Project Controls Expo – 18th Nov 2014
Emirates Stadium, London

Cost Estimate Risk Analysis:
For Capital Projects and Maintenance Turnarounds

About the Speaker

Steve Jewell is the Risk Management Practice Leader for Asset Performance Networks.

Steve has over 38 years of experience in the oil and gas sector, with more than 20 years spent in risk management roles.

Prior to joining AP-Networks, he was Senior Risk Advisor at BP and led a team providing risk management guidance to BP's mega projects.

Steve also spent 10 years reviewing cost estimates and schedules and running cost and schedule risk analysis in support of project sanction.

Steve has also been a guest lecturer on risk management and cost & schedule risk analysis at a number of leading universities including Imperial College, MIT and The Moscow School of Management Skolkovo.

Outline

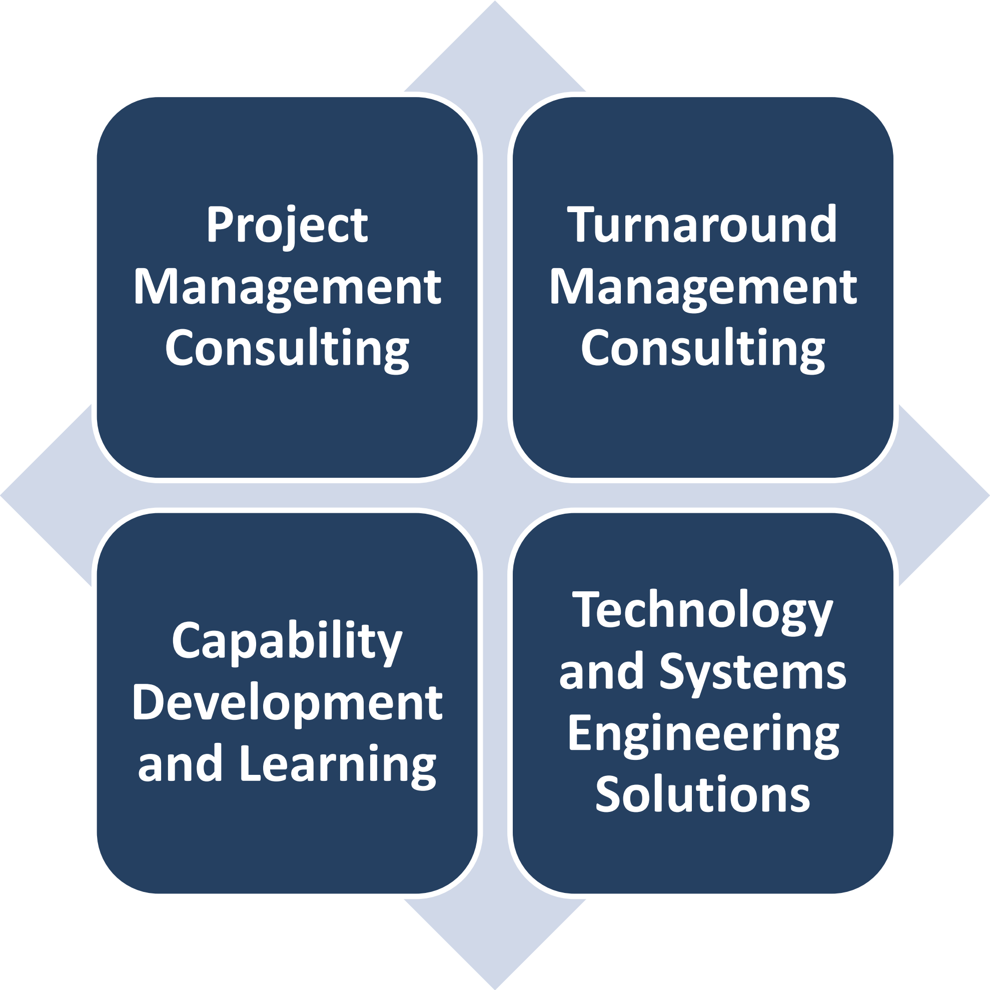
Overview of Asset Performance Networks LLC.

Who we are and what we do

- Turnaround and Capital Project solutions implementation firm
- Headquartered outside Washington D.C.
  - Operational offices in:
    - Houston, TX ,
    - Calgary, AB
    - Amsterdam, NL.
  - Additional locations:
    - nr. London, UK
    - Melbourne, Australia
- We provide experience driven consultancy services:
  - To improve Turnaround and Capital Project performance through a hybrid of Assurance Review Programs and Proprietary Tools
- www.ap-networks.com

Asset Performance Networks

Overview of Services



Project Management Consulting

Turnaround Management Consulting

Capability Development and Learning

Technology and Systems Engineering Solutions

AP-Networks

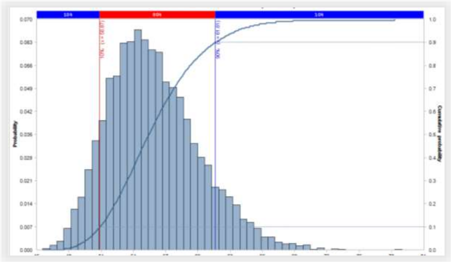
Project Management Consulting

- Cost & Schedule Risk Analysis
- Project Excellence & Assurance Consulting (PEAC) Reviews
- Facilitated Risk Workshops
- Value & Competitiveness Assessment of Plant Based Projects
- Facilitation of Project/Turnaround Integration
- Customized/Tailored Consulting Solutions

NAVITRACK 2.0

Project Pyramid
Drive Project Performance

PYXIS



Our Clients

A cross section of integrated oil, energy, and chemical companies

bp
Bayer
Chevron
lyondellbasell
Suncor Energy
Total
ConocoPhillips
Chevron Phillips Chemical Company LLC
Phillips 66
Valero
Syncrude
Statoil
Agrium
KNPC
Sabic
ADGAS
TransAlta
Canadian Natural
Mubadala Petroleum
BASF The Chemical Company
Tesoro
GASCO
Georgia-Pacific
NYNAS
BG GROUP
DYNO Dyno Nobel
NOVA Chemicals
INVISTA
Marathon Oil Corporation
cenovus energy
KOCH Industries Inc.
ESSAR
Celanese
TCO
NuStar
NESTE OIL
SRC Oil & Fuel
PBF Energy
Gazprom
NWR
Flint Hills resources
DSM
Chevron CABGOC
HollyFrontier
NWU North West Upgrading
IRVING
Sunoco
HMEL
Petrotrin
Motiva Enterprises LLC
CHS
Monroe Energy
Philadelphia Energy Solutions
Braskem
dcp Midstream
Western Refining
Caltex
Transocean
Alberta Envirofuels Inc.
Westlake Chemical
Citgo
OMV
Petrom
Britannia
AP Networks

Outline

1. Introduction to AP-Networks
2. **The Problem: Calculating Range & Contingency**
3. Option 1-Using Estimate “Class”
4. Option 2- Expert Judgment & Optimism Bias
5. Option 3 – Parametric Modelling
6. Option 4 - Simulation Analysis
7. Simulation Analysis - Common Errors and Biases
8. Simulation Analysis - Towards Better Practice

The Problem- "We need a Credible Estimate"

Why do businesses need cost estimates ?

- To screen investment opportunities
- Plan expenditure cycles
- Obtain Financial sanction both internally and joint venture partners
- Budget , Control and Reporting on projects progress
  - Internally
  - JV partners
  - Fiscal reporting

An estimate is a guess and you need to convince your audience that it is a good guess

Importance of Good Estimates

Cost

Over Estimate

- *Project Cancelled- Lost economic opportunity*
- *Project proceeds – excess capital tied up*

Correct Project Cost

Under estimate

- *Project proceeds*
  - ○ *Capital overspend*
  - ○ *Project economic criteria not achieved*
  - ○ *Loss of confidence in company*
  - ○ *Share/Stock price may be effected*
  - ○ *Adversely effect financing of future investment opportunities*

Establishing the Estimate

"Systemic"
Uncertainty
How well defined is the project?
FEED Package
Deliverables, etc.

Technical Basis

- *Process design*
- *Codes & standards*
- *quantities*

Execution Plan

- *contracting strategy*
- *Schedule*
- *Resources*

Estimate Basis

- *Unit rates*
- *Productivity assumption*
- *Owners management*
- *Exclusions*

Causes of Over-runs

Studies of sources of cost over-runs on completed projects in one major oil and gas company showed that:

Lack of Technical Definition and Poorly developed Execution Strategy at project approval accounted for more than 60% of over-runs on major projects in a 15 year period

Poor Estimating at project approval accounted for less than 10% of over-runs during the same period

Estimate Key Components

An estimate should comprise of:

A well worked base estimate

A realistic contingency budget

A credible accuracy range that reflects the project uncertainties and risks (threats and opportunities)

Definitions – Contingency / Management Reserve

Co **mate:**

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Body of Knowledge, PMBOK)

The base estimate + Contingency –would be a good basis for the project performance Target

The base estimate + Contingency+ Management Reserve could set the project sanction case. The project should still be profitable at this cost.

Definition of Management Reserve

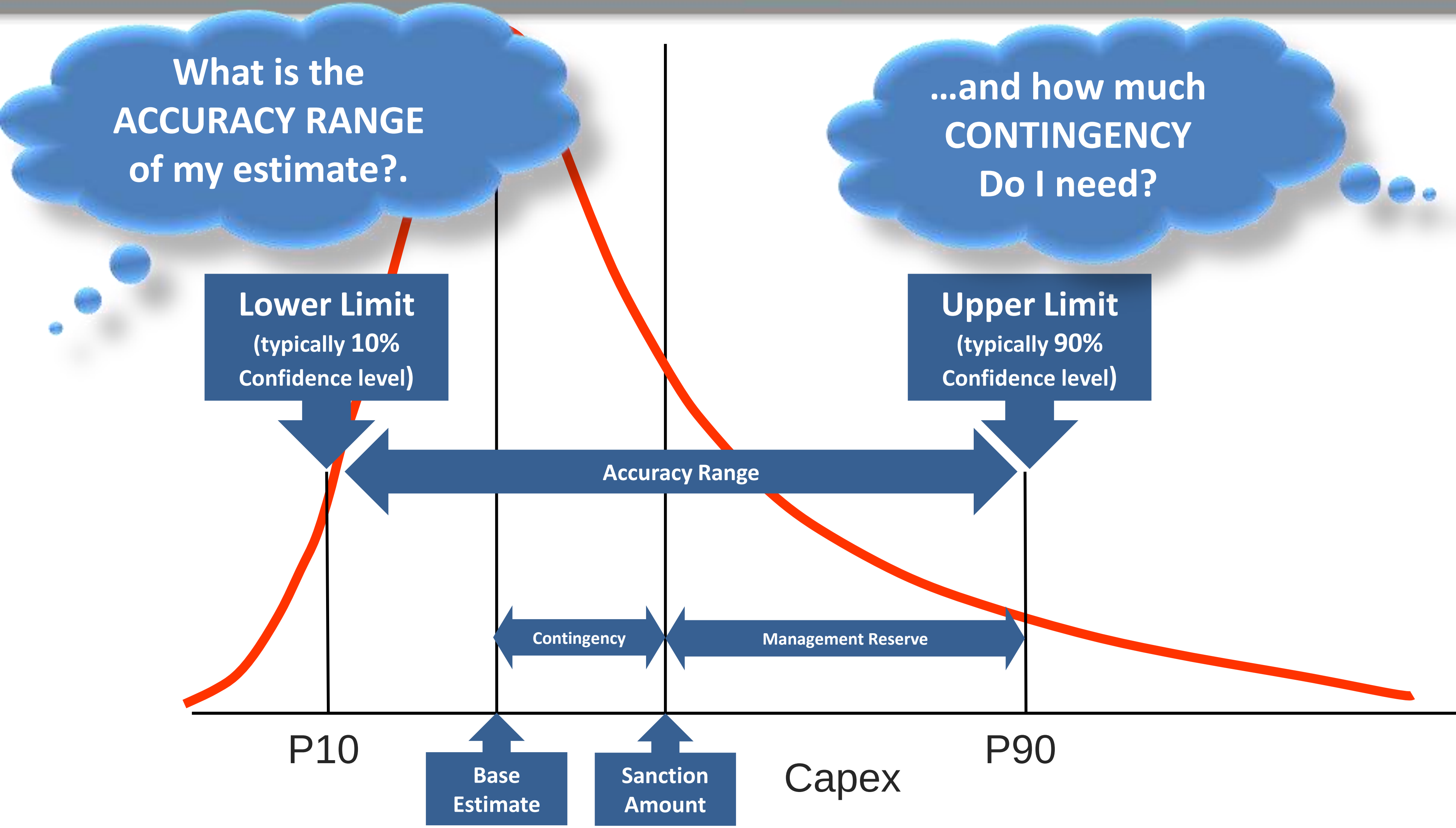
An amount added to an estimate to allow for discretionary manage oses outsi the defined scope of the project, as otherwise estimated. May include amounts that are within th defined scope, but for which management does not want to fund as contingency or that cannot be effectively managed using contingency. (AACE)

"A reserve fund for 'unknown unknowns' /risks. Handled by senior management – not included in the project baseline cost."(PMBOK)

An allowance added to the estimate , above which the project must seek further financial approval. A project that needs funds in excess of the management reserve, is likely to be considered as delivering a very poor performance

Developing a Cost Estimate

Determining the Accuracy Range and the Contingency Requirement?



