Calibration of Risk Analysis to Ensure Realism

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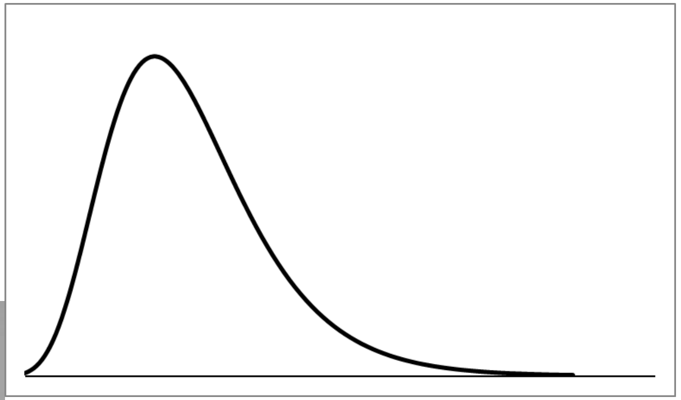
THE MEDIAN IS *NOT* THE MESSAGE

A SINGLE NUMBER DOES NOT SUFFICE IN THE FACE OF UNCERTAINTY!

STEPHEN JAY GOULD

Famous paleontologist, evolutionary biologist, and writer
Diagnosed with a rare form of cancer in 1982



"8 MONTHS TO LIVE"

Told he could expect 8 months to live
Gould researched the medical literature and discovered this expected value was a median and that it was significantly less than the mean

SKEW YOU

Gould lived for another 20 years and died from an unrelated illness – the number Gould was given was highly inaccurate

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PROJECT RISK MANAGEMENT

OPPORTUNITY IN RISK

PROJECTS ARE INHERENTLY RISKY

Projects of all types, large and small, experience regular amounts of significant cost and schedule growth

This growth is strong evidence not only of risk, but lack of proper risk management

