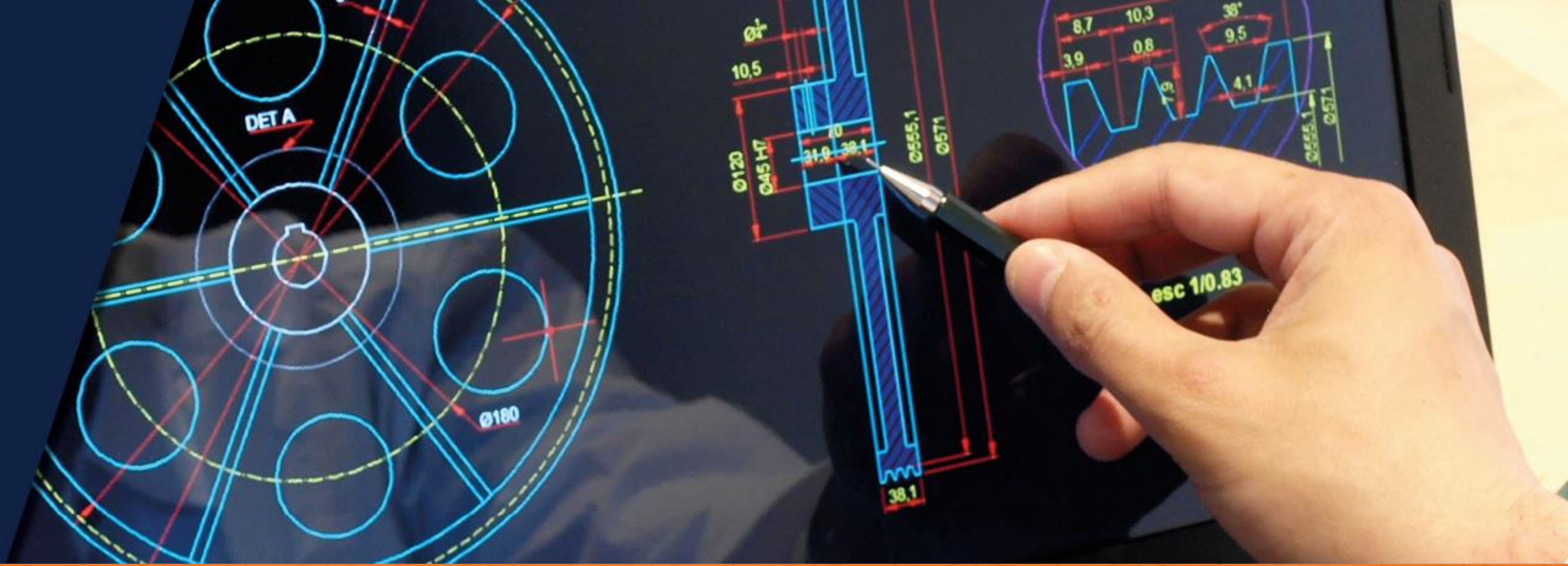
Cost Engineering



HOW COST ESTIMATION CAN DRIVE SMARTER PROJECT MANAGEMENT IN TECHNICAL INDUSTRIES

By Ko des Bouvrie

Cost Engineering Consultancy

IWSM MENSURA

HAARLEM 7-9 OCTOBER 2019

About Ko des Bouvrie

Experience:

- Co-founder of Cost Engineering Consultancy and Cleopatra Enterprise
- Senior Consultant with more than 40 years of experience
- Consulting industries such as oil & gas, petrochemical, power, mining & minerals, chemicals, construction and pharmaceutical

Field associations:

- Member of NAP/DACE, AACE International, ICEC and AcostE
- Teacher of cost engineering courses

Cost EngineerinG

Topics

- Introduction
- What is estimating?
- Estimating techniques
- Accuracy of the estimate
- Benchmarking and continuous improvement

A Brief Introduction

- 24+ years experience
- Software and consultancy solution
- Operating worldwide
- Knowledge Provider
- Empowering organizations to improve their project performance

Clients and Industries

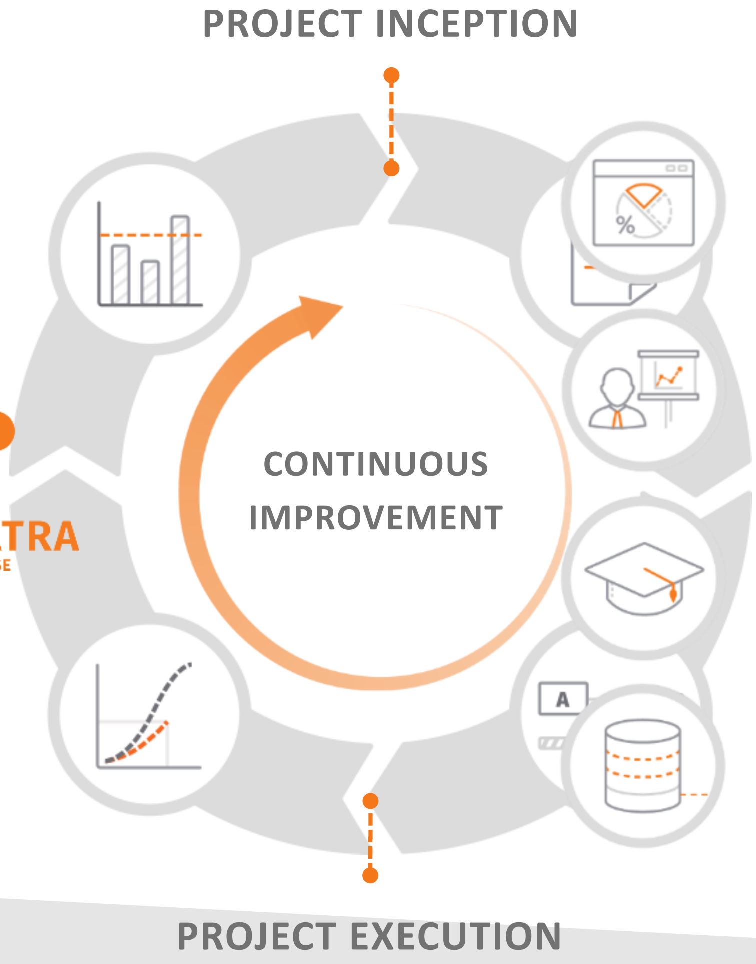
- Bulk storage
- Construction industry
- EPC(M)
- Food and Nutrition
- Infrastructure
- Offshore
- Oil & Gas industry
- Heavy industry
- Pharmaceutical industry
- Petro-/chemical industry
- Power industry
- Mining & Minerals

Our vision:

Benchmarking

Cost Management

CLEOPATRA
ENTERPRISE



Cleopatra Enterprise
Estimating

Consultancy

Academy

Scheduling
CESK

What is estimating?