What is the ACCURACY RANGE of my estimate?.

…and how much CONTINGENCY Do I need?

Lower Limit
(typically 10% Confidence level)

Upper Limit
(typically 90% Confidence level)

Accuracy Range

Contingency

Management Reserve

P10

P90

Capex

Base Estimate

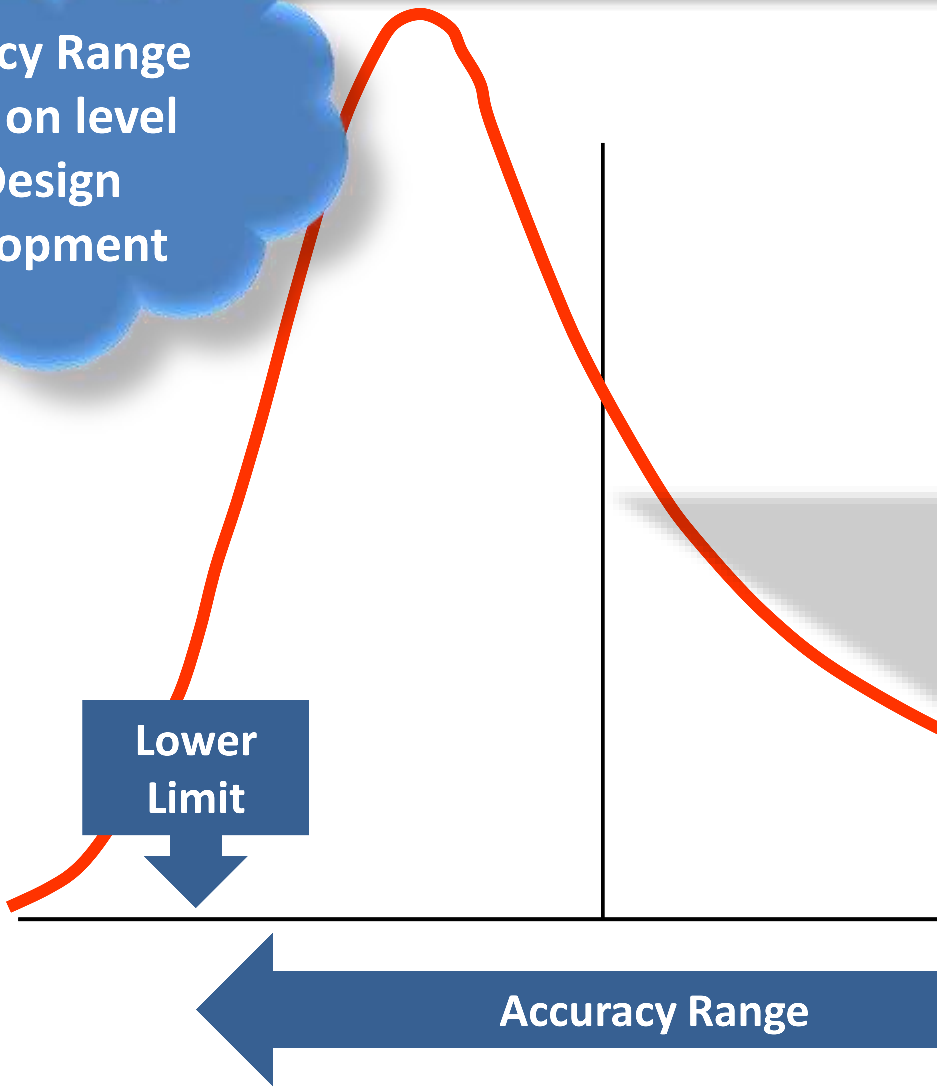
Sanction Amount

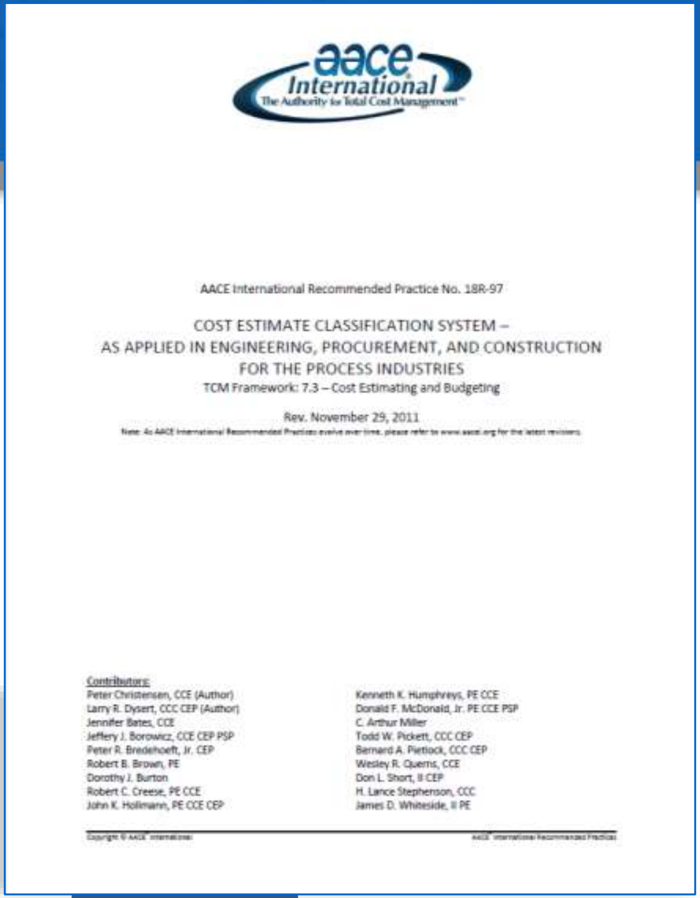
Outline

What is My Accuracy Range?

Estimate Classification eg AACE RP 18R-97

Accuracy Range Based on level of Design Development





AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM –
AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION
FOR THE PROCESS INDUSTRIES
TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. November 29, 2011

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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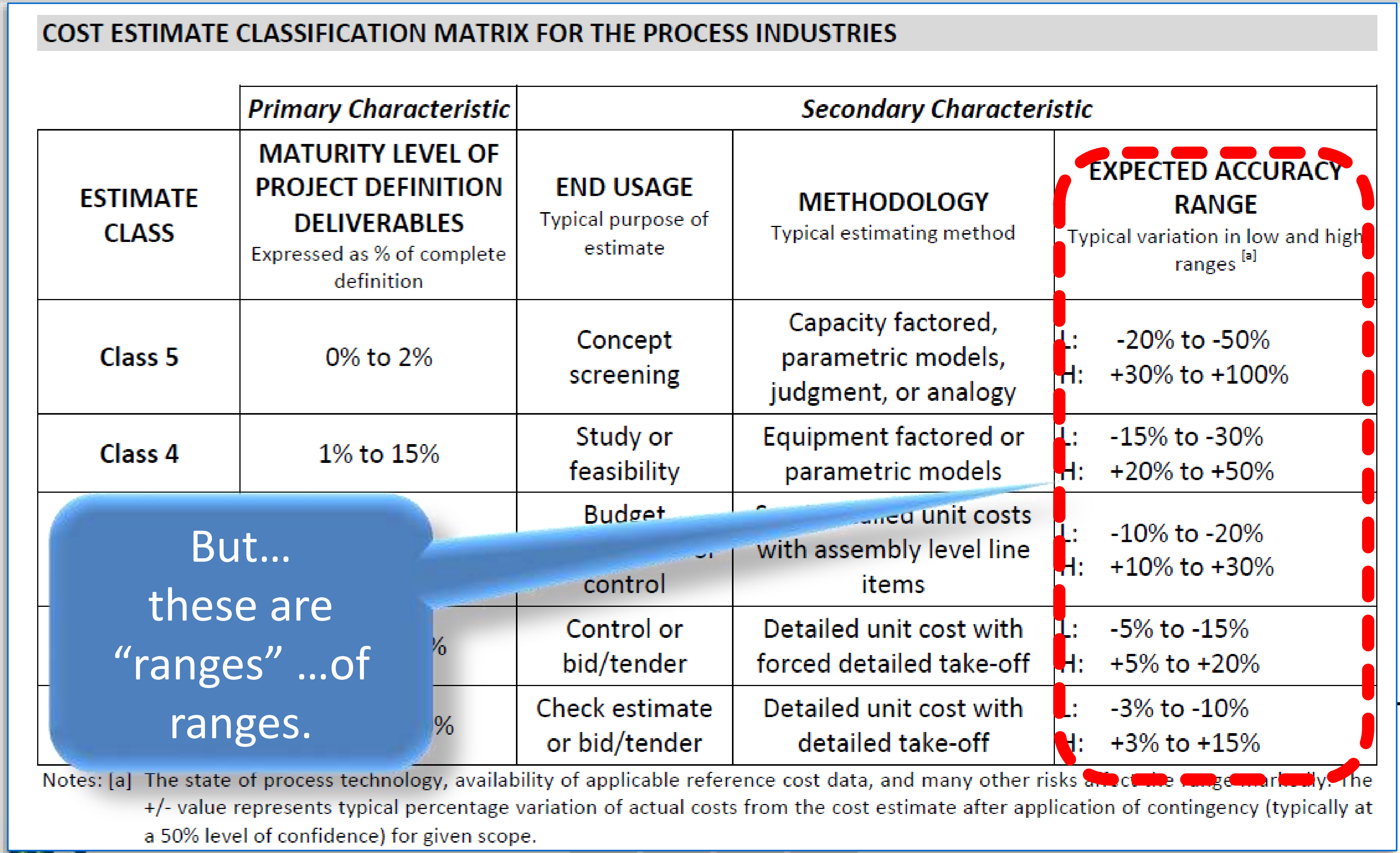
AACE International Recommended Practices

What is My Accuracy Range?

