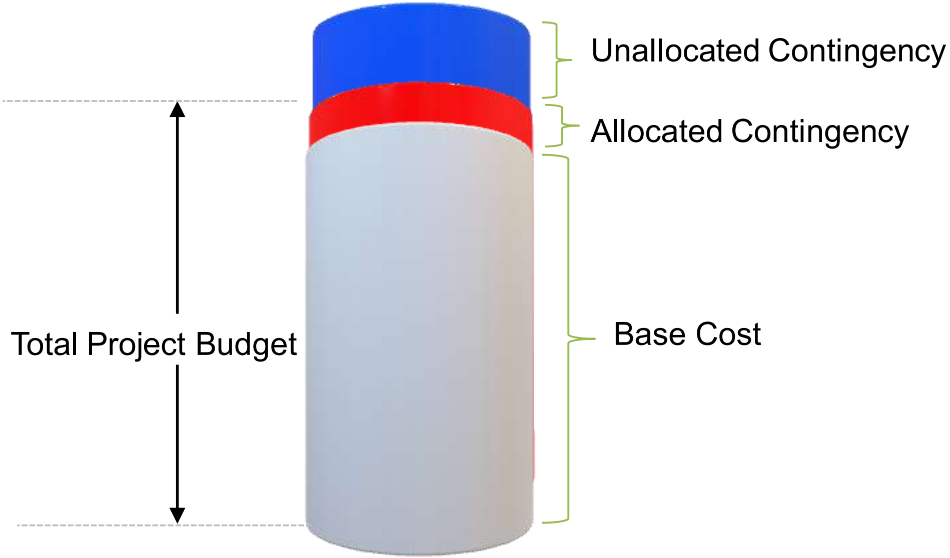
(Flyvbjerg, Garbuio, and Lovallo 2009).

Project Cost Estimate

Components of Total Project Cost

- **Base cost** is the most likely outcome of the project cost.
- **Contingency** is an amount added to an estimate to account for uncertain events, conditionals that experience shows will likely result in additional costs also known as “expected to be expected”.
- **Management Reserve** is defined as the cost or time reserve that is used to manage the unidentified risks or “unknown-unknown”.

Budget Components



Allocated Contingency

What does cost contingency exclude -

- Project scope change
- Extraordinary events such as major strikes and natural disasters
- Design allowance
- Management Reserve
- Cost escalation and exchange rate
- Profit

Expected Monitory Value

Expected monitory value is a risk management technique to help quantify and compare risks in many aspects of the project.

Source: Risk-Project

- Decision Tree Analysis
- EMV of opportunities +ve
- EMV of threats –ve

How to Calculate EMV

EMV relies on two basic numbers –

- the probability that the risk will occur
- the impact to project if the risk occurs.

EMV = Probability x Impact

(%) ($)

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Example – Expected Monetary Value

Risk	Probablility (%)	Impact ($)	P x I (EMV)
Risk $_1$	P_1	R_1	$P_1 X R_1$
Risk $_2$	P_2	R_2	$P_2 X R_2$
Risk $_3$	P_3	R_3	$P_3 X R_3$
Risk $_4$	P_4	R_4	$P_4 X R_4$
Risk $_5$	P_5	R_5	$P_5 X R_5$
Risk $_6$	P_6	R_6	$P_6 X R_6$
Risk $_n$	P_n	R_n	$P_n X R_n$
Total			$\Sigma P_i X R_i$

EMV Strengths/Weaknesses

Strengths

- EMV allows the user to calculate the weighted average value of an event that includes uncertain outcomes
- It is well-suited to Decision Tree Analysis
- EMV incorporates both the probability and impact of the uncertain events
- EMV is a simple calculation that does not require specialized software

Weaknesses

- This technique involves expert opinions to finalise the probability and impact of the risk. Therefore, personal bias may affect the result.
- EMV provides only the expected value of uncertain events; risk decision often require more information than EMV can provide
- EMV is sometimes used in situations where Monte Carlo simulation would be more appropriate and provide additional information about risk

Monte Carlo

Source : Goodfon

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Story Behind Monte Carlo Simulation

Source : Giphy

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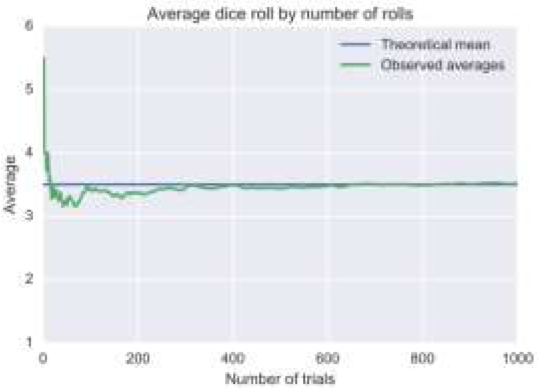
Monte Carlo Simulation

A **Monte Carlo Simulation** calculates numerous scenarios of a model by repeatedly picking random values from the input variable distributions for each "uncertain" variable and calculating the results.