Cost engineering

To start: **what is cost engineering?**

- *That area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problems of cost estimating, cost control and profitability.*

COST ENGINEERING

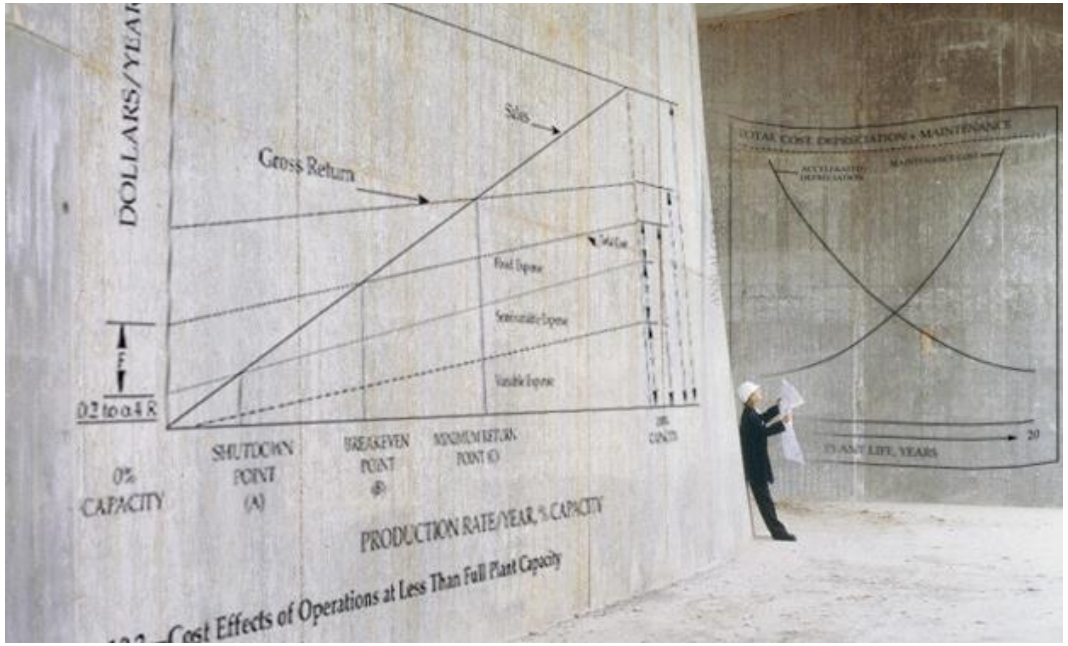
Cost engineering

The **Profession of Cost Engineering:**

Applying methods and techniques for:

- *Cost estimating,*
- *Cost control,*
- *Scheduling,*
- *Value engineering,*
- *Contracting & Tendering,*
- *Quantity surveying,*
- *Risk management,*
- *Profitability analysis,*
- *Business planning & management science*

to support asset and project management.



COST ENGINEERING

Cost is everything

“It **costs** time”
“It **costs** resources”
“ It **costs** money”

Everything invested
in assets and projects
is a Cost

What is estimating?

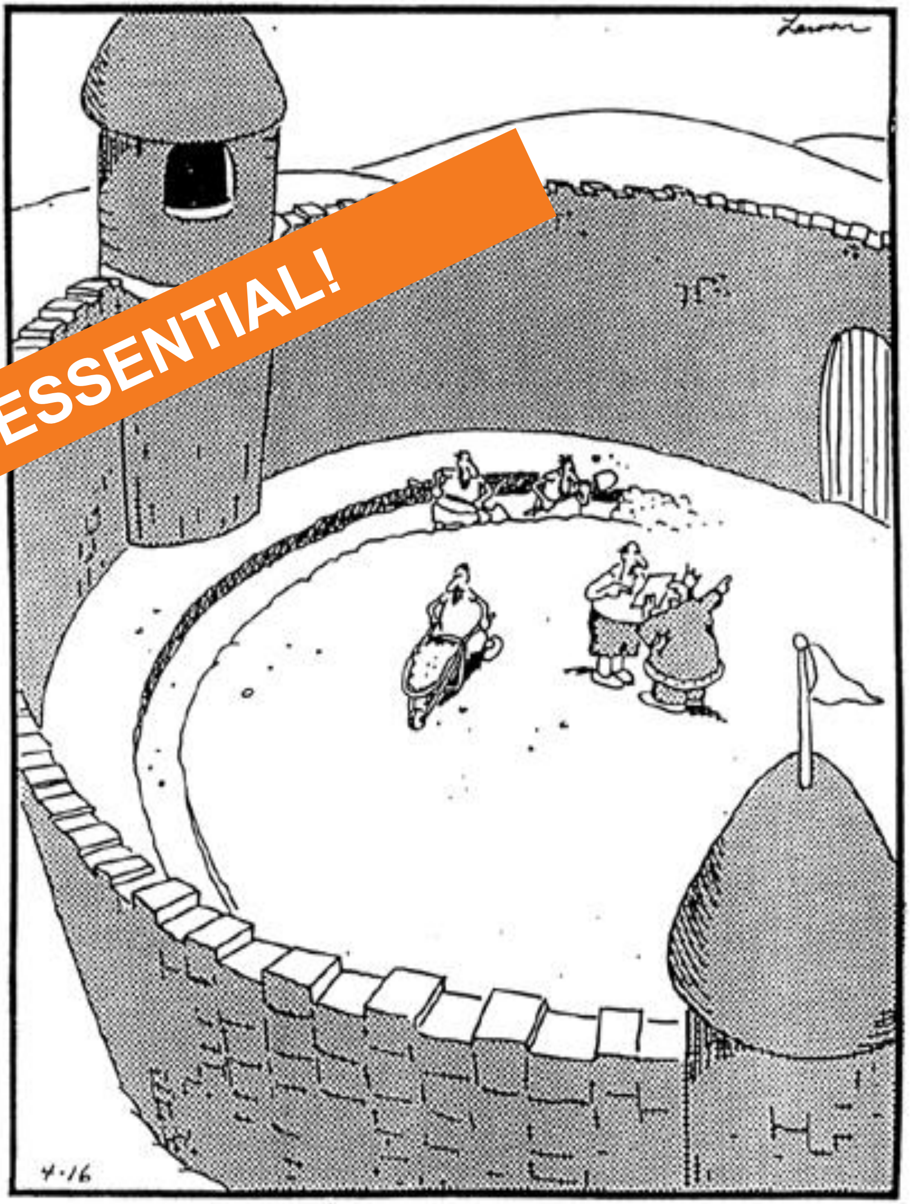
What is estimating?

- Predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project.
- Involves assumptions and unknowns
- Goal is to minimize the uncertainty of the estimate given the level of scope definition.

- *A heated exchange took place between the King and the project manager.*
- What was **objective**?
  - “dig a ditch next to the cas

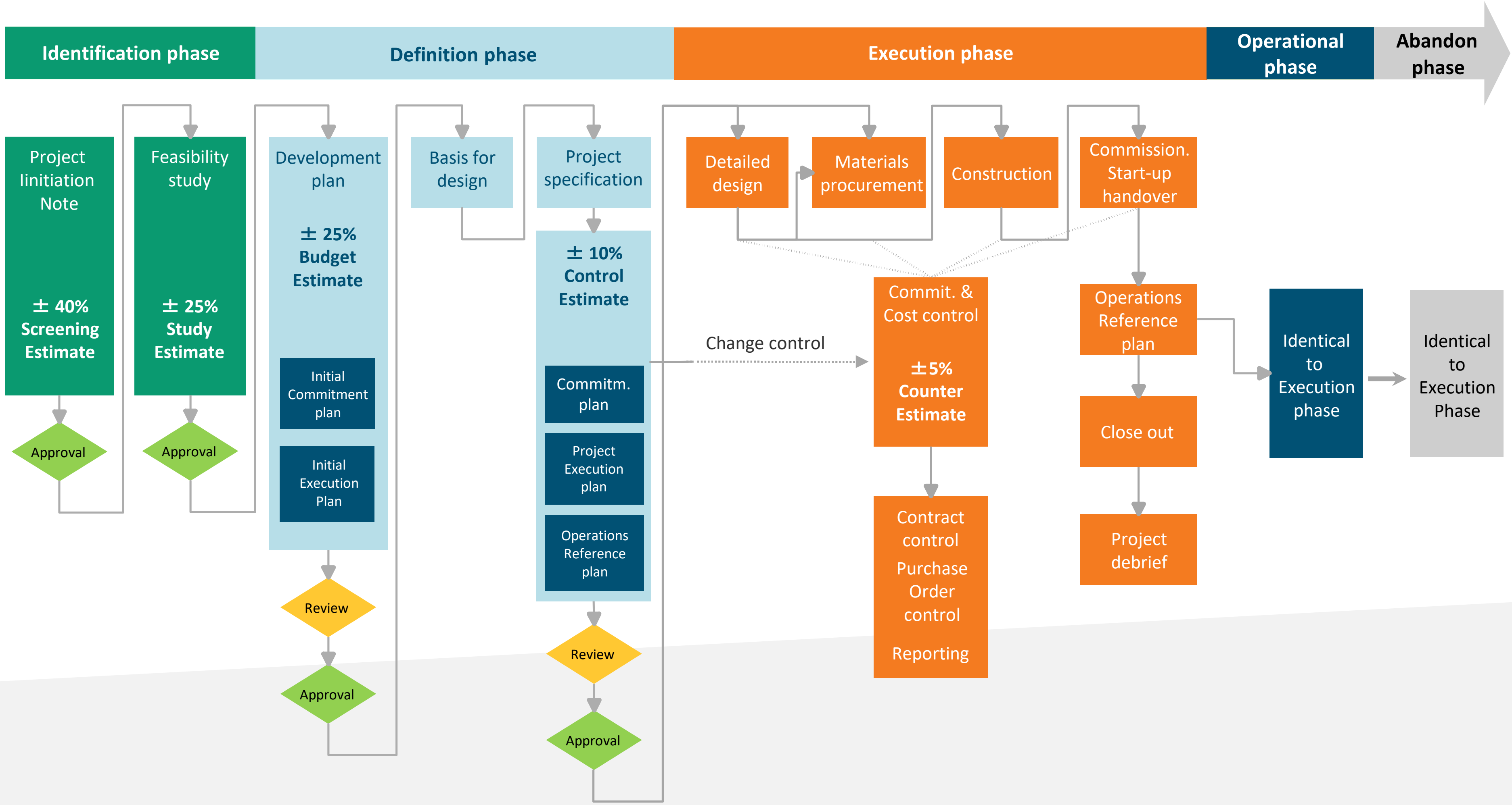
    or
  - “defend tle from attack”