Estimate Classification -eg AACE RP 18R-97



COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
[illegible]	[illegible]	Budget [illegible] control	[illegible] unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
[illegible]	[illegible]%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
[illegible]	[illegible]%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

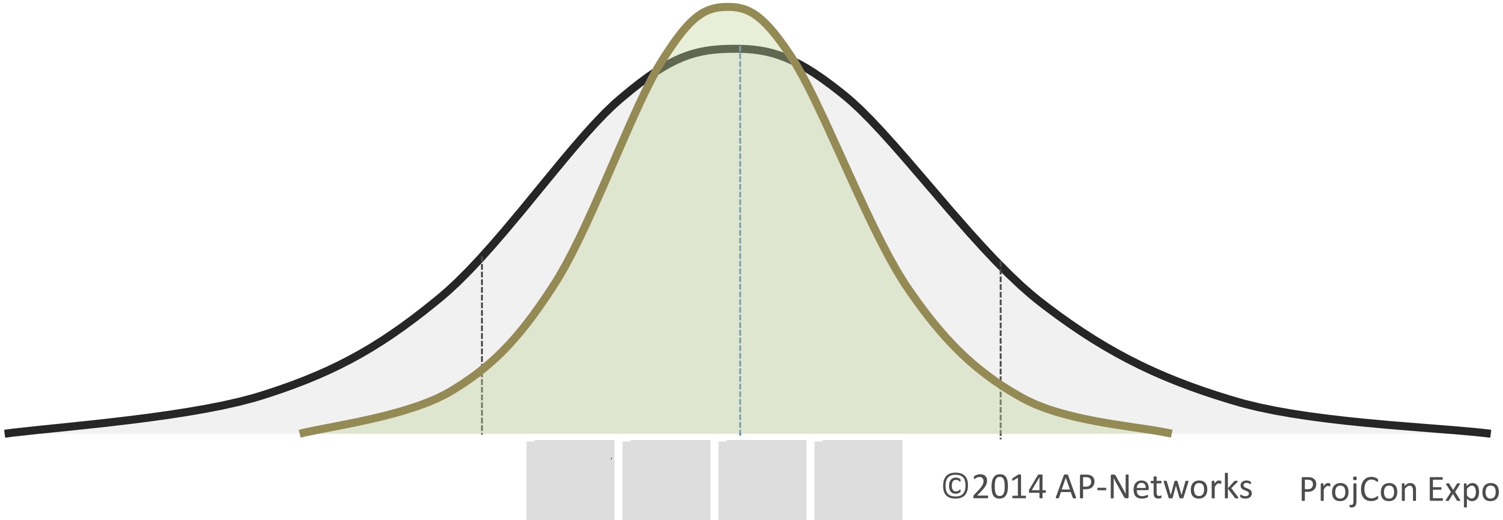
Notes: [a] The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

But…
these are
“ranges” …of
ranges.

Accuracy Range & Contingency Requirement

These are Functions of Uncertainty & Risk

- “Systemic” Uncertainty
  - How well defined is the project?
    - FEED Package Deliverables, etc.
- “Project-Specific Uncertainty & Risk
  - New technology? Remote location? Volatile materials market?....etc.
    - Uncertainty “Range Estimating” (Low, Likely, High)
    - Risk Register “Expected Value” (Probability and Impact)



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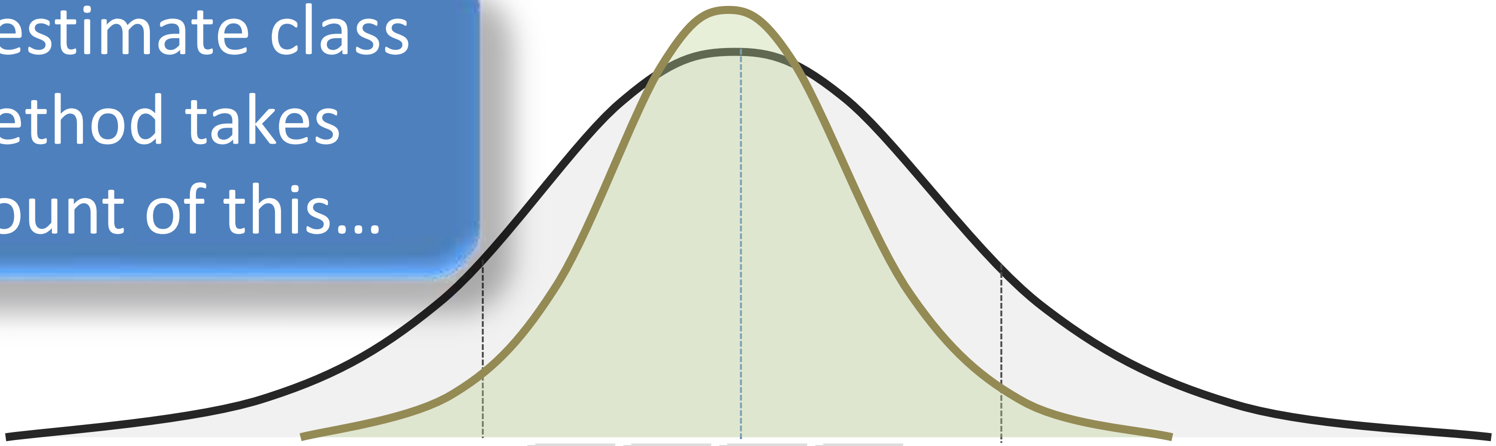
The estimate class method takes account of this…



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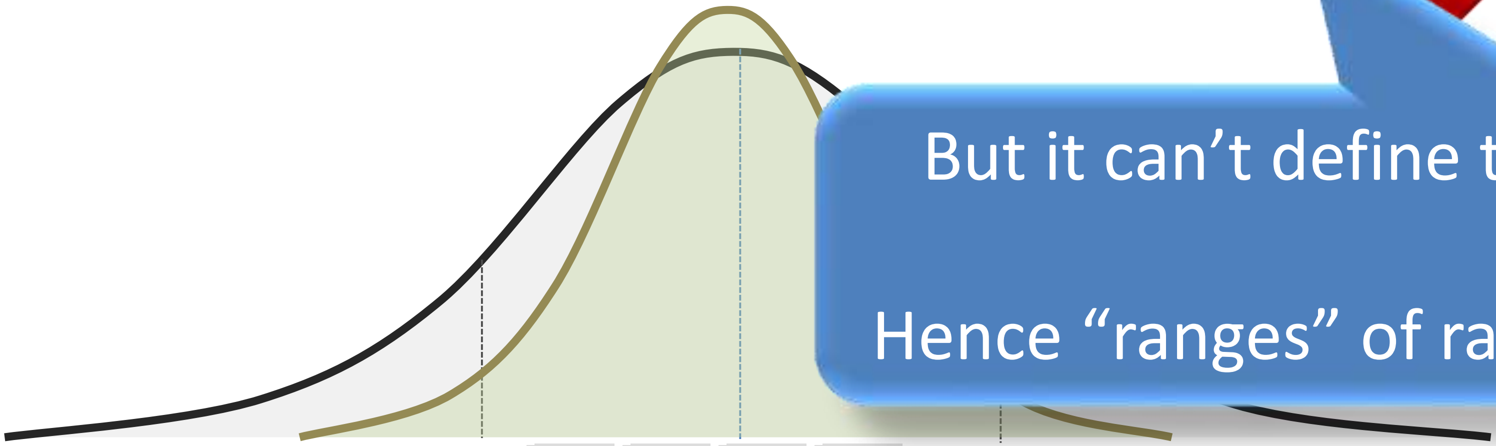
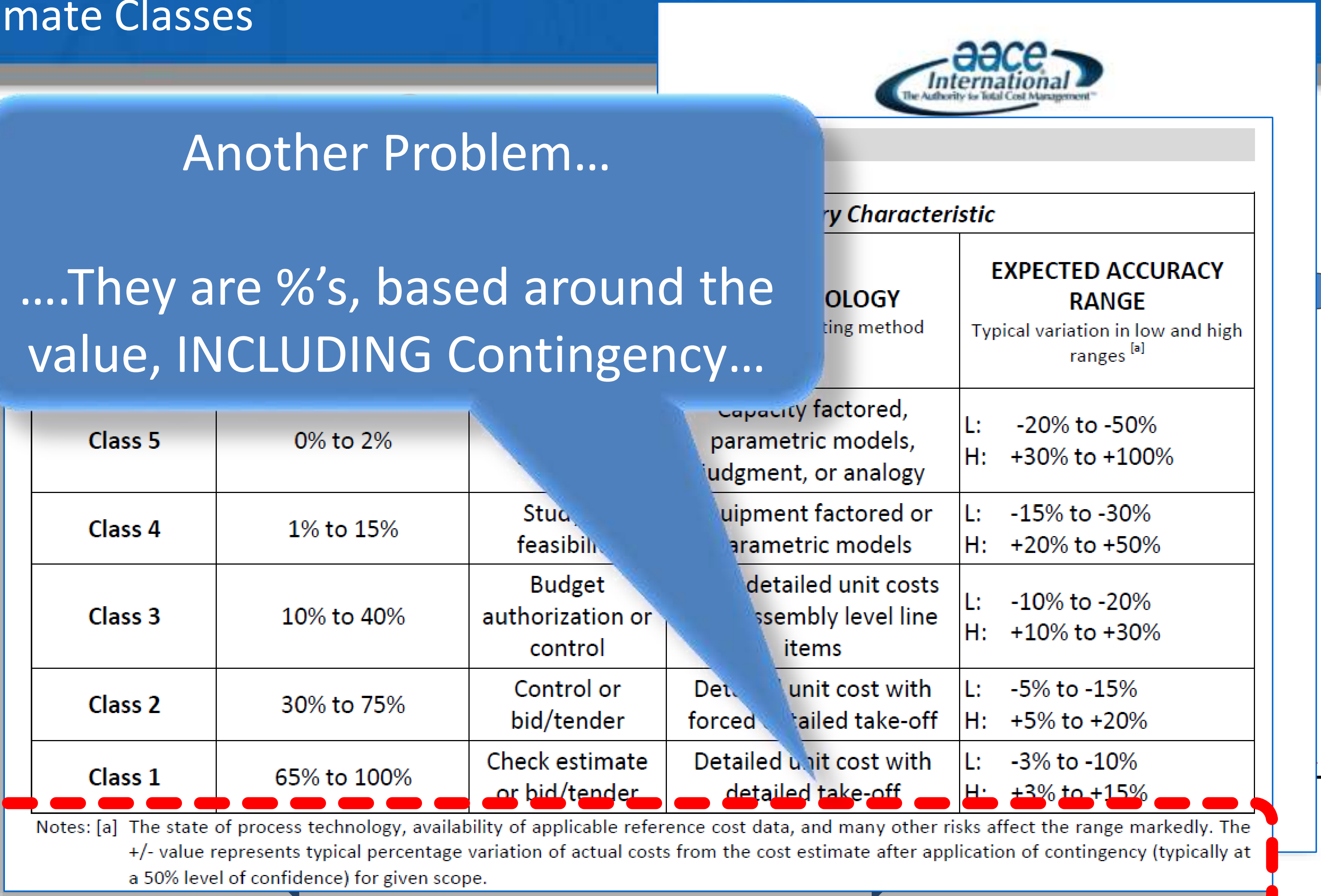


But it can’t define this.

Hence “ranges” of ranges.

What is My Accuracy Range?

Estimate Classes



aace International
The Authority for Total Cost Management

y Characteristic

			OLOGY ting method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges [a]
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Class 3	10% to 40%	Budget authorization or control	detailed unit costs ssembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Det unit cost with forced ailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

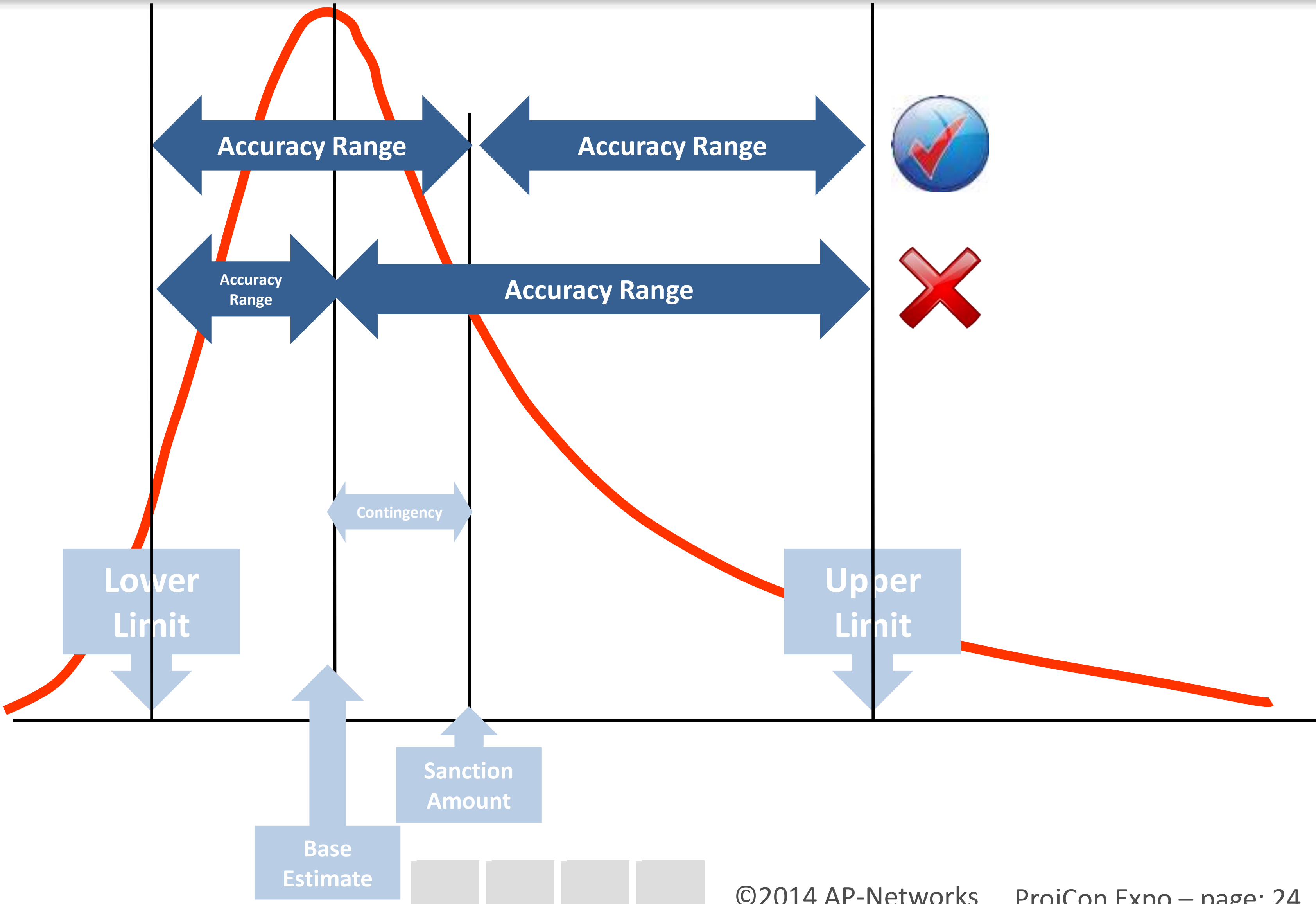
Notes: [a] The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