- **Population:** a set of examples
- **Sample:** a proper subset of a population
- **Key fact:** a Random sample tends to exhibit the same properties as the population from which it is drawn
- **Variance:** As the Variance grows, a larger sample is required to have same degree of confidence

Theory of Large Numbers

According to the law, the average of the results obtained from a large number of trials should be close to the expected value, and will tend to become closer as more trials are performed.

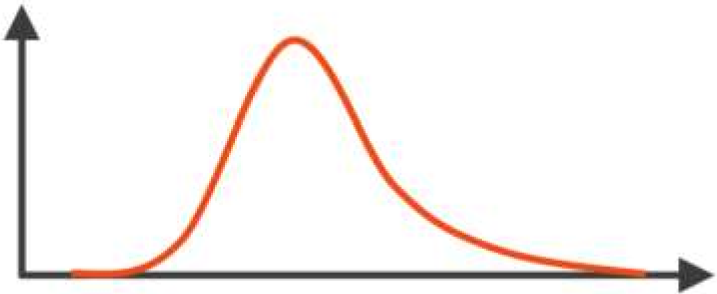


Source : Wikipedia

Source : dribbble

Calculating Contingency Using MCS

Three points estimates provide an indication of the possible range of actual costs for each item. This range is used to define a probability density distribution for each item.



Best case scenario **$2m**

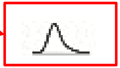
Most Likely Outcome **$4m**

Worst case scenario **$8m**

Risk Event With Distributed Range of Outcomes

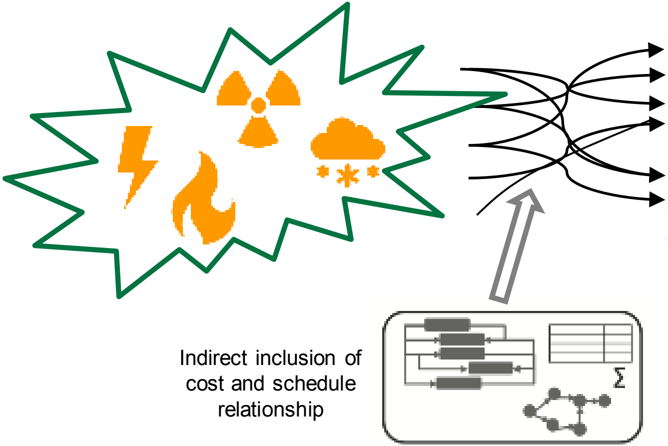
Monte Carlo simulations can use a probability and impact distribution to model each risk register item.

Risk	Probablility (%)	Impact ($)	P x I (MC)
Risk $_1$	P $_1$		$P_1 X R_1$
Risk $_2$	P $_2$		$P_2 X R_2$
Risk $_3$	P $_3$		$P_3 X R_3$
Risk $_4$	P $_4$		$P_4 X R_4$
Risk $_5$	P $_5$		$P_5 X R_5$
Risk $_6$	P $_6$		$P_6 X R_6$
Risk $_n$	P $_n$		$P_n X R_n$
Total			$\Sigma P_i X R_i$

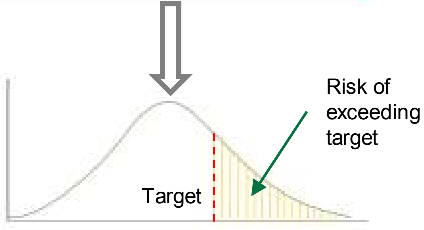


Risk Modelling in Monte Carlo

Risk Modelling can represent the effect of more than one of the risks in the register and one risk's effects might show up in more than one risk factor.