Good Scope and Communication is ESSENTIAL!



Estimating techniques

Estimate types through the project lifecycle



AACE Cost Estimate Classification System

	Primary Characteristic				
Estimate Level	**Level of Project definition**	**End Usage**	**Methodology**	**Expected Accuracy Range**	**Preparation Effort**
5	0% to 2%	Concept Screening	Capacity factored Parametric Models, Judgment or analogy	L: -20% to -50% H: +30% to +100%	1
4	1% to 15%	Study or Feasibility	Equipment factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
3	10% to 40%	Budget, Authorization or Control	Semi-detailed unit cost with assembly level line items	L: -10% to -20% H: +10% to +30%	3 to 10
2	30% to 70%	Control or Bid / Tender	Detailed Unit Cost with Forced Detailed take-off	L: -5% to -15% H: +5% to +20%	4 to 20
1	50% to 100%	Check Estimate or Bid / Tender	Detailed Unit Cost with Detailed take-off	L: -3% to -10% H: +3% to +15%	5 to 100

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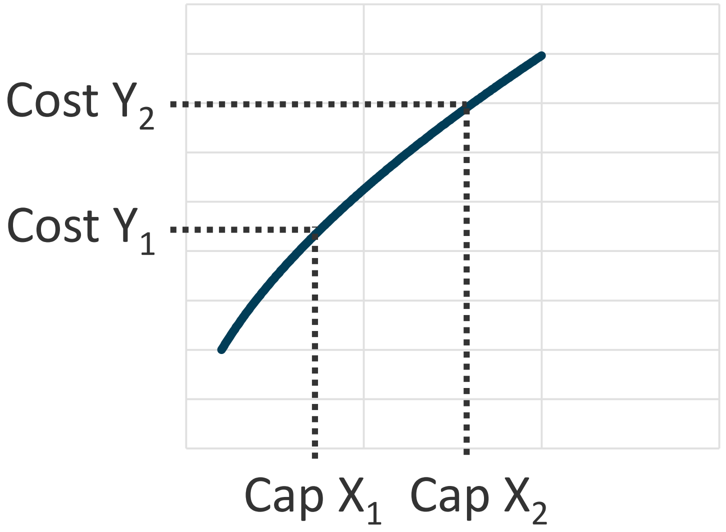
Class 5 estimate

- Prepared based on very limited information, and subsequently have wide accuracy ranges.
- Prepared for strategic business planning purposes:
  - Market studies, assessment of initial viability, evaluation of alternate solutions, location studies, etc.
- **Methods** include capacity scaling:



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Class 5 estimate

- Example: wind turbine, scaled per MW:

$$\text{Cost new wind turbine} = \text{Cost reference}\left(\frac{\text{Capacity new}}{\text{Capacity reference}}\right)^{X}$$

$$\text{Cost new wind turbine} = €\ 654{,}000\left(\frac{1.24\ \text{MW}}{1.05\ \text{MW}}\right)^{0.6} = €\ 723{,}000$$

Class 4 estimate

- Prepared based on limited information and subsequently have fairly wide accuracy ranges.
- Typically used for project screening, determination of feasibility, concept evaluation, and preliminary (but generally not final) budget approval.
- **Methods:** factor and parametric estimating.

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Class 4 estimate

- **Factor estimating example: Lang factor method**
  - More detailed than the six-tenth method
  - Needs sufficient specification of equipment
  - Basis: equipment prices free at site (including transportation cost to site)

$$\text{Total Installed Cost} = \text{Process equipment cost} \times \text{Lang factor}$$

Lang Factors

Process equipment
Free at site — 1.00

Foundation
Supporting
Platforms
Insulation
Assembly — On behalf of equipment

1.43

Piping, including Insulation

1.57(A)
1.79(B)
2.79(C)

Preparing the terrain for building
Buildings
Electrical installations
Instrumentation
Insurance, taxes

2.36 (A)
2.68 (B)
3.43 (C)

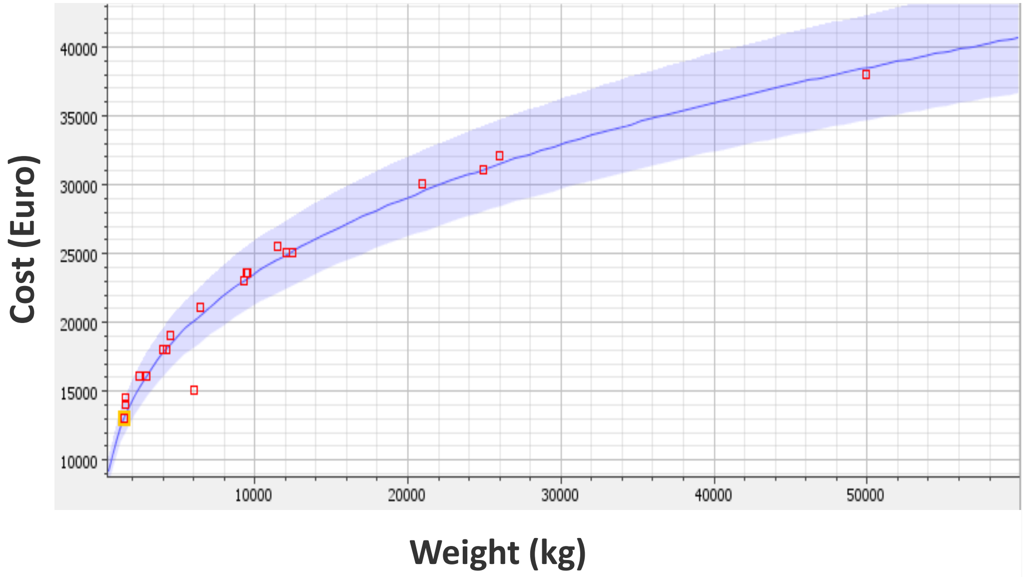
Contingency
Engineering including temporary facilities and construction supervision

3.10 (A)
3.63 (B)
4.74 (C)