Risk is often considered just another a four-letter word

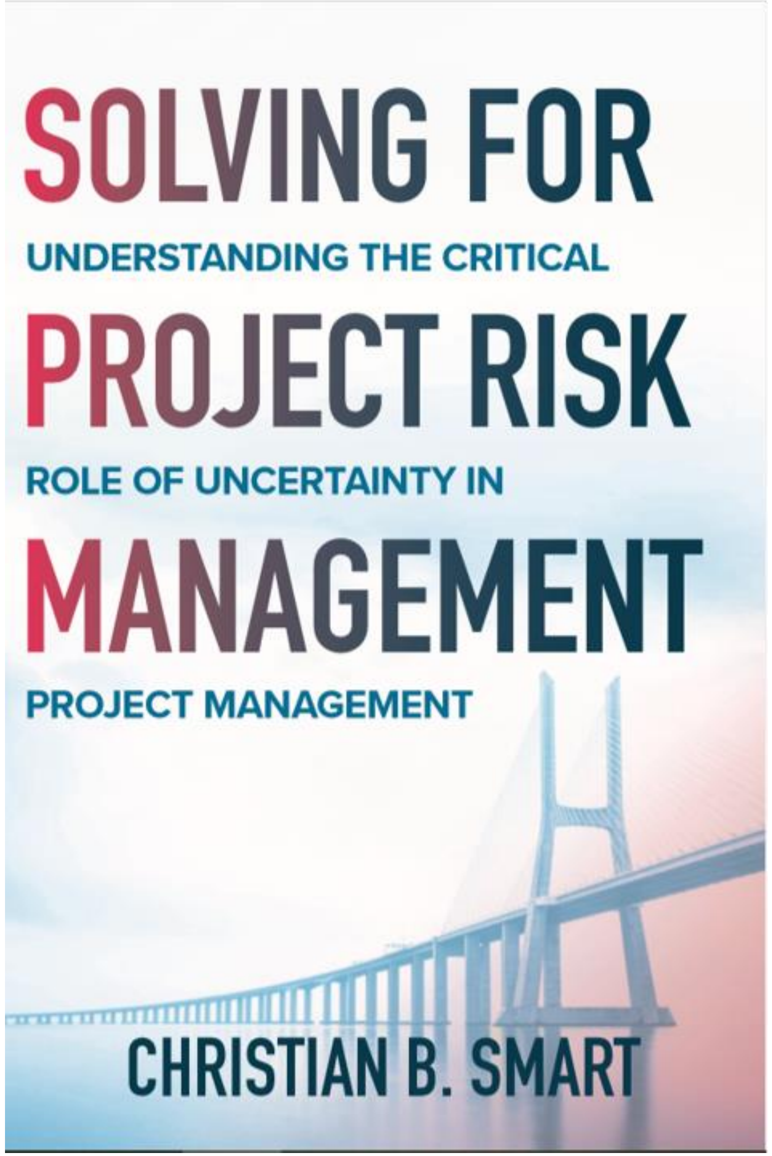
QUANTITATIVE RISK ASSESSMENT

Projects need to conduct quantitative cost and schedule risk analysis

The application of quantitative methods is fraught with obstacles

THIS PRESENTATION

The focus of this presentation is one aspect of the book, which focuses on the need for quantitative risk assessment



Read Chapter 1 for free:
https://bit.ly/3ggPZK2

COST AND SCHEDULE GROWTH

A LEGACY OF DISASTER

	Olympics	Software/ IT	Dams	NASA/ DoD	Rail	Bridges/ Tunnels	Roads
Average Cost Growth	156%	43-56%	24-96%	52%	45%	34%	20%
Frequency of Occurrence	10/10	8/10	8/10	8/10	9/10	9/10	9/10
Frequency of Doubling	1 in 2	1 in 4	1 in 5	1 in 6	1 in 12	1 in 12	1 in 50
Average Schedule Delay	0%	63-84%	27-44%	27-52%	45%	23%	38%
Frequency of Schedule Delay	0/10	9/10	7/10	9/10	8/10	7/10	7/10

1 **COMMON**

Multiple Industries Experience Significant Cost and Schedule Growth – Has Been a Problem for a Long Time

2 **FREQUENT**

70-80% of Projects Experience Cost and Schedule Growth

3 **HIGH**

Cost: 50% or More on Average (Mean)

Schedule: 30% or More on Average (Mean)

4 **EXTREME (FOR COST)**

Cost Growth in Excess of 100% Is a Common Occurrence in Most Projects (1 in 6)

Why Cost and Schedule Growth Occur

Numerous Reasons, Both Internal and External:

- Optimism
- Cost, Schedule, and Technical Misalignment
- Errors in Estimation
- Moore's Law
- Black Swans

"The Non-Secret of Good Cost [and Schedule] Estimating: Don't Drink the Kool-Aid"- *Lawrence Goeller, OSD Cost Analysis Improvement Group*

1 **OPTIMISM**

Innate bias - Planning Fallacy

Prospect Theory - Project managers are risk-seeking

2 **COST, SCHEDULE, TECHNICAL MISALIGNMENT**

Like a three-legged stool, all need to be consistent in order for a project to balance

3 **MOORE'S LAW**

Exponential growth in technology Paired with projects that take a decade or longer to complete means that either requirements must be continually updated or the product is obsolete on delivery

4 **BLACK SWANS**

Unpredictable, rare, unprecedented events that have a huge impact

5 **LAKE WOBEGON**

Project managers and their staff are not like the children of Garrison Keillor's fictional town – they all above average

EXAMPLES

JAMES WEBB SPACE TELESCOPE

Next generation space telescope
Highly complex but leadership was optimistic

MOSES

Venice's flood prevention project – has taken so long to develop that it is already obsolete

CALIFORNIA HIGH-SPEED RAIL

Designed to link LA and SF, but now will only connect two small cities, a mega project that is a mega waste

SYDNEY OPERA HOUSE

Began construction without a detailed plan in place, one of the highest cost increases and longest schedule in history

COST GROWTH AND SCHEDULE DELAYS

EVEN WORSE THAN THEY APPEAR

LOOKING BEHIND THE DATA FACADE

As bad as cost growth and schedule delays are, these problems are even worse than they appear!