Another Problem…

….They are %'s, based around the value, INCLUDING Contingency…

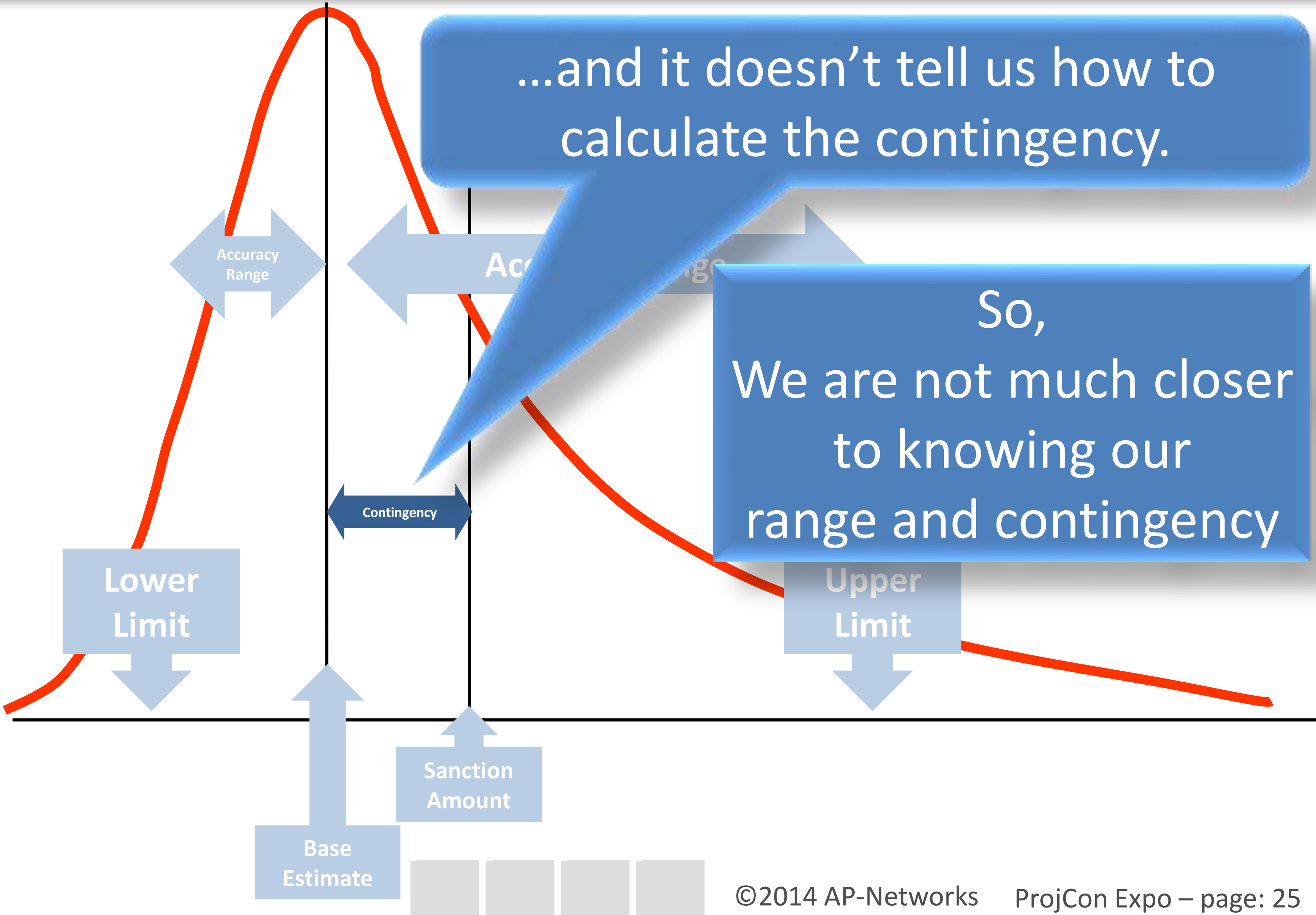
Developing a Cost Estimate

Determining the Accuracy Range and the Contingency Requirement?



Developing a Cost Estimate

Determining the Accuracy Range and the Contingency Requirement?



…and it doesn't tell us how to calculate the contingency.

So,
We are not much closer to knowing our range and contingency

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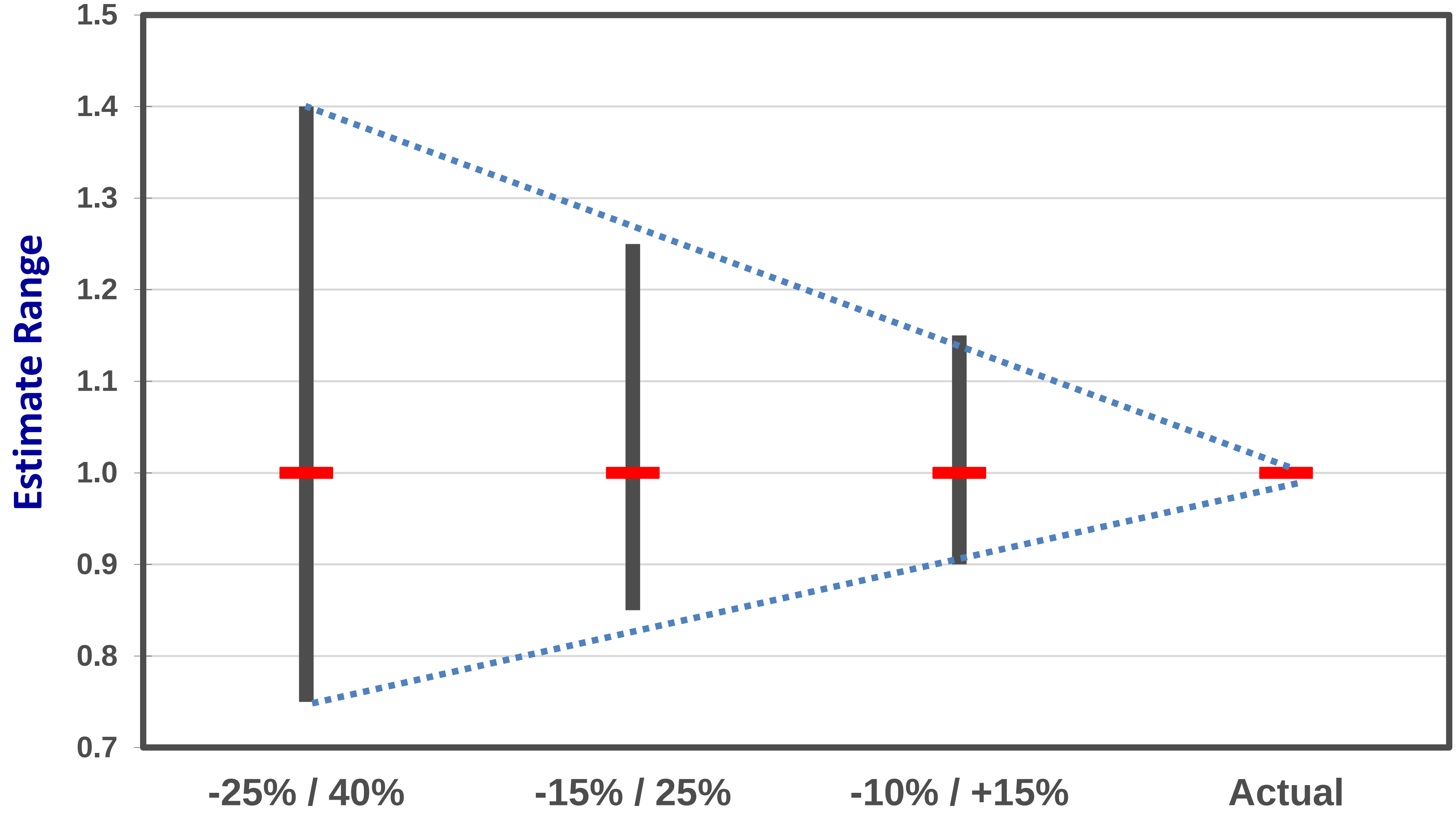
Expert Judgment

- Need an expert to be available
- Historically demonstrated to be highly open to “bias”
- Bias can be minimized by obtaining the consensus of multiple experts provided there is varied, independent opinion.