(A) = Solids
(B) = Solids/Liquids
(C) = Liquids

Class 4 estimate

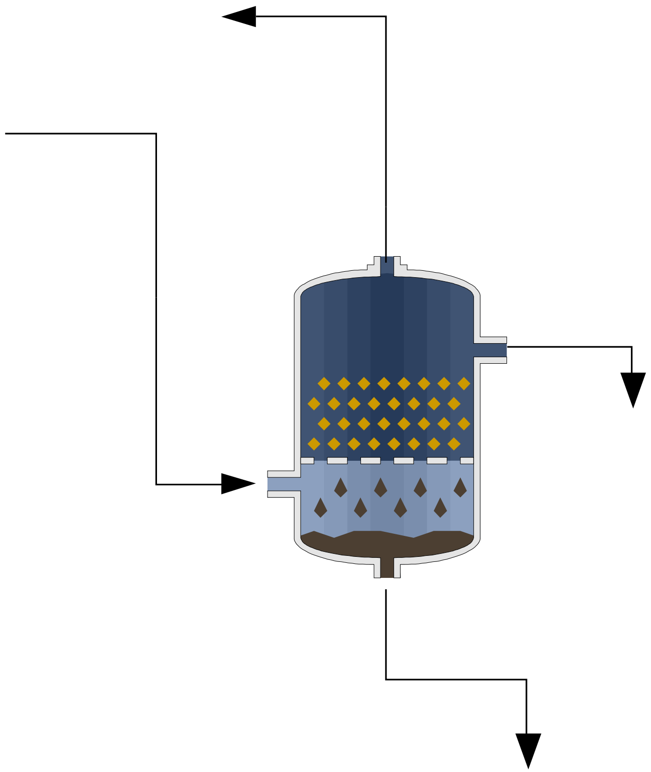
- **Parametric estimating example**
  - Parametric relation between cost and weight of a pressure vessel:



Cost engineering

Class 3 estimate

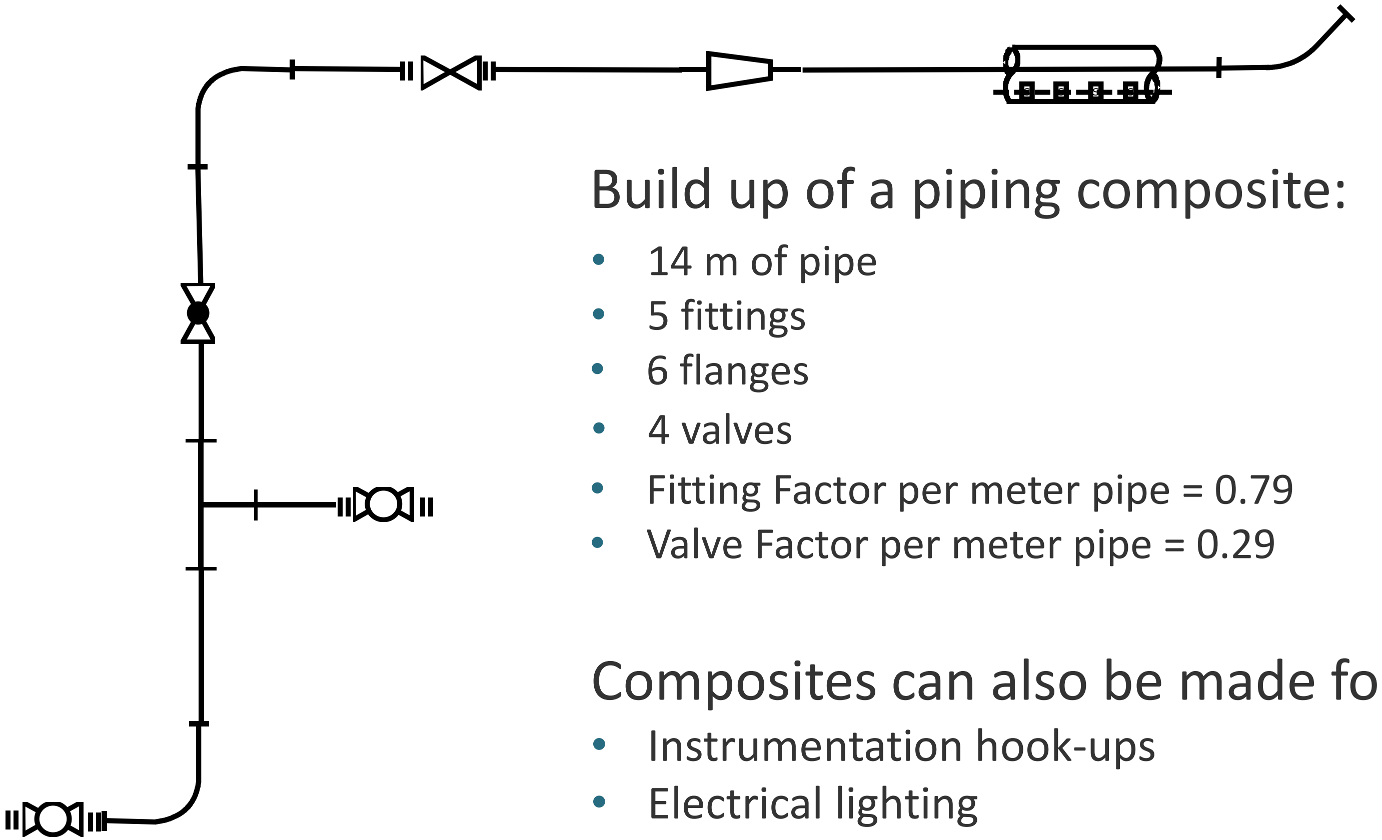
- Prepared to form the basis for budget authorization, appropriation, and/ or funding.
- In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/ schedule control.
- **Methods:** hybrids between factor/ parametric and deterministic methods.



Cost engineering

Class 3 estimate

- Composites for generating more detailed estimates, based on limited information:



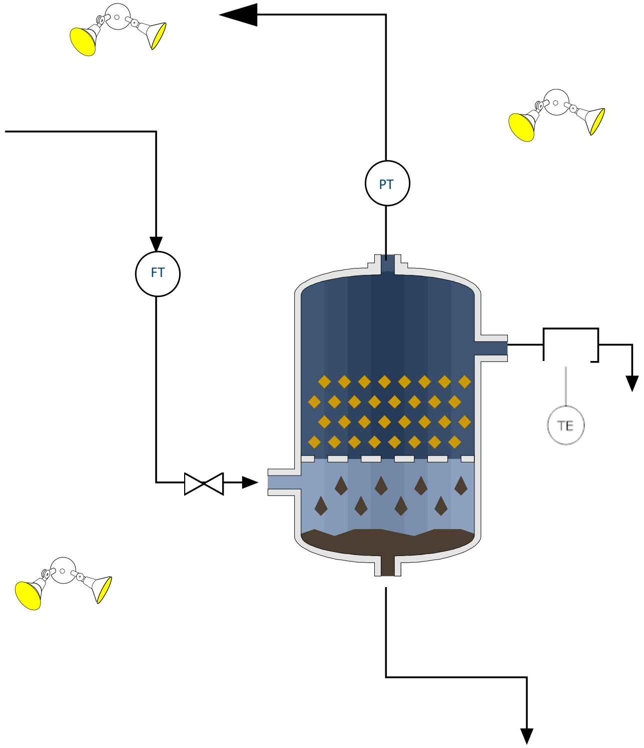
Build up of a piping composite:

- 14 m of pipe
- 5 fittings
- 6 flanges
- 4 valves
- Fitting Factor per meter pipe = 0.79
- Valve Factor per meter pipe = 0.29

Composites can also be made for:

- Instrumentation hook-ups
- Electrical lighting
- Structures / pipe racks

Class 3 estimate



- Objects combine composites:
  - 4.5” pipe
  - 150 m pipe per equipment
  - 0.9 – 1.2 Control valve per equipment
  - 5.5 Field instruments per equipment
  - 3 lighting fixtures per equipment

Class 2 and 1 estimate

- Deterministic (detailed) estimate.
- Forms a detailed control baseline against which all project work is monitored in terms of cost and progress control.
- For contractors, this class of estimate is often used as the “bid” estimate to establish contract value.
- **Method:** prepared from material lists and detailed design drawings. At this stage, not all quantities are known yet, so some still need to be based on typical quantities.