CETERIS PARIBUS

Latin for "everything else held constant," this does *NOT* apply to cost overruns and schedule slips – many projects are descoped to mitigate these issues, and some are cancelled outright

PAYING MORE AND TAKING LONGER BUT GETTING LESS IN RETURN

While de-scoped projects are still able to achieve some objectives, many cancelled projects are a total waste – also applies to shelved projects such as the J2-X rocket engine

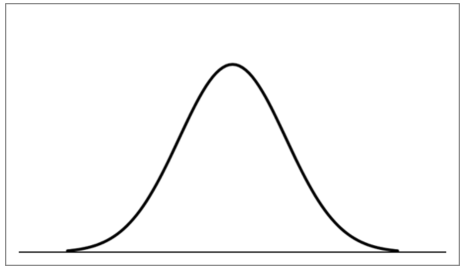
UNCERTAINTY IS A SHAPE

FOUR COMMONLY USED PROBABILITY DISTRIBUTIONS

1

GAUSSIAN

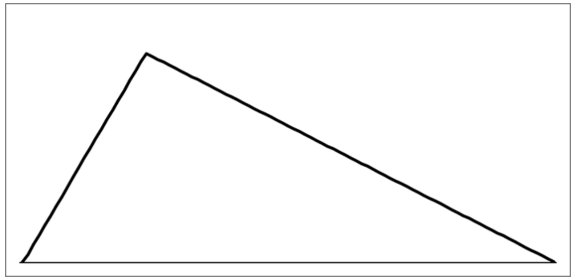
The "Normal" distribution is commonly used but not applicable to cost and schedule (skew; fat tails)



2

TRIANGULAR

Simple, but too simple
Has no tail
Can only model limited range



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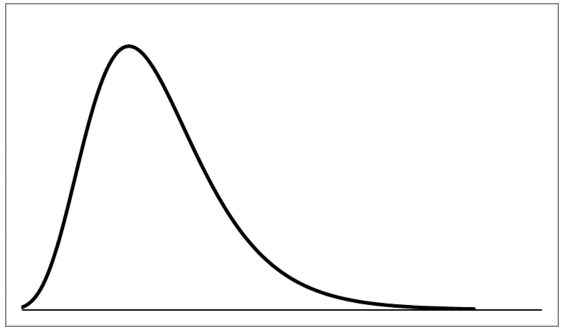
LOGNORMAL

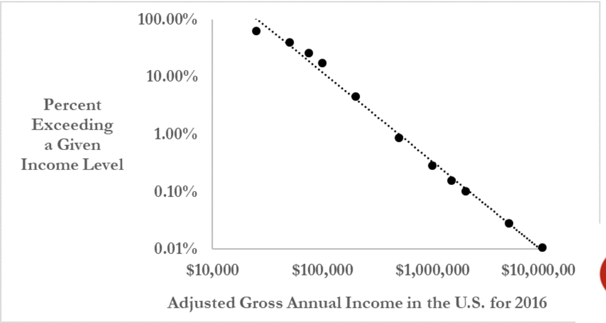
Can model skew
Can model relatively fat tails
In-between thin tails and fat tails



4

PARETO

80/20 Rule
Used to model extreme risks



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ISSUES WITH THE CURRENT PRACTICE OF RISK ANALYSIS

RISK ANALYSIS FAILINGS

Even when quantitative risk analysis is conducted it is not implemented well

Variety of issues

RISK RANGES ARE NOT REALISTIC

In practice, most risk analysis results in tight ranges that do not reflect the true potential for cost or schedule growth