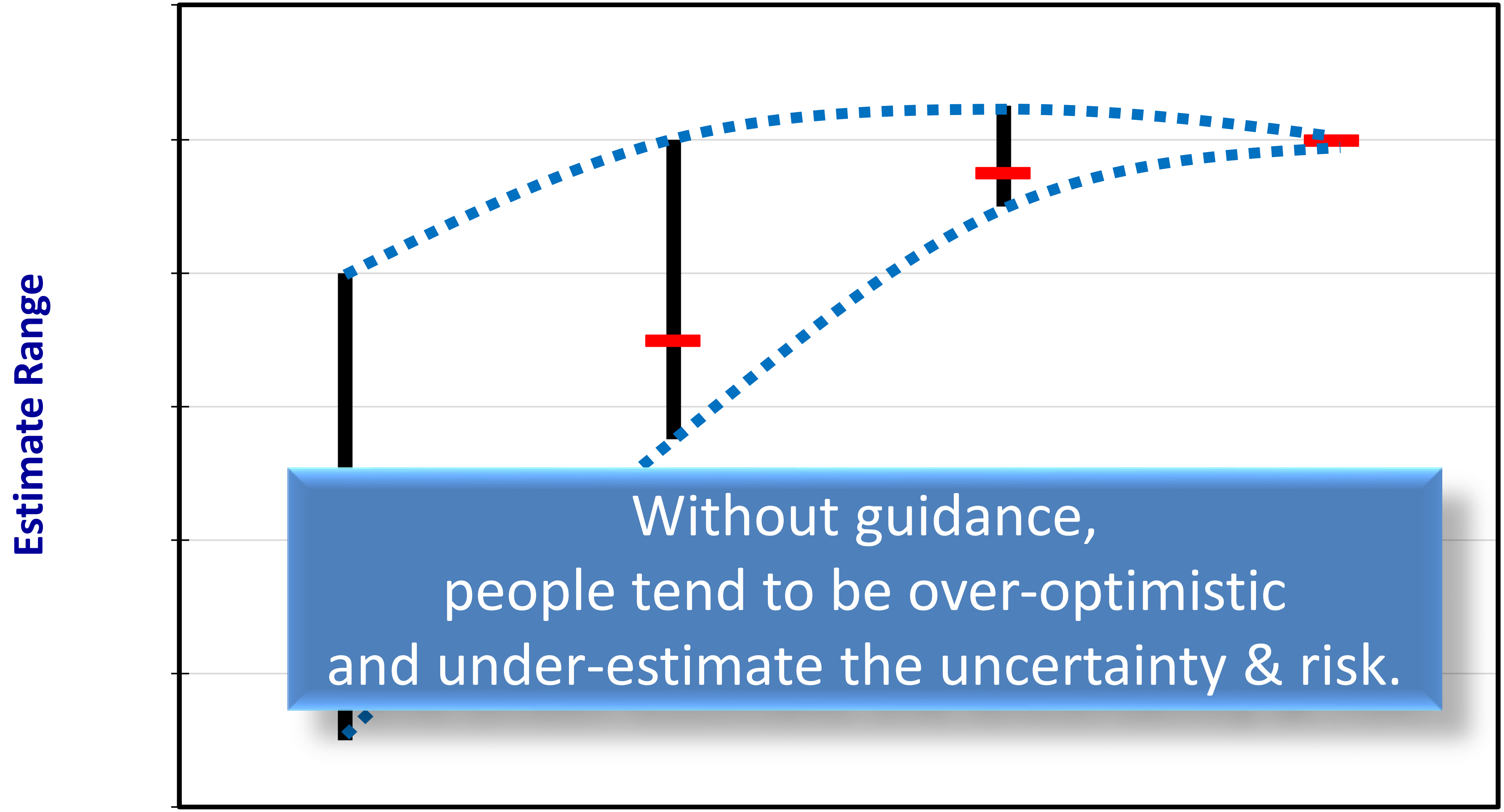
Optimism Bias

Many people think estimates develop like this…



Reality

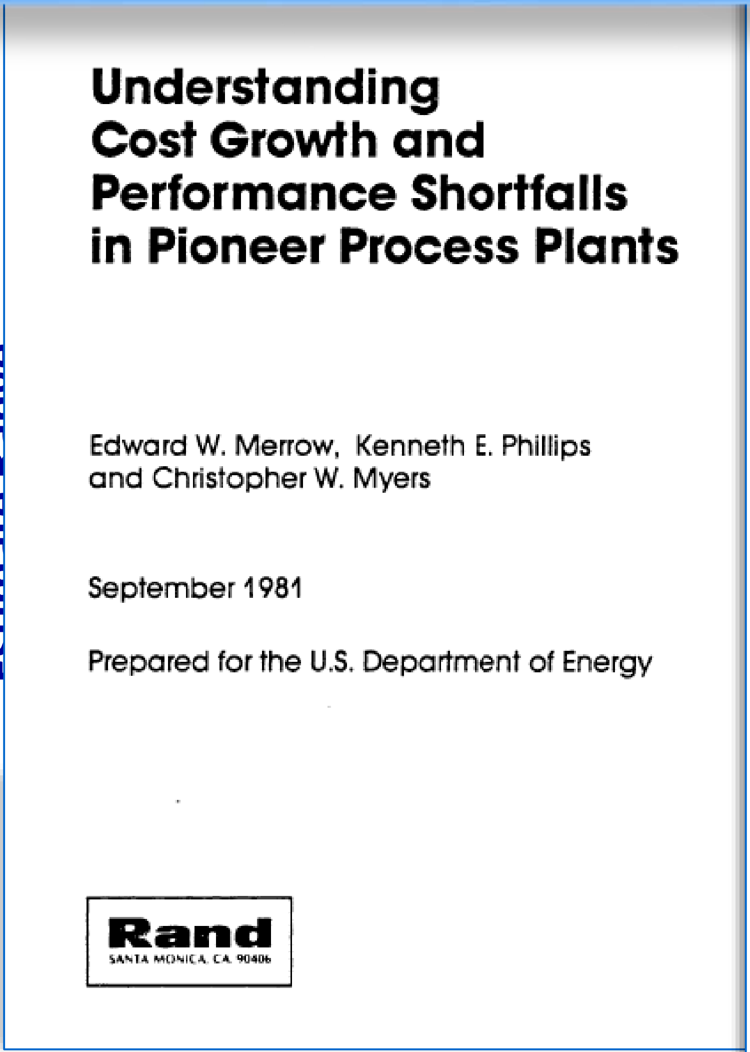
But actually, they often develop like this…



Without guidance,
people tend to be over-optimistic
and under-estimate the uncertainty & risk.

The Rand Corporation knew about it in 1981!

Estimate Range



Understanding Cost Growth and Performance Shortfalls in Pioneer Process Plants

Edward W. Merrow, Kenneth E. Phillips
and Christopher W. Myers

September 1981

Prepared for the U.S. Department of Energy

Rand
SANTA MONICA, CA 90406

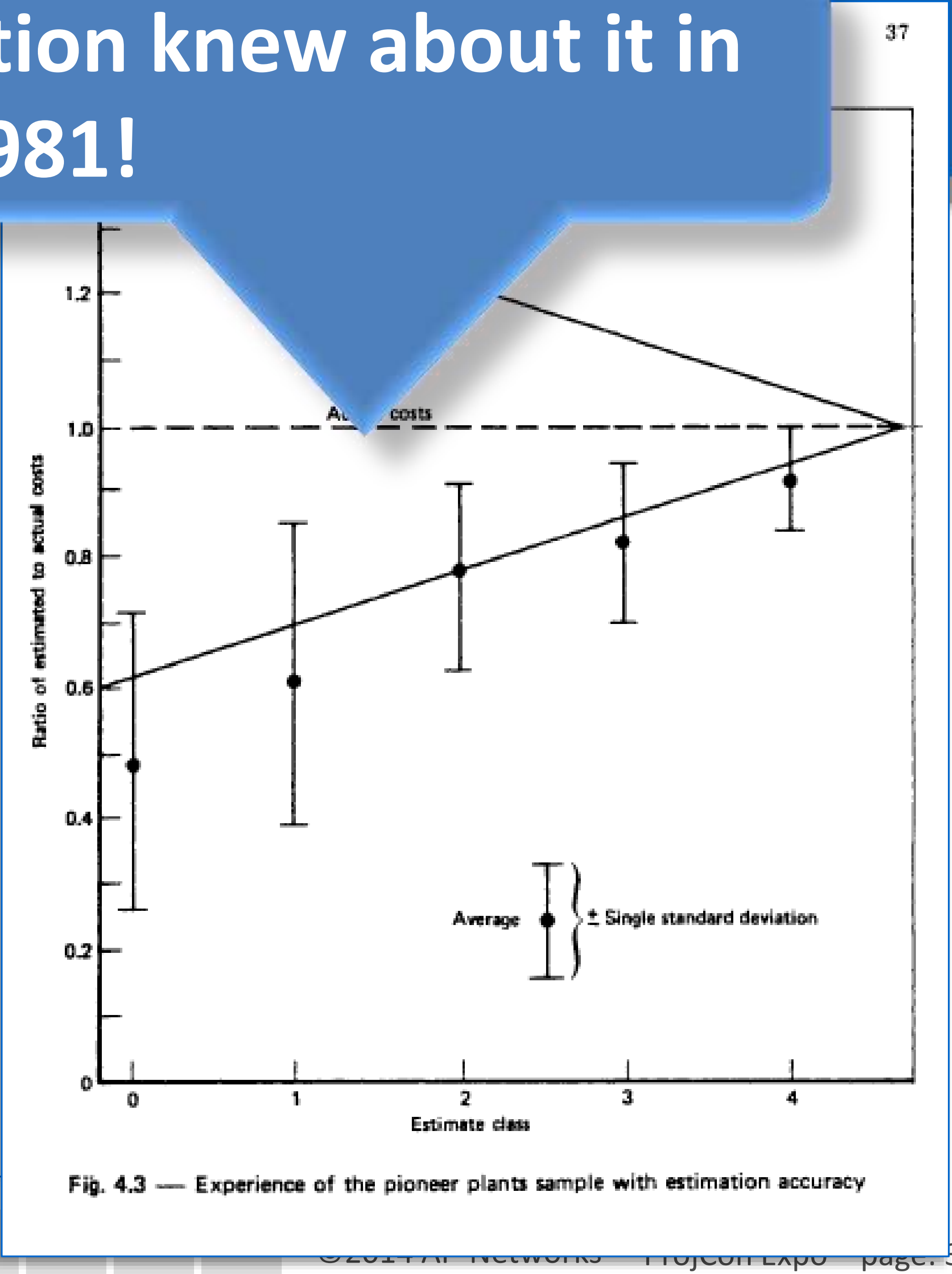


Fig. 4.3 — Experience of the pioneer plants sample with estimation accuracy

Cost Estimate Development

Typical Project Reality – Early Estimates are Under-Estimates

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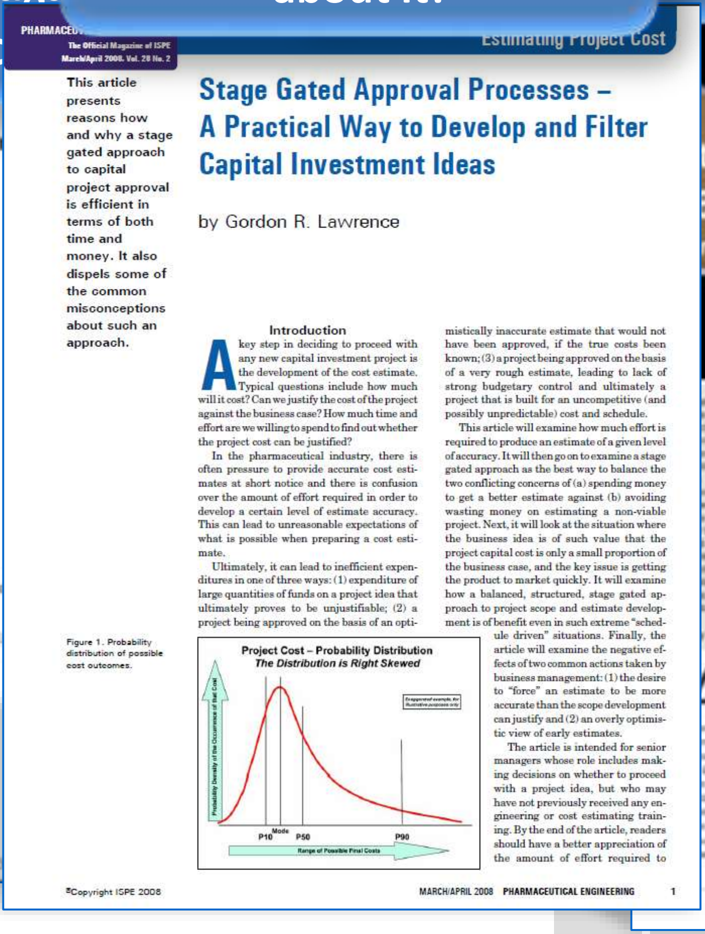
My Colleague, Gordon Lawrence has written about it!

…and, John Hollmann is still, today, trying to get teams to accept reality!

SA has seen the problem!



PHARMACEU
The Official Magazine of ISPE
March/April 2008. Vol. 28 No. 2

Estimating Project Cost

This article presents reasons how and why a stage gated approach to capital project approval is efficient in terms of both time and money. It also dispels some of the common misconceptions about such an approach.

Stage Gated Approval Processes – A Practical Way to Develop and Filter Capital Investment Ideas

by Gordon R. Lawrence

Introduction

A key step in deciding to proceed with any new capital investment project is the development of the cost estimate. Typical questions include how much will it cost? Can we justify the cost of the project against the business case? How much time and effort are we willing to spend to find out whether the project cost can be justified?

In the pharmaceutical industry, there is often pressure to provide accurate cost estimates at short notice and there is confusion over the amount of effort required in order to develop a certain level of estimate accuracy. This can lead to unreasonable expectations of what is possible when preparing a cost estimate.

Ultimately, it can lead to inefficient expenditures in one of three ways: (1) expenditure of large quantities of funds on a project idea that ultimately proves to be unjustifiable; (2) a project being approved on the basis of an optimistically inaccurate estimate that would not have been approved, if the true costs been known; (3) a project being approved on the basis of a very rough estimate, leading to lack of strong budgetary control and ultimately a project that is built for an uncompetitive (and possibly unpredictable) cost and schedule.