Risk	Probablility (%)	Impact ($)	P x I (MC)
Risk $_1$	P_1		$P_1 X R_1$
Risk $_2$	P_2		$P_2 X R_2$
Risk $_3$	P_3		$P_3 X R_3$
Risk $_4$	P_4		$P_4 X R_4$
Risk $_5$	P_5		$P_5 X R_5$
Risk $_6$	P_6		$P_6 X R_6$
Risk $_n$	P_n		$P_n X R_n$
Total			$\Sigma P_i X R_i$



Concept: Broadleaf

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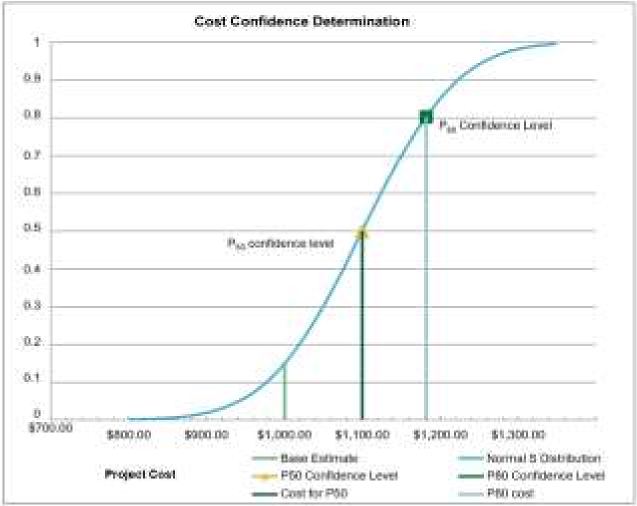
Chance of Exceeding Target



Source: Department of Finance

The S Curve is a cumulative probability curve arising from the normal distribution analysis of the risks identified.

Entities must use a **P50** confidence level in the cost estimate at First Stage of the Two Stage Capital Works Approval Process and requires a **P80** confidence at Second Stage Approval.

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Example - MCS

The model randomly selects values from the distribution, use those values in their calculations, record key results, repeat the process many times, and then summarise your record of results.

	Best Case	Most Likely	Worst Case
Material	2.50	2.80	3.00
Labour	0.80	1.00	2.00
Other	0.15	0.20	1.00
Total Project Cost		**4.00**	

Simulated Cost
2.99
1.63
0.49
5.11

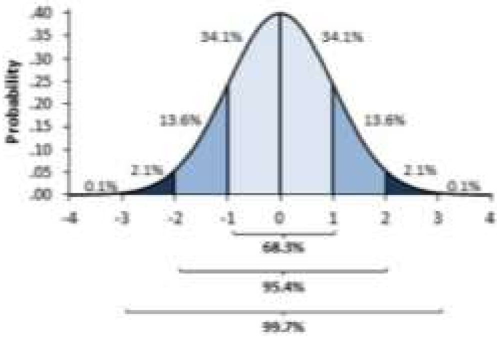
Total Base Cost

Total Simulated Project Cost

Example – MCS Cont.

Base Cost	$ 4.00
Probability of Exceeding Budget	95%
Mean	$ 4.72
P70	$ 4.98
Contingency for P70 Estimate	$ 0.98

Natural Distribution



Graph: Exceluser

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MCS Strengths/Weaknesses

Strengths

- Used primarily for project schedule and cost risk analysis in strategic decisions
- Allows all specified risks to vary simultaneously
- Calculates quantitively estimates of overall project risk; reflects the reality that several risks may occur together on the project
- Provides answers to questions such as (1) How likely is the base plan to be successful? (2) How much contingency in time and cost do we need to achieve our desired level of confidence?

Weaknesses

- Schedules are not simple and often cannot be used in simulation without significant de-bugging by an expert scheduler
- The quality of the input data depends heavily on the expert judgment and the effort and expertise of the risk analyst
- Will provide unrealistic results unless input data include both threats and opportunities

Part 3 – Project Continuity Management

FROM

THROUGH MANAGING RISK

TO

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Mission Impossible Solution …

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Heroic effort from superstar Professional, …

… amazing special effects, …

… high levels of skills & tech support, ….

…huge budget $$$$ and …

… improbable good luck.

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Mission Accomplished

Practical Project Continuity Management

- Focus on 'true' risks
- Capture both threats and opportunities
- Appropriate risk budget & contingency
- Respond flexibly to risks
- Resilience

Linda Hamilton as Sarah Connor
in *Terminator 2: Judgment Day*

Sarah Connor: *Are you saying it* [the Terminator] *is from the future?*

Kyle Reese: *One **possible** future. From your point of view.*

Manage risk and control the future!

We can turn some **Possible Futures** into impossibilities,

we can make some **Probable Futures** less likely,

and we can turn our **Preferable Future** into reality.

Manage risk and control the future!

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