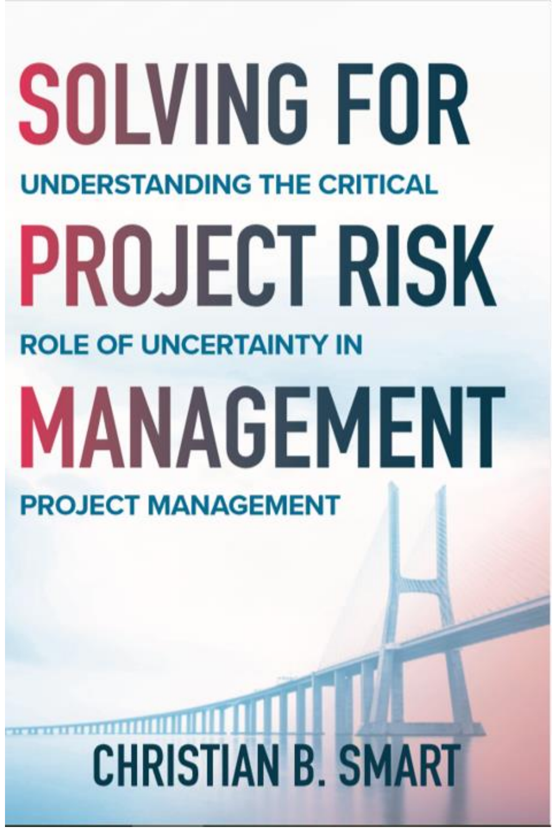
PORTFOLIO ANALYSIS IS NOT CONDUCTED

Risk analysis is typically conducted at the project level – but not at the portfolio level

BEYOND S-CURVES

S-curve provide useful information, but do not provide critical information about the tails

Focus of the remainder of this presentation



These issues and more are addressed in my book, which is now available from Amazon, Barnes and Noble, and others
Read Chapter 1 for free: https://bit.ly/3ggPZK2

TRACK RECORD FOR RISK ANALYSIS

WORSE THAN RANDOM

Project	Cost Growth	Ratio of Actual Cost to 90% Confidence Level
1	0%	0.6
2	19%	1.1
3	31%	1.0
4	32%	1.1
5	greater than 45%	greater than 1.0
6	52%	1.5
7	84%	1.7
8	93%	1.6
9	121%	2.0
10	280%	2.2

It's hard to improve if you don't know how well you have done in the past.

1

SCARCE

The results of risk analysis are rarely compared to the actual outcome – like a darts player that turns away from the board after throwing a dart

2

WHAT LITTLE EXISTS IS NOT GOOD

The limited data available is mainly for cost

The 90 percent confidence level means there is only a 10% probability that this level will be exceeded

3

OPPOSITE OF EXPECTED

For the 10 risk analyses in the table, the actual cost was less than the 90 percent confidence level for only one of the ten

4

EXTREMELY UNLIKELY

While a small data set, the odds of such an occurrence is extremely remote – 1 in 2.7 million

You are more likely to be struck by lightning

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COVERED WITH OIL: REALISM IN RISK ANALYSIS

1

"ALL OF THOSE TOURISTS COVERED WITH OIL"

Jimmy Buffett, in writing the song Margaritaville, probably never imagined that beach goers would be covered with crude oil

Gulf of Mexico oil spill in 2010 set records

2

RISK UNDERESTIMATION IS PREVELANT

Variety of reasons – correlation, overreliance on normal distribution, etc.