This article will examine how much effort is required to produce an estimate of a given level of accuracy. It will then go on to examine a stage gated approach as the best way to balance the two conflicting concerns of (a) spending money to get a better estimate against (b) avoiding wasting money on estimating a non-viable project. Next, it will look at the situation where the business idea is of such value that the project capital cost is only a small proportion of the business case, and the key issue is getting the product to market quickly. It will examine how a balanced, structured, stage gated approach to project scope and estimate development is of benefit even in such extreme "schedule driven" situations. Finally, the article will examine the negative effects of two common actions taken by business management: (1) the desire to "force" an estimate to be more accurate than the scope development can justify and (2) an overly optimistic view of early estimates.

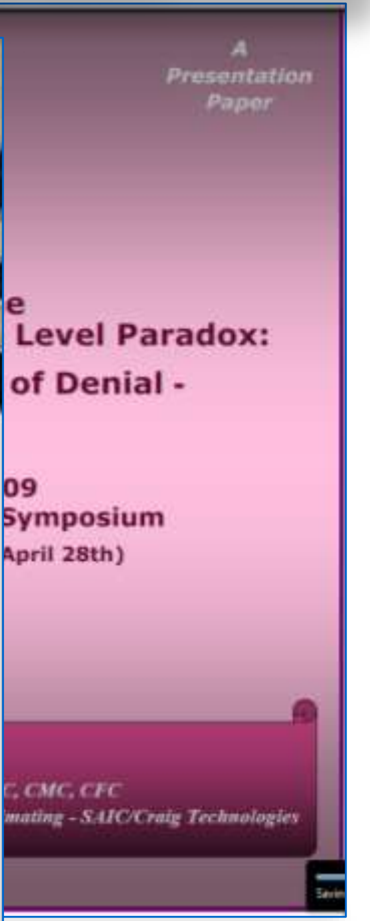
The article is intended for senior managers whose role includes making decisions on whether to proceed with a project idea, but who may have not previously received any engineering or cost estimating training. By the end of the article, readers should have a better appreciation of the amount of effort required to

Figure 1. Probability distribution of possible cost outcomes.

TECHNICAL ARTICLE

timate Accuracy:
ealing With Reality

n K. Hollmann, PE CCE CEP



A Presentation Paper

e
Level Paradox:
of Denial -

09
Symposium
April 28th)

C, CMC, CFC
mating - SAIC/Craig Technologies

Outline

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6	Option 4 - Simulation Analysis
7	Uncertainty & Risk : Overcoming Heuristic Bias
8	CERA Service from AP-Networks

Parametric Model

Calculating the Range and Contingency - AACE RP 40R-08

- A disadvantage is the complexity of developing the parametric model which requires statistical skills and historical data with a range of risks and outcomes.
- The method also cannot effectively address risks that are unique to a specific project, or risks that are common, but may have inordinate or unusual impacts on a given project.
- For that reason it is most useful for early estimates when systemic (i.e., non project specific)risks such as the level of scope definition are dominant. In all cases, outcomes must be tempered with expert judgment.

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Simulation Analysis

- Combination of :
  - Expert judgment of uncertainties & risks
  - Monte-Carlo type, Analytical model, providing probabilistic output
- Takes account of “systemic” and “project-specific” uncertainty & risk

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Common errors

- Many teams use "**Line Item Ranging**" as their Monte-Carlo based, simulation analysis.
  - i.e. Low, Likely, High range <u>for each line item in the estimate</u>
- This method is popular, but is **flawed**.

It ignores:

1) Dependencies between line items.

2) "Systemic" uncertainties.

Errors in Line Item Ranging

Dependencies Between Line Items

- Simple Example:
  - Cost of Equipment = No of Items of equipment x Price of each item of equipment
  - Cost of Piping = Quantity (tonnes (or diam/inches)) x Price/ tonne.
- These are not independent.
  - If you increase the number of items of equipment then the quantity of piping will increase
  - In a heated market, if equipment costs are high then it is more likely so will piping prices
- Line item ranging tends to ignore scope dependency and other dependencies, so you can get simulations when No of equipment items is high and piping quantities are at the low end of the range.
- As shown earlier it is scope that is often the most uncertain parameter

Bias in Assessing Uncertainty & Risk

- Pre-determined guidelines
  - Need expert available for initial set-up
  - Take no account of “
- Expert Judgment
  - Need an expert to b
  - Historically demonst
- Parametric Model
  - Needs a large datase
  - Takes little account
- Simulation Analysis
  - Combination of :
    - Expert judgment of uncertainties & risks
    - Monte-Carlo type, Analytical model, providing probabilistic output
  - Takes account of “systemic” and “project-specific” uncertainty & risk

All three methods require humans to assess uncertainty and risk.

Bias in Assessing Uncertainty & Risk

Left to their own devices…People are Generally NOT GOOD AT IT!

- Nobel Prize in Economics, 2002
  - Daniel Kahneman
    - "for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty."

- Prior to Kahneman (& Tversky), economists assumed that:
  - people correctly estimate probabilities of various outcomes
  - or, at least, do not estimate these probabilities in a biased way
- Kahneman (& Tversky) found that:
  - the vast majority of people poorly estimate probabilities (for uncertainty & risk) in predictable ways.

Bias in Assessing Uncertainty & Risk

Kahneman & Tversky's Findings

Adapted from:
http://www.econlib.org/library/Enc/bios/Kahneman.html

- Bias:
  - "Representativeness- The law of small numbers"
    - People tend to generalize from small amounts of data.
      - If a mutual fund manager has had three above-average years in a row, many people will conclude that the fund manager is better than average.
      - If the first four tosses of a coin give three heads, many people will believe that the next toss is likely to be tails.
  - "Availability,"
    - People judge probabilities based on how available examples are to them.
      - People tend to overstate the risk from driving without a seat belt if they personally know someone who was killed while driving without.
      - Repetition of stories in the news media, such as stories about children being killed by guns, causes people to overstate the risk of guns to children.

Bias in Assessing Uncertainty & Risk

Kahneman & Tversky's Findings

Adapted from:
http://www.econlib.org/library/Enc/bios/Kahneman.html

- Irrational Behaviour
  - "Prospect theory" – The way the problem is framed, affects people's responses
    - A person's attitude to risk is dependent on the prize.
      - seven out of ten people prefer a 25 percent probability of losing $6,000 to a 50 percent probability of losing either $4,000 or $2,000, with an equal probability (25 percent) for each. In each case the expected loss—that is, the loss multiplied by its probability, is $1,500. But here they prefer the bigger loss ($6,000) to the smaller one ($2,000 or $4,000).
    - A person's attitude to gains/savings is proportionate, not absolute.
      - Many people will drive an extra ten minutes to save $10 on a $50 toy. But they will not drive ten minutes to save $20 on a $20,000 car. The gain from driving the extra ten minutes for the car is twice the gain of driving the extra ten minutes for the toy.
        - » people compare the percentage saving, not the absolute saving.

Common Biases and Errors

- Adjustment & Anchoring - by choosing a most likely value first (or being given one) you wont think widely enough and become overconfident
- Availability - ability to remember the past
- Unwillingness to consider extremes - If I am uncertain then I can’t be an expert
- Recency bias - overestimation of the likelihood that a rare event that occurred recently will soon reoccur
- Correlation bias refers to the tendency to see patterns or correlations that don't really exist, for example, believing that the geographic location of a supplier is related to the quality of its products.
- Expert too Busy - just put +/- 20% around my most likely
- Inexpert Expert - nominate the wrong person to provide the opinion
- Culture of Organisation - Sales people optimistic, Managers putting in fat to budgets
- Conflicting Agendas - Approve the project and I get the PM’s job
- **There are many many more biases which affect the way people estimate values.**

Outline

Cost Estimate Risk Analysis (CERA©)

Approach Adopted by AP-Networks

- **Check the Basis of the Estimate:**
  - Technical Definition
  - Execution Strategy
  - Basis of estimation
- **Model Construction:**
  - Focuses on the scope, price/ rate, productivities variables etc. that are used to build the individual estimate line items rather than just the line items themselves
  - Addresses systemic AND project-specific uncertainty & risk drivers
  - Takes account of dependencies & correlations in the monte-carlo simulation
- **Facilitation of Uncertainty & Risk Assessment:**
  - Takes account of people's inherent pre-disposition to ignore risks and assign narrow ranges to uncertainties and risk outcomes.
- Output:
  - Generates fully justifiable, transparent calculation of contingency & estimate accuracy.
  - Provides indicators of where to focus effort in order to reduce uncertainty and hence improve estimate accuracy and reduce contingency requirements.

Step 1

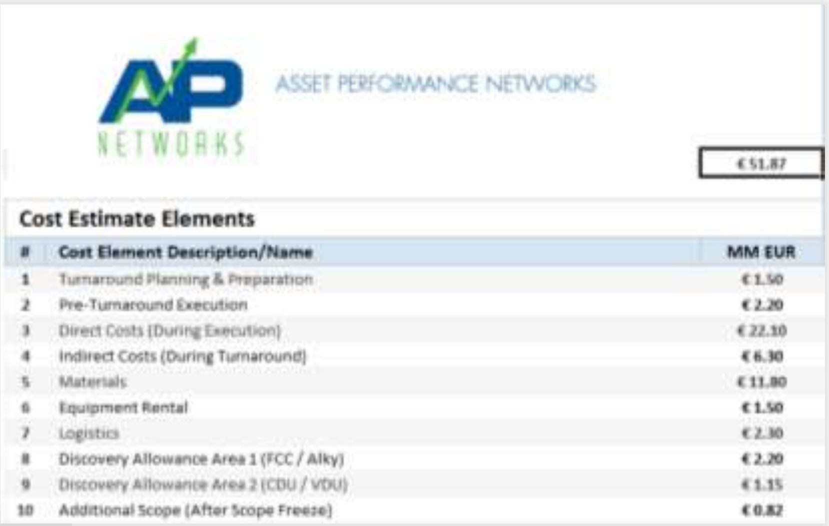
A sound basis- Check the Basis of the Estimate

- Undertake a review of the estimate to ensure that:
  - All the project scope has been included
  - The level of technical definition meets the stage gate requirements
  - The estimate reflects the project execution & contracting strategy
  - Any duration related elements in the estimate are inline with the project schedule
  - Risk mitigation costs are included
  - The allowances that have been included represent good estimating practice
  - Contingencies have been excluded

Step 2

Build the Model - Cost Estimate Breakdown

- The model will be derived from the Cost Estimate but will not necessarily replicate its detail
  - Summary level is usually sufficient. With more detail broken out where appropriate.
- Try to minimise the number of cost items.
  - Many major project estimates can be summarised with 25 -35 cost items in the model
- Major areas of risk identified in the risk register will also influence the break out of costs



ASSET PERFORMANCE NETWORKS

€ 51.87

Cost Estimate Elements

#	Cost Element Description/Name	MM EUR
1	Turnaround Planning & Preparation	€ 1.50
2	Pre-Turnaround Execution	€ 2.20
3	Direct Costs (During Execution)	€ 22.10
4	Indirect Costs (During Turnaround)	€ 6.30
5	Materials	€ 11.80
6	Equipment Rental	€ 1.50
7	Logistics	€ 2.30
8	Discovery Allowance Area 1 (FCC / Alky)	€ 2.20
9	Discovery Allowance Area 2 (CDU / VDU)	€ 1.15
10	Additional Scope (After Scope Freeze)	€ 0.82

Step 3

Build the Model – Develop the Risk and Uncertainty Drivers

- Drivers
  - Typical Examples:
    - Manhours
      - Quantity
      - Rate
    - Materials
      - Weight
      - Cost/tonne
    - Fabrication
      - Cost/tonne
    - Installation
      - Mobilization/Demobilization
        - » Time
        - » Cost
      - On-Hire
        - » Time
        - » Cost