Cost engineering

Class 2 and 1 estimate

- Example unit rate for painting a 2” steel pipe.
- Cost contains:
  - Labour hours and rate
  - Rental tools and materials

Level ID	Description	Unit	Cost	Labour hours	Rental hours	Non labour cost
Unit-Rates	Painting + Blasting [SA2.5] + 3% Touch-up, D= 2" / DN 50, >+120 up to +200 °C, CS, Pipe	m	14.00	0.13	0.04	4.97

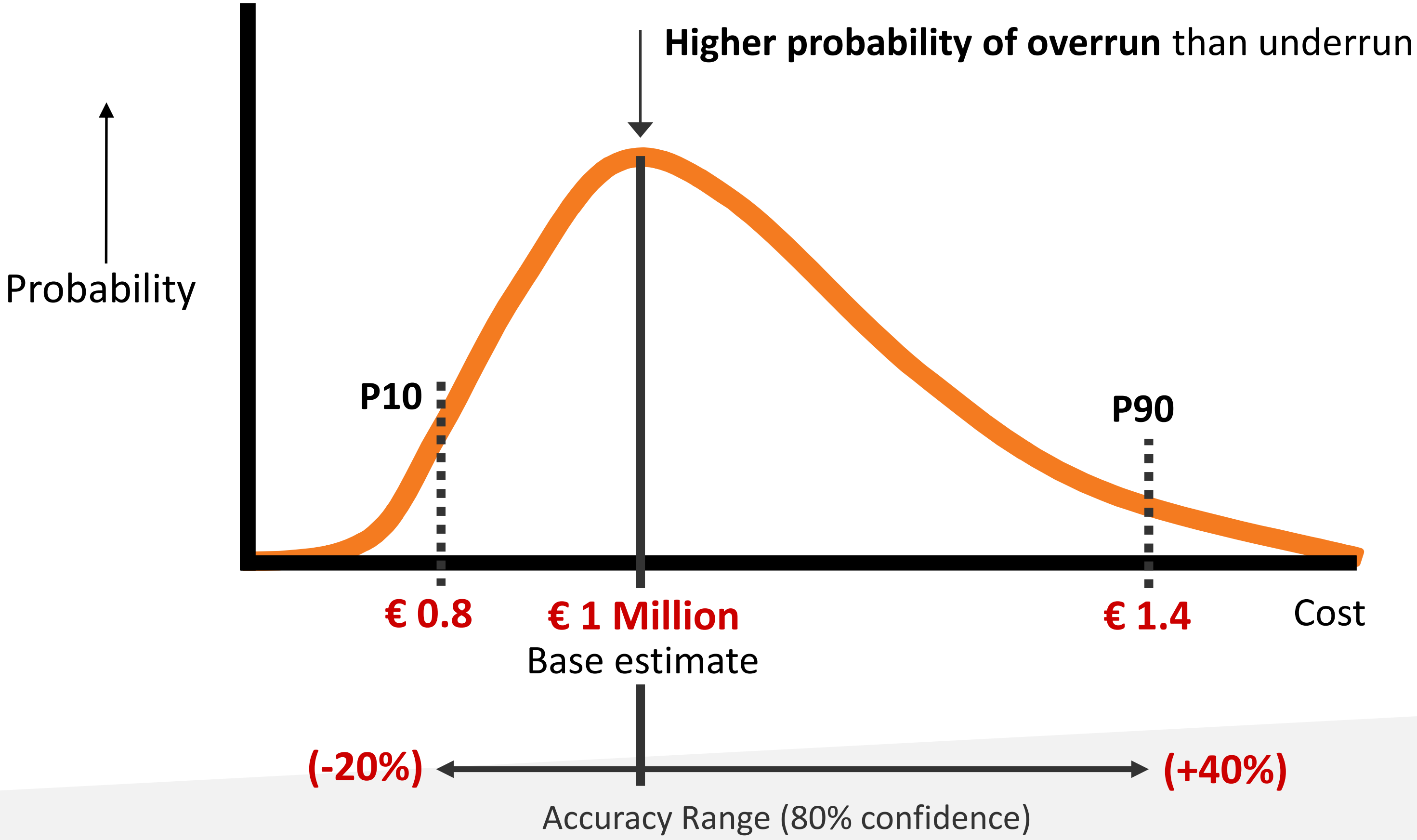
Lev...	Description	Quantity	Unit	Total cost	Cost category	Non labour cost	Labour hours	Labour cost per hour
Details	Surface preparation, Power tool cleaning St3, Re7- 40/50%	0.01	m²	0.08	Install	0.00	0.19	54.40
Details	Surface preparation, Near-White Blast cleaning, SA2.5	0.25	m²	5.36	Install	0.00	0.40	54.40
Details	Surface preparation, Blasting grit, Supply	0.01	t	0.96	Material	111.59		
Details	Surface preparation, Blastgrit equipment, Rent	0.03	h	1.88	Construction tools & equipment	0.00		
Details	Surface preparation, Compressor, Rent	0.00	h	0.02	Construction tools & equipment	0.00		
Details	Surface preparation, Chipping hammer, Rent	0.00	h	0.00	Construction tools & equipment	0.00		
Details	Surface preparation, Blasting grit, Disposal	0.01	t	1.14	Miscellaneous	131.79		
Details	Painting, >+120 up to +200 °C, CS, (m2), Field	0.25	m²	0.84	Install	0.00	0.08	44.10
Details	Painting, >+120 up to +200 °C, CS, (m2), Prefab	0.25	m²	0.85	Prefabrication	0.00	0.06	61.40
Details	Painting, >+120 up to +200 °C, CS, (m2), Material	0.25	m²	2.87	Material	11.32		