We do not have a good track record of estimating risk

3

PERCEPTION VS. REALITY

Plato Vs. Diogenes

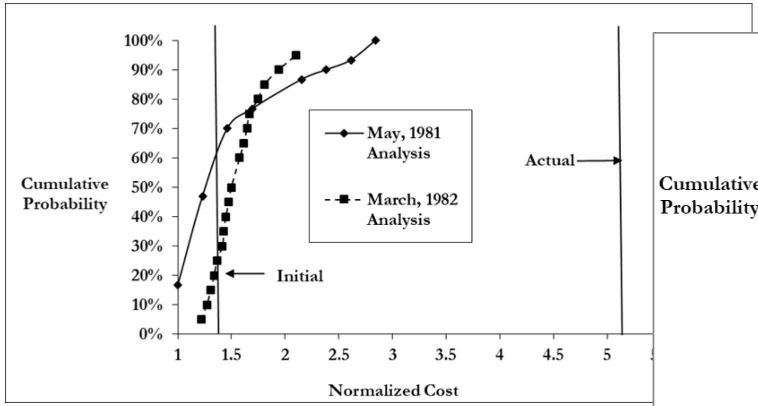
Home Economicus and the Iron Bowl

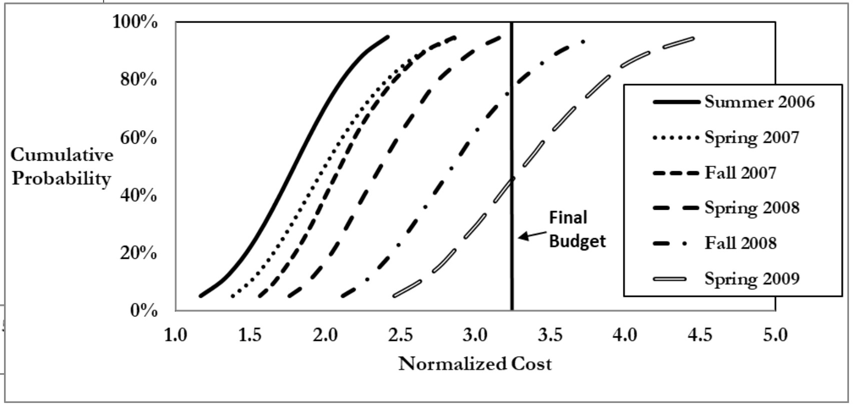
Notion is risk decreases over time, but risk perception increases up to critical design as risks are discovered/admitted, and then decreases as these risks are addressed

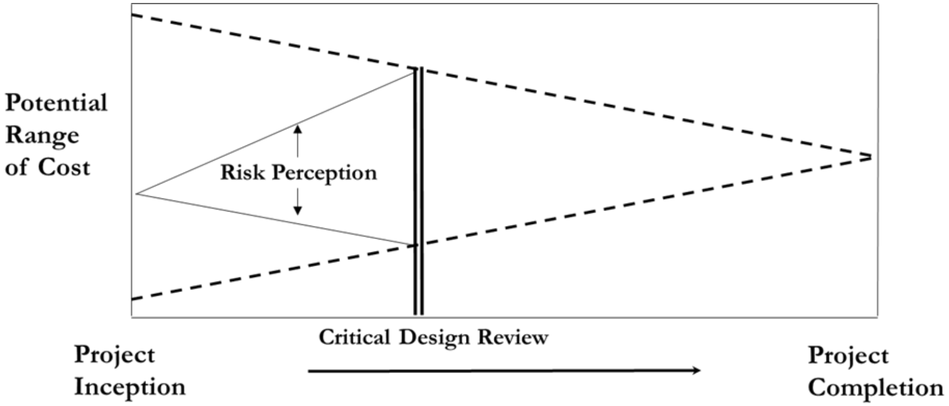
4

CALIBRATION IS THE ANSWER

Augustine's Laws - "Unknown-unknowns cannot be specified in advance but their existence in the aggregate can be predicted with every bit as much confidence as insurance companies place in actuarial statistics."