Cost Uncertainty and Risk Analysis

DRAFT for internal use only

Cost Estimating Uncertainty Variables

#	Type	Name	Low	Most Likely	High
1	Scope	Planning Team Size	90%	95%	110%
2	Price	Planning Team Man-Hour Rate	95%	100%	110%
3	Scope	Pre-TA DFL Hours	90%	100%	140%
4	Price	Pre-TA Man-Hour Rate	95%	100%	130%
5	Scope	Direct Field Labor Hours	85%	95%	150%
6	Price	DFL Man-Hour Rate	95%	100%	130%
7	Scope	Indirect Field Labor Hours	85%	95%	140%
8	Price	IFL Man-Hour Rate	95%	100%	130%
9	Scope	Amount of Materials	90%	95%	130%
10	Price	Materials Price	95%	100%	135%
11	Scope	Scaffolding	75%	100%	125%
12	Price	Cost of Scaffolding	90%	100%	125%
13	Scope	Number of Rental Tools	90%	100%	120%
14	Price	Cost of Rental Tools	80%	100%	140%
15	Price	Field Execution Productivity	99%	100%	135%
16	Scope	Logistic Scope	90%	100%	130%
17	Price	Cost of Logistics	90%	100%	120%
18	Scope	Discovery Work Area 1	99%	100%	125%
19	Scope	Discovery Work Area 2	95%	100%	150%
20	Scope	Additional Scope	95%	100%	130%

Step 4

Build the Model – Assess Interdependencies & Correlations

- Interdependencies (Common Risk Drivers)
  - e.g. Increase in Topsides Weight Affects:
    - Engineering, Jacket, Pile, etc.
- Trending Correlations between Risk Drivers
  - e.g. Higher rates in one area are linked with higher/lower rates in other areas
    - e.g. Engineering rates, yard rates & offshore labor rates

€ 51.87

Cost Estimate Elements

#	Cost Element Description/Name	MM EUR	Planning Team Size	Planning Team Man-Hour Rate	Pre-TA DFL Hours	Pre-TA Man-Hour Rate	Direct Field Labor Hours	DFL Man-Hour Rate	Indirect Field Labor Hours	IFL Man-Hour Rate	Amount of Materials	Materials Price	Scaffolding	Cost of Scaffolding	Number of Rental Tools	Cost of Rental Tools	Field Execution Productivity	Logistic Scope	Cost of Logistics	Discovery Work Area 1	Discovery Work Area 2	Additional Scope
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Turnaround Planning & Preparation	€ 1.50	✓	✓																		
2	Pre-Turnaround Execution	€ 2.20			✓	✓																
3	Direct Costs (During Execution)	€ 22.10					✓	✓											✓			
4	Indirect Costs (During Turnaround)	€ 6.30							✓	✓												
5	Materials	€ 11.80									✓	✓										
6	Equipment Rental	€ 1.50											✓	✓	✓	✓						
7	Logistics	€ 2.30															✓	✓				
8	Discovery Allowance Area 1 (FCC / Alky)	€ 2.20					✓	✓			✓	✓								✓		
9	Discovery Allowance Area 2 (CDU / VDU)	€ 1.15					✓	✓			✓	✓									✓	
10	Additional Scope (After Scope Freeze)	€ 0.82					✓	✓			✓	✓										✓

Step 5

Build the Model – Put Ranges on the Uncertainty Variables

- For each uncertainty variable develop a view on:
  - Value used in Basis of Estimate, versus “most likely” value
  - Lowest realistic value
  - Absolute highest realistic value
  - Distribution curve (eg Uniform, Triangle, BetaPert, LogNormal)

- This is done through:
  - Interview of project team members

  And verified using
  - risk analysis facilitator experience (estimating and risk)
  - in-house proprietary data
  - Public domain data
    - Eg Review of current economic data

Step 5

Build the Model – Put Ranges on the Uncertainty Variables

- F

Knowledge of “biases and erroros” is useful here.

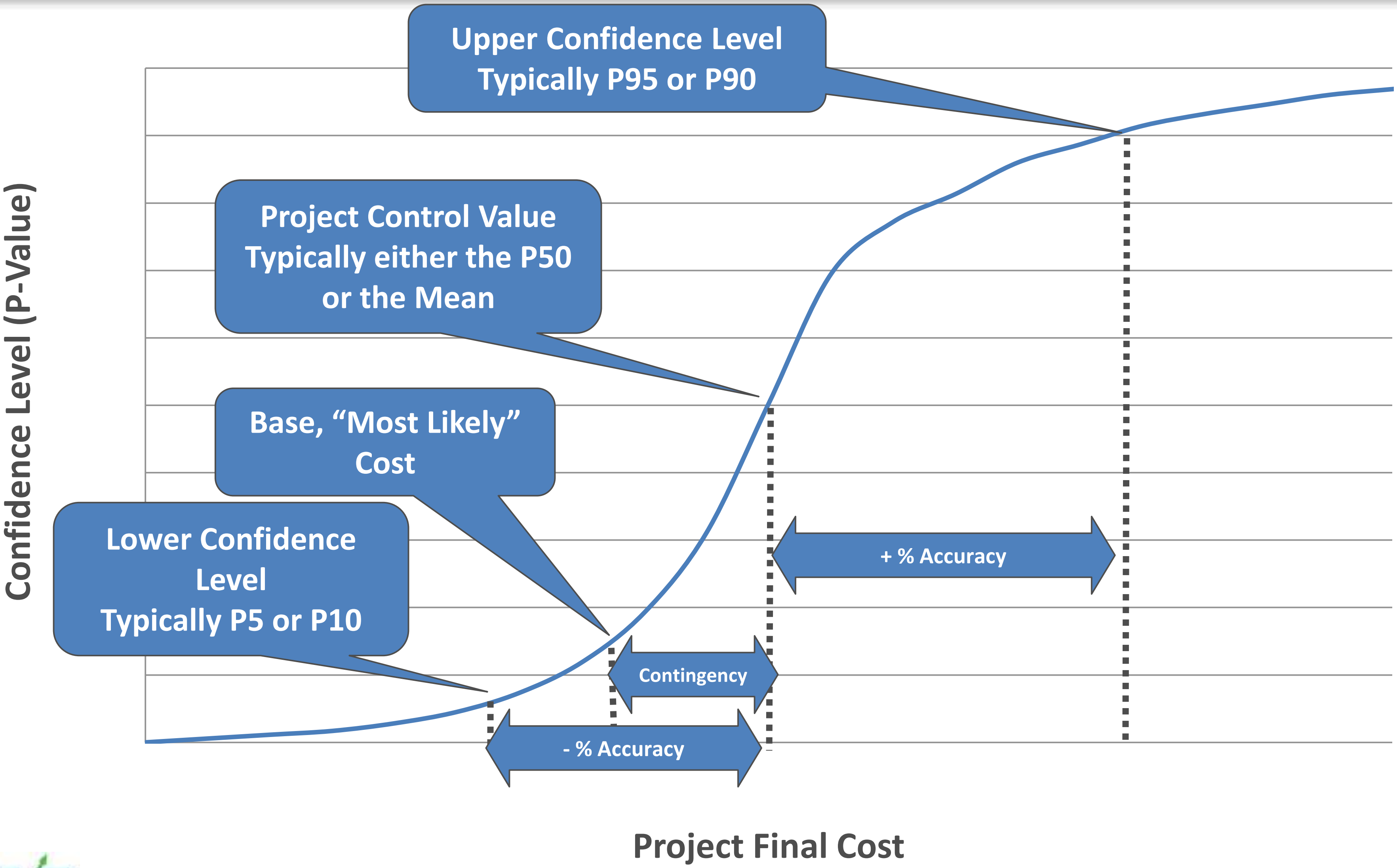
“Are ranges realistic?”

- This is done through:
  - Interview of project team membe

  And verified using
  - risk analysis facilitator experience (estimating and risk)
  - in-house proprietary data
  - Public domain data
    - Eg Review of current economic data

“S” Curve (Cumulative Probability Curve)

P10, “Most Likely”, P50, Mean, P90



Upper Confidence Level
Typically P95 or P90

Project Control Value
Typically either the P50
or the Mean

Base, “Most Likely”
Cost

Lower Confidence
Level
Typically P5 or P10

Step 6

Build the Model - Add Risk Events – gather information

- Gather Risk Event Information
  - Preparation includes:
    - Having a risk register
    - Ensuring the costs of any risk mitigation actions planned, are included in estimate
    - Estimate “likelihood of occurrence” after mitigation, for each risk
    - Estimate “Impact“ if it occurs, even after mitigation, for each risk

Requires a risk register that contains quantitative assessments NOT Qualitative

Knowledge of Heuristic biases is also useful here.

“Have all risks been considered?” “Are probabilities and impacts realistic?”

Register View: Default View | Edit Custom View | » All Risks » My Risks | Filter: No Filter

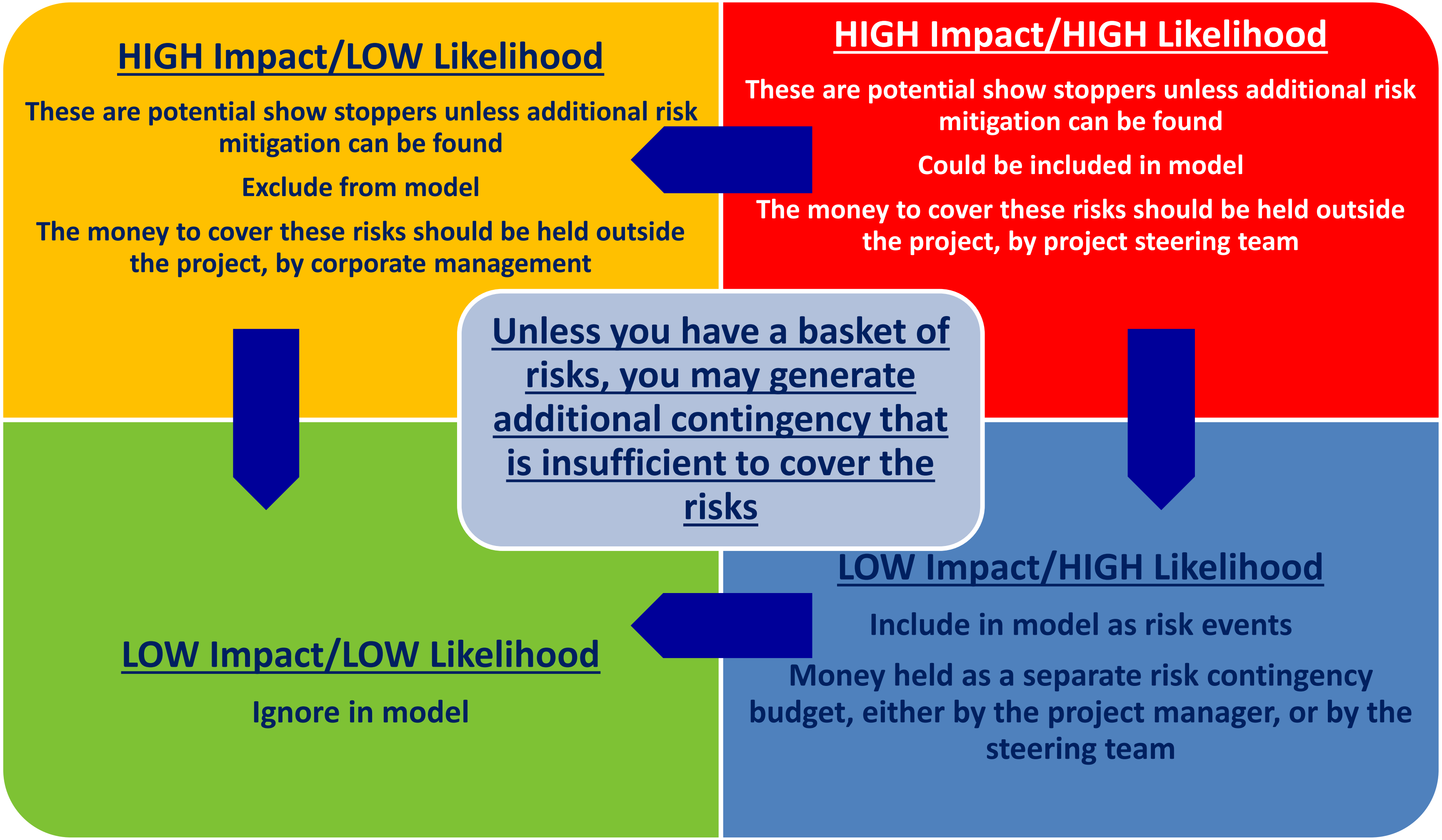
Register Name:

RSI Score (Threat):