Accuracy of the estimate

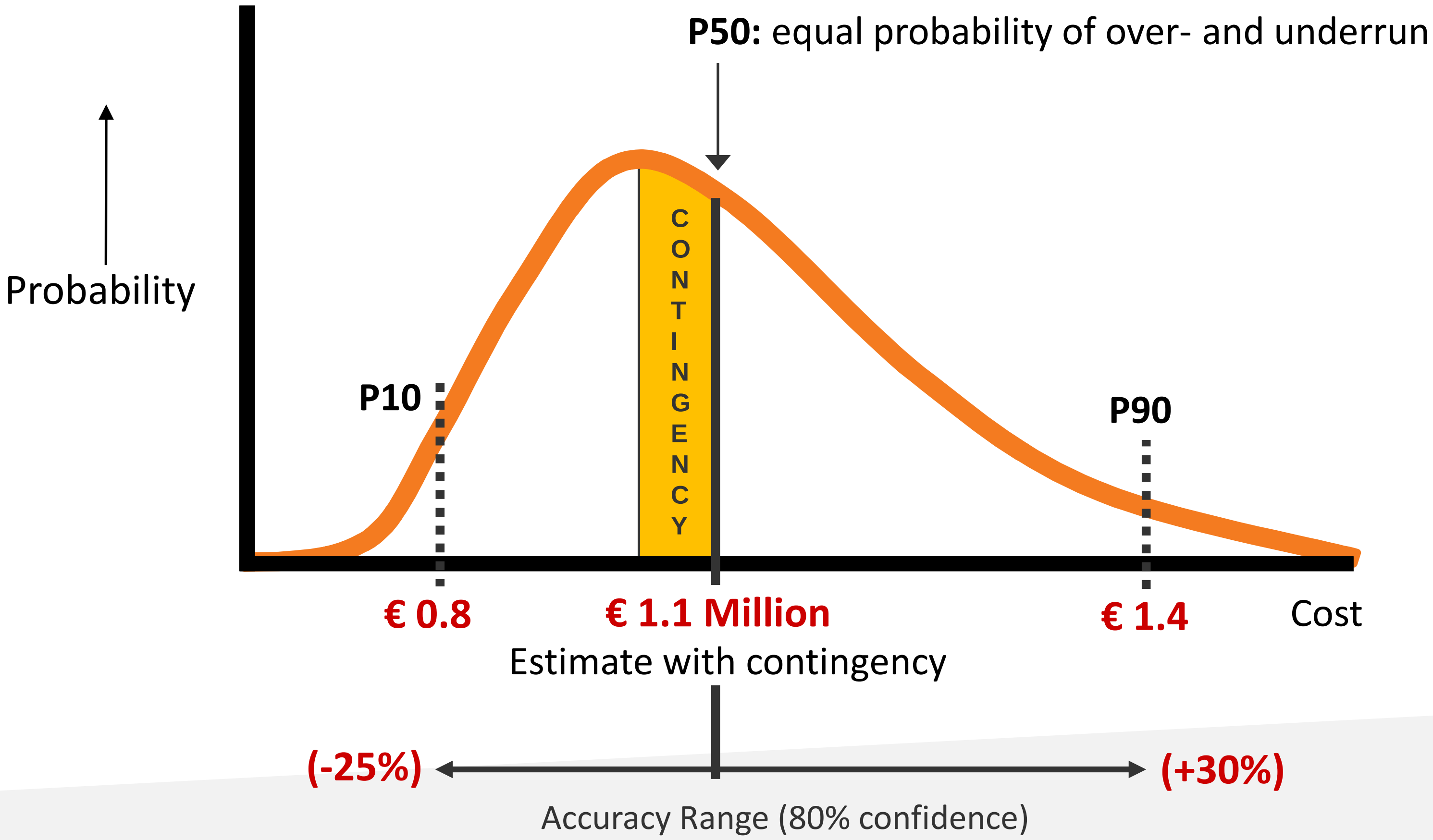
Accuracy of the estimate

- An estimate should not be regarded as a single point number (or cost)
- An estimate is a **range of potential cost outcomes**, and associated probabilities of occurrence
- Thus – the accuracy range of an estimate is a probabilistic assessment of how far a project’s final actual cost can be expected to vary from the estimate
    - **The range is driven by risks**