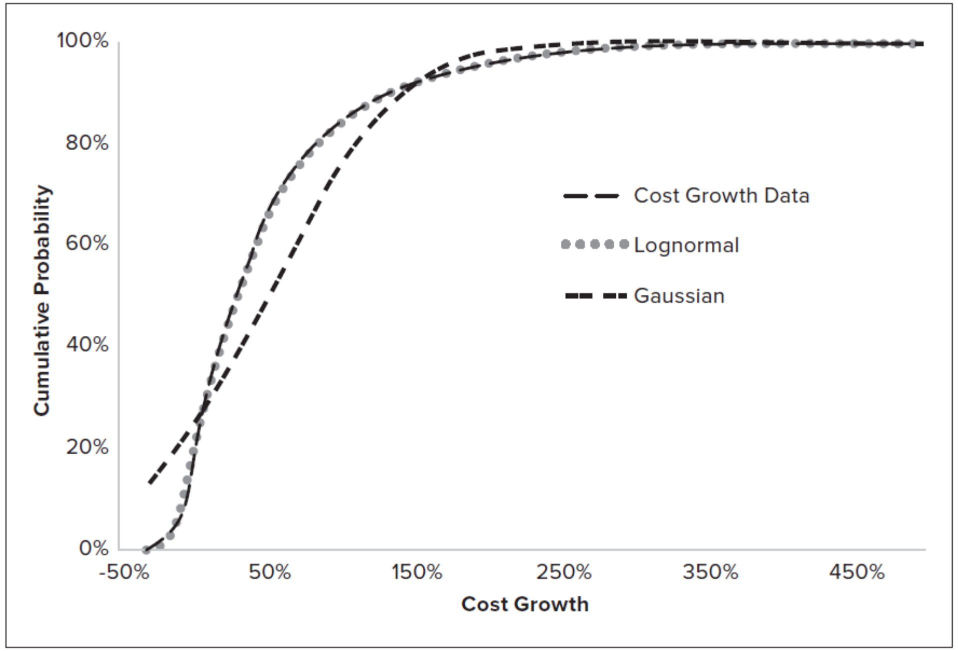


It is always riskier than you think, even taking into account that it is riskier than you think.

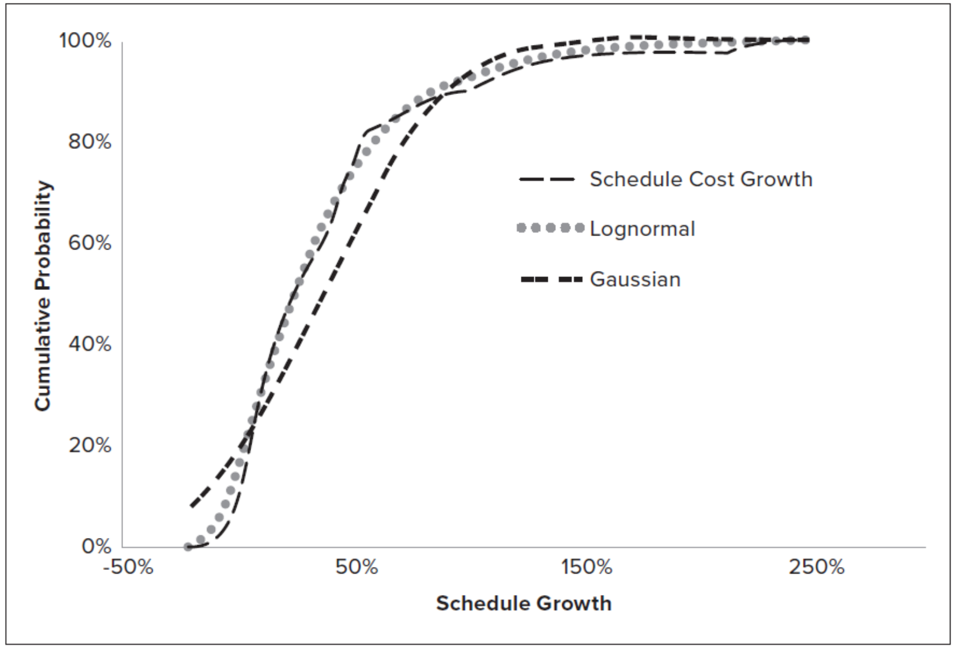
CALIBRATION TO HISTORY

As cost growth and schedule delays are instances of the realization of risk, calibration to historical growth data provides a means to realistically assess risk

COST GROWTH DATA



SCHEDULE DELAY DATA



Both cost growth and schedule delay data closely follow a three-parameter lognormal distribution

THREE-PARAMETER LOGNORMAL

MEAN, VARIANCE, AND LOCATION

MEAN

The expected value of the distribution, measures the center For a lognormal the mean is greater than the median, which in turn is greater than the mode (peak)