Delete	Risk ID	RBS	Risk Name	Probability Rating	Impact Rating	Risk Severity
☐	C.2	C-Planning Sched Cost Control-	Not having a detailed schedule review	High	Very High	🟥
☐	E.4	E-Shutdown and Startup-	Effectiveness of RTI cleanup; not locally proven, first time use.	Medium	Very High	🟥
☐	F.1	F-Organization and Communications-	All TA information doesn't flow down to workers to understand responsibilities.	High	High	🟥
☐	A.4	A-HSE-	Not having enough locks for isolating systems and equipment (borrowing locks from other TSO refineries)	High	High	🟥
☐	D.5	D-Field Execution and Logistics-	Difficulty obtaining equipment we will need to do the work (e.g. cranes).	High	High	🟥
☐	A.3	A-HSE-	Safe work permitting and new lock boxes not implemented correctly	Medium	Very High	🟥
☐	E.3	E-Shutdown and Startup-	Operator TA experience is lacking	Medium	High	🟨
☐	F.5	F-Organization and Communications-	Not understanding role in the new organization (e.g., operators)	Medium	High	🟨

Step 6

Build the Model - Add Risk Events – Decide which to include



HIGH Impact/LOW Likelihood

These are potential show stoppers unless additional risk mitigation can be found

Exclude from model

The money to cover these risks should be held outside the project, by corporate management

HIGH Impact/HIGH Likelihood

These are potential show stoppers unless additional risk mitigation can be found

Could be included in model

The money to cover these risks should be held outside the project, by project steering team

Unless you have a basket of risks, you may generate additional contingency that is insufficient to cover the risks

LOW Impact/HIGH Likelihood

Include in model as risk events

Money held as a separate risk contingency budget, either by the project manager, or by the steering team

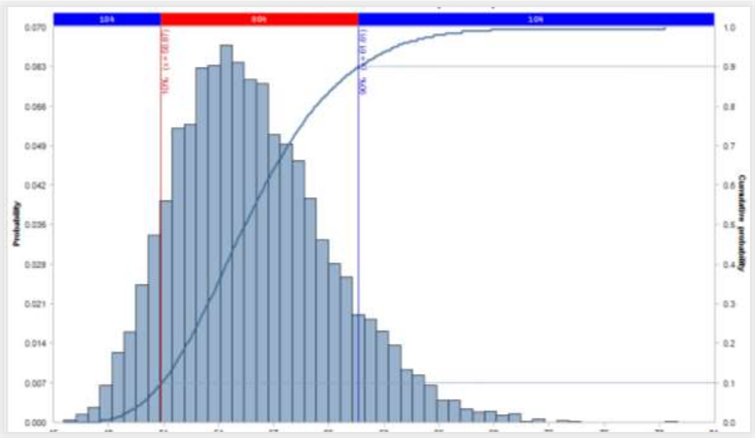
LOW Impact/LOW Likelihood

Ignore in model

Step 7

Run Model & Analyze Results

- Monte-Carlo simulation
  - Run the model both with and without risk events included.
    - The project leadership can then decide whether to give the risk element to the PM or hold at a higher organizational level
  - Can run the model with pre & post mitigation risk "likelihood" & "impact".
    - This is a good practice to do, because many project teams fail to carry out the planned risk mitigation activities.

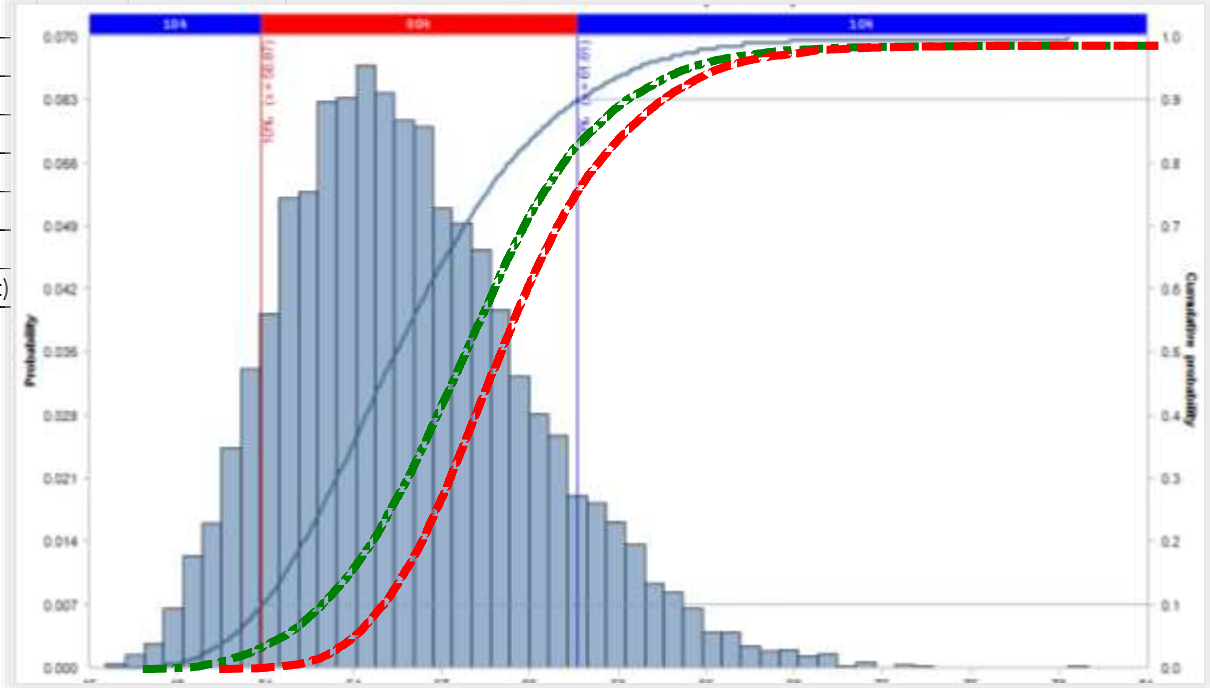


CERA© Service Outputs - 1

Contingency & Range

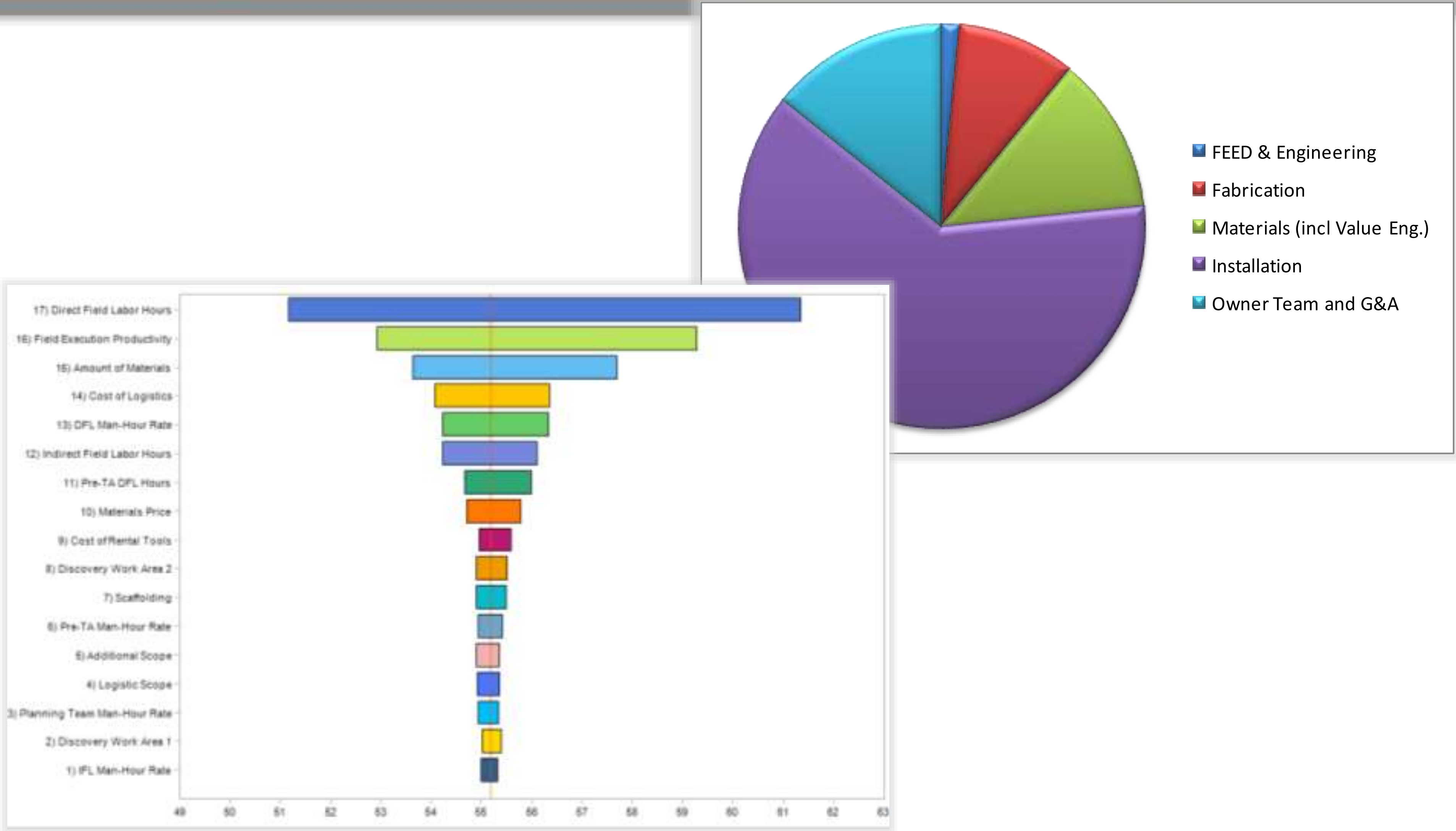
🟦 Project		No Risks $Million
Base Cost Estimate		$ 103.9
Contingency (Sum of Money given to PM)	13%	$ 13.8
Total Cost at Estimate Confidence Level	Mean	$ 117.7
P50 Total Cost	P50	$ 114.5
Upper Confidence Limit		
Lower Confidence Limit		
Accuracy Range vs No Risks Total Cost +		
Accuracy Range vs No Risks Total Cost -		
Management Reserve (Upper Confidence Limit- Total Cost)		

You can get a suite of curves/ results Without risks, with risks, without mitigation, with mitigation



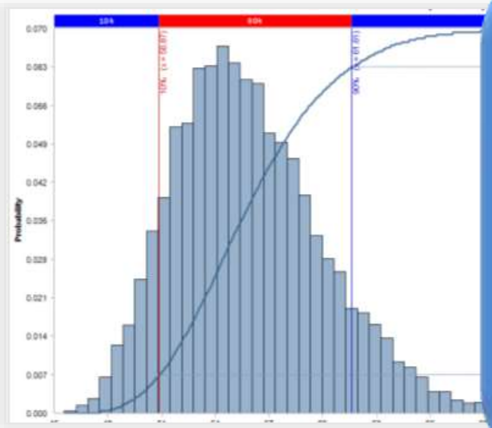
CERA© Service Outputs - 2

Uncertainty (Range) and Contingency Contributors

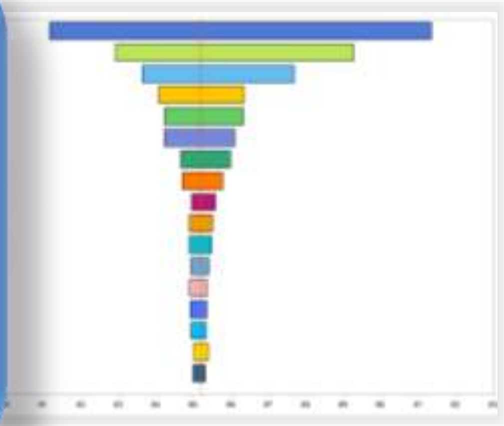


Summary

- A properly executed cost risk analysis provides:
  - Transparent, justifiable assessment of contingency requirements & estimate range.
    - Defensible results for presentation to management
  - Assessment of the uncertainties that are driving the contingency requirement and estimate range.
    - Giving the team guidance on where to focus effort to reduce costs



Perhaps the main benefit is the discussion that takes place during process enabling the team to understand the weaknesses in the assumptions that underpin the estimate and the major risk drivers of those assumptions.



Questions?