Estimate Accuracy Range

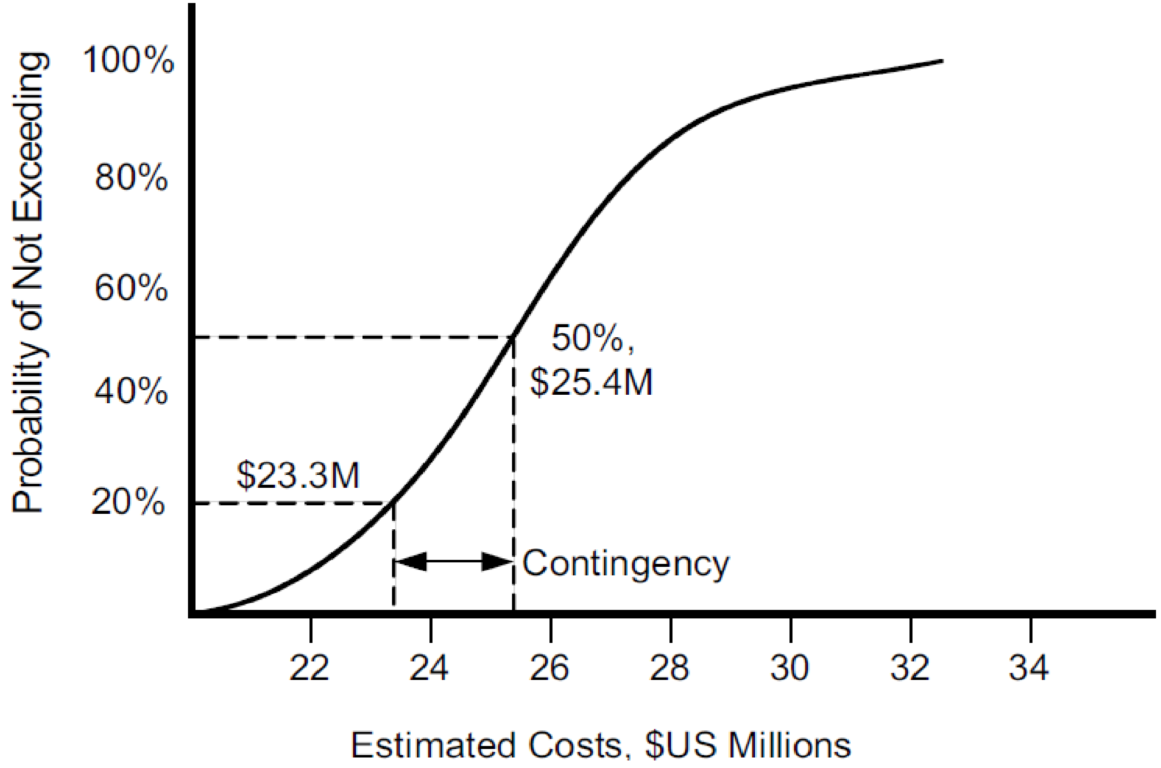


Estimate Accuracy Range

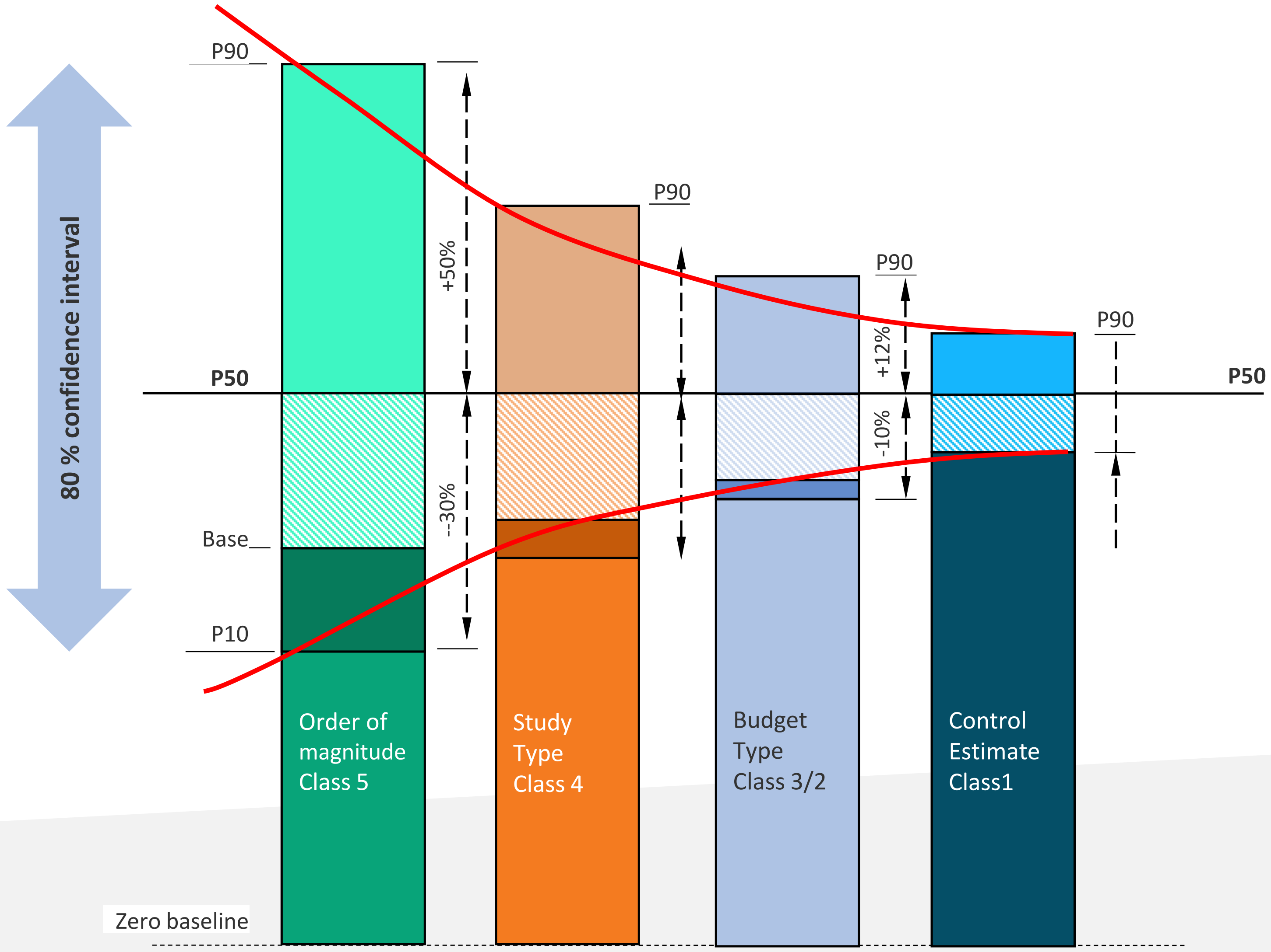


Accuracy and contingency

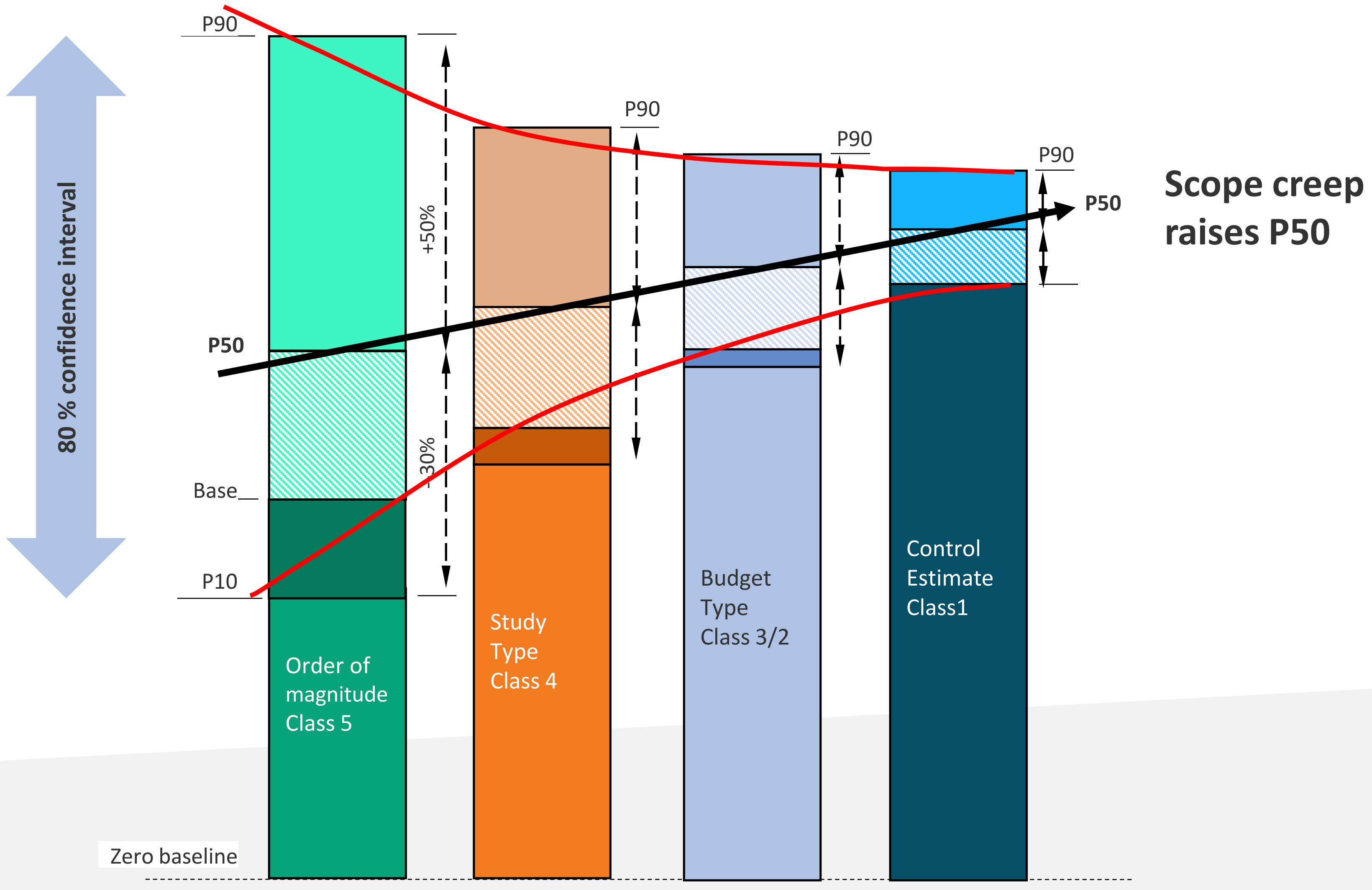
- Contingency does not increase the accuracy of the estimate
- Contingency reduces the probability of overrunning the budget
- **Management decides**



Estimate Accuracy and Project Definition



Estimate Accuracy and Project Definition



What defines the accuracy?

Influences on the estimate

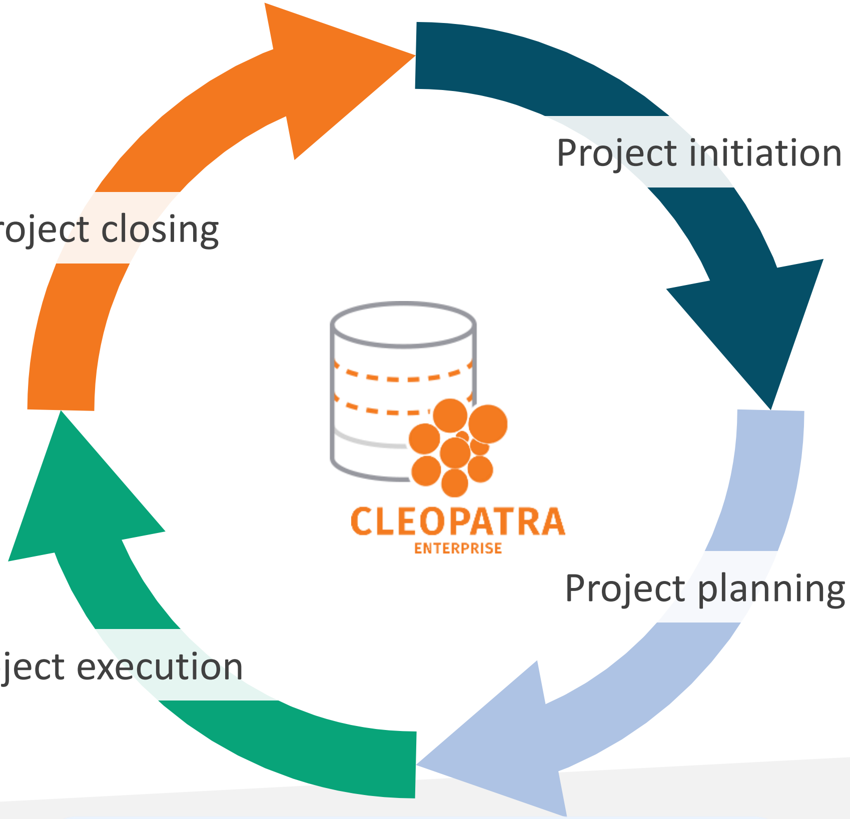
- Scope definition
- Software Tools
- Database
- Risk
  - Systemic risk (driven by organisation)
  - Project-specific risk
- Market influences
- Knowledge of the cost engineer