VARIANCE

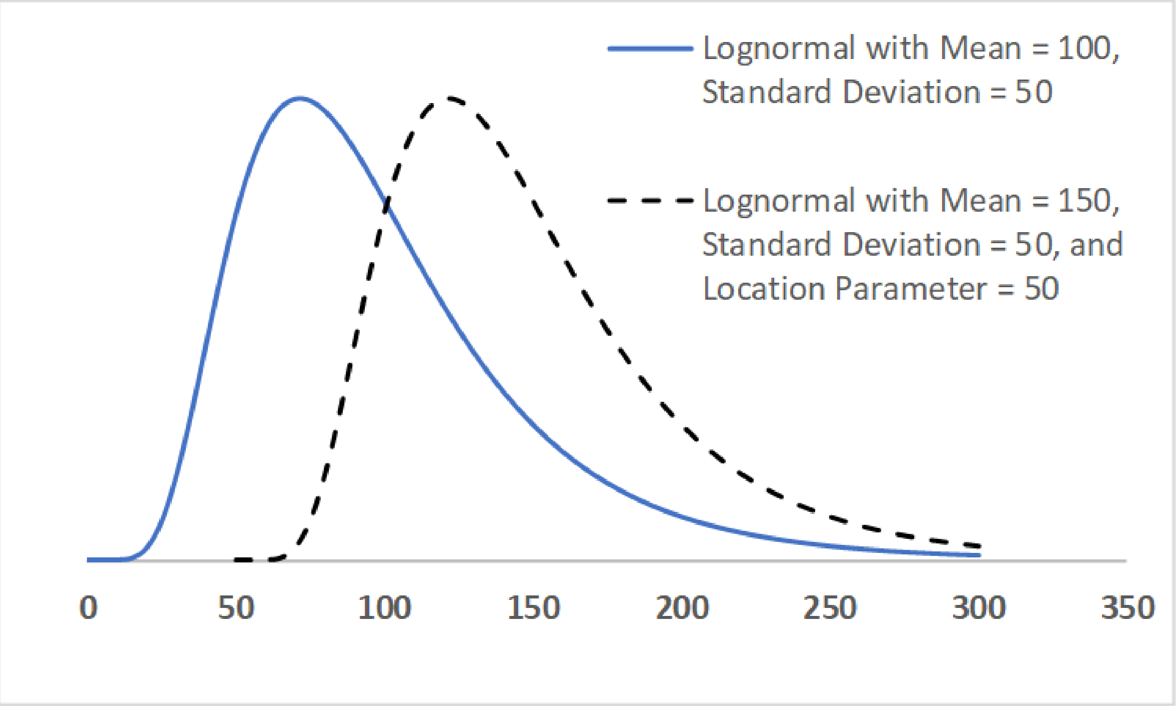
Measures the dispersion around the mean

The higher the variance, the greater the uncertainty

LOCATION

A two-parameter lognormal distribution is bounded below by zero

Location parameter shifts this in one direction or the other



HISTORICAL BASIS

FOR EACH PARAMETER

Project Type	CV
Process Plants	156%
Mining and Metals	153%
Information Technology	111%
Olympics	108%
NASA	94%
High-Speed Rail	93%
Aerospace and Defense	90%
Refineries	81%
Tunnels/Bridges	74%
Urban Rail	67%
Hydropower	56%
Roads	50%
Median	92%

LOCATION

Numerous studies show 80-90% of projects overrun, indicates typical point estimates of cost are between the 10^{th} and 20^{th} percentiles

VARIATION

Effective coefficient of variation for historical project overruns varies from 50% for roads to more than 150% for mining and metals and process plants

MINIMUM

The minimum value attainable (underrun) is typically 30-50% (without significant scope reductions)

G A L O R A T H

RISK and ESTIMATING METHODS

ANALOGY

Analogies can account for uncertainty in the similarity of the project to the precedent and in adjustment factors – will tend to underestimate risk

PARAMETRIC

Incorporates input and estimating uncertainty (including historical unknown unknowns) - most uncertainty of any method, most realistic depiction of risk

ENGINEERING BUILD-UP

Typically accounts for the least amount of risk as it often relies on subjective ranges

EXTRAPOLATION

Can incorporate uncertainty via time series methods such as ARIMA

CALIBRATION IN EXCEL

FOUR DIFFERENT POINT ESTIMATES

PERCENTILE

Often applicable to engineering build-ups and project estimates that do not have an independent cross-check

Typical values are 10-20%

MEAN

Parametric models can produce mean estimates

MODE

Most likely estimate, could be produced by an analogy estimate or extrapolation

MAIMS (MONEY ALLOCATED IS MONEY SPENT)

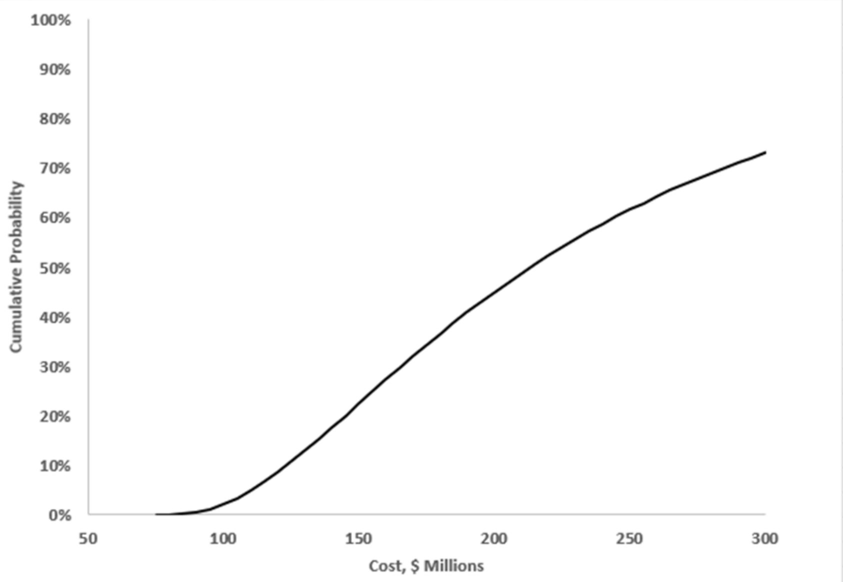
With transparency, project manager will spend all available funds, this accounts for that tendency

Coefficient of Variation (CV)	0.6
Point Estimate	150
Percentile	0.2
Minimum /Location	75

Calibration to:	Percentile
CV*	0.9000
mu	4.9658
sigma	0.7703

Effective CV

Percentile	Cost
5%	$115.4
10%	$128.4
15%	$139.5
20%	$150.0
25%	$160.3
30%	$170.8
35%	$181.6
40%	$193.0
45%	$205.2
50%	$218.4
55%	$233.0
60%	$249.3
65%	$268.0
70%	$289.8
75%	$316.1
80%	$349.3
85%	$393.7
90%	$459.9
95%	$584.2



WHAT CAN BE DONE

THREE KEYS TO SUCCESS

1: RECOGNIZE THE PROBLEM

Recognize that lack of planning for risk hinders projects success

Don't plan for best case

Realize that you are prone to biases such as optimism – don't drink the Kool-Aid!

Look for independent and critical input

2: MEASURE RISK MORE ACCURATELY

Recognize that risk is underestimated, especially early in planning

Quantitative risk measurement is a necessity – matrices and qualitative methods are not enough!

Use methods such as calibration to ensure realism

Measure risk coherently – S-curves are not sufficient! Take the right tail into account

3: MANAGE RISK EFFECTIVELY

Projects need to manage risk, not just measure it

Need a measure of risk plus ways to address significant growth

Calculate risk at the portfolio level

Assess the impact of potential new missions over a long time

Think strategically

Projects must do things differently in risk management if they want to be more successful

ABOUT THE PRESENTER

- Chief Scientist with Galorath Federal
- Former Cost Director for Missile Defense Agency
- Twenty years of experience with cost and schedule risk analysis, predictive analytics, probabilistic reliability analysis, and machine learning
- Exceptional public service medal from NASA
- Named Parametrician of the Year by the International Society of Parametric Analysts
- Ph.D. in Applied Mathematics
- Contact: csmart@galorath.com

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Q & A

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