Benchmarking and continuous improvement

Benchmarking for continuous improvement

Benchmarking:
Develop metrics and
characteristic values

Gather
key quantities



Early estimates using factors
and parametric models

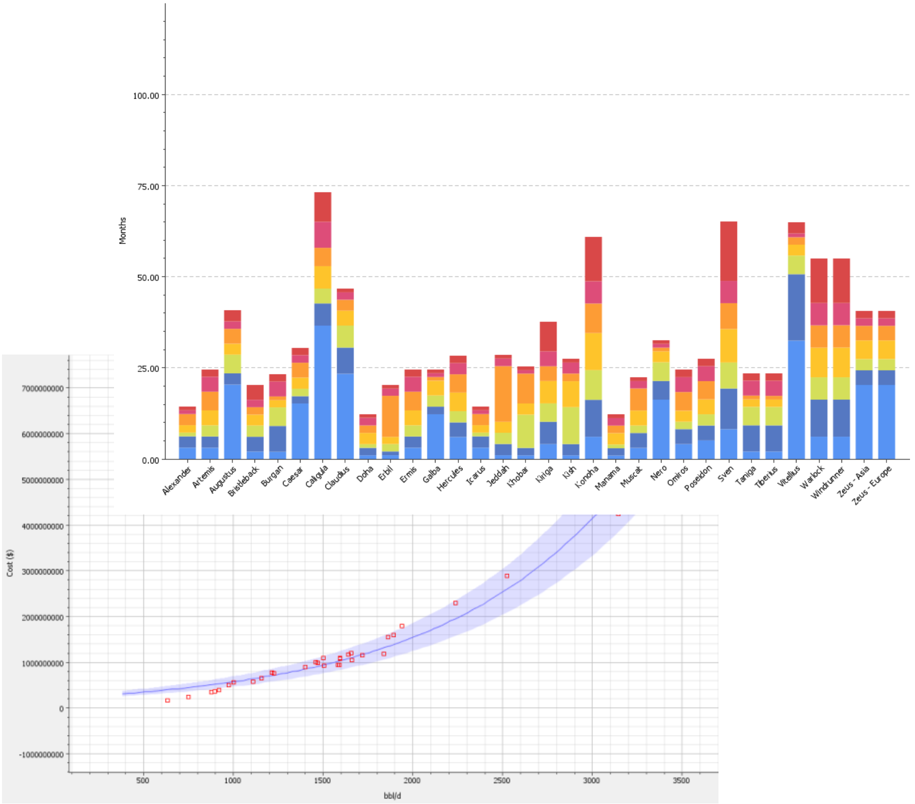
€ ✖ TIC factor

Quantitative estimating
using key quantities

Detailed Estimate
Based on detailed Material Take-Off

Examples

- Cost & schedule competitiveness
  - How did the project perform compared to similar projects (internal and/or external)?
- Cost & schedule factor
  - How does productivity compare?
- Cost & schedule growth
  - How good were the estimate and schedule at predicting final outcomes?



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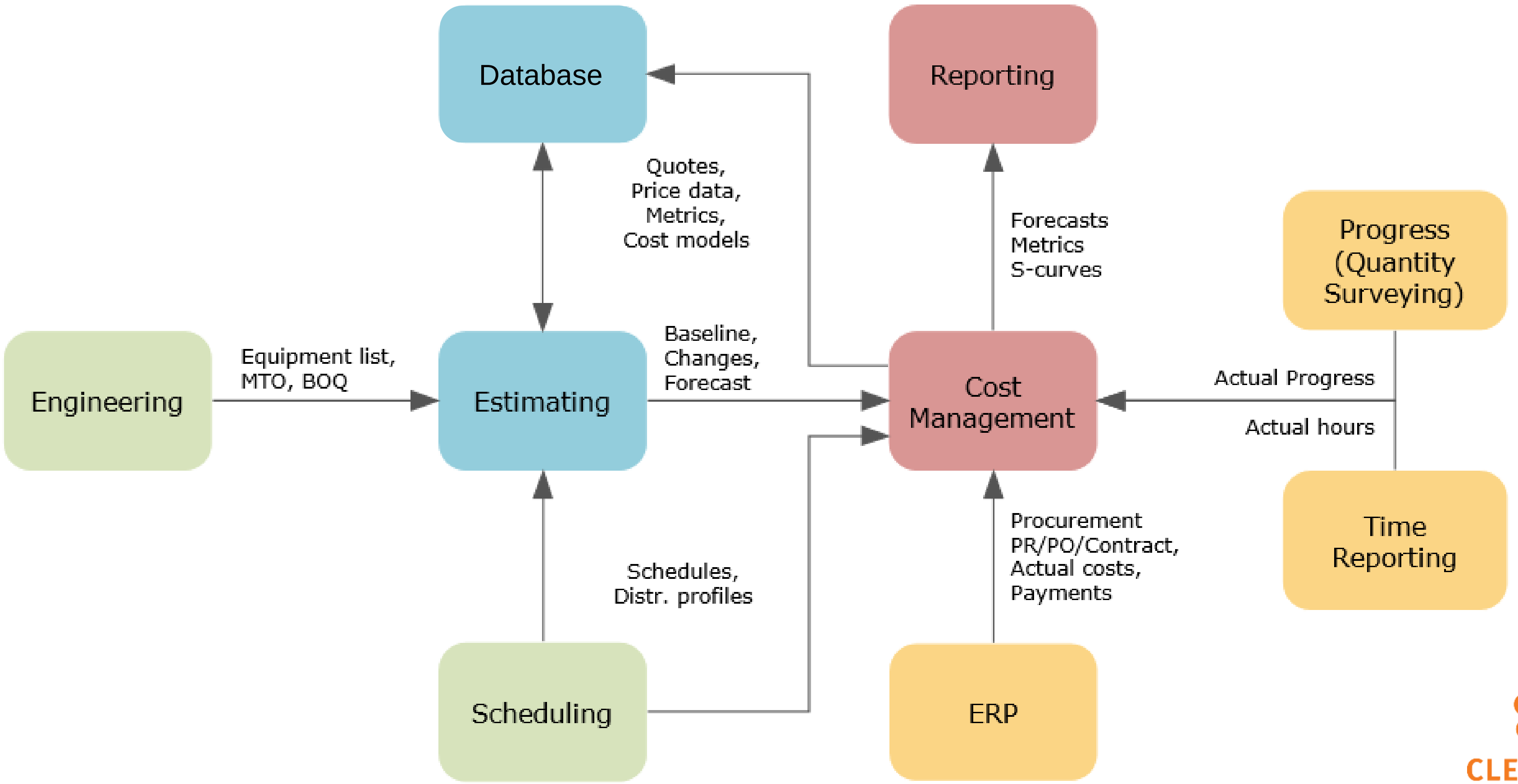
Integrated software for continuous improvement

- Software systems support an integrated approach.
  As a result, maximum performance can be achieved.
- Examples:
  - Setting up a **transparent budget** meeting stakeholder requirements.
  - **Monitoring** of project costs and planning during execution
  - **Visualize** performance indicators / KPIs
  - Provide improved **forecasting** information
  - Perform **Big Data** analysis to retrieve meaningful ratios and metrics from projects to Benchmark and calibrate estimating data.

Integrated software for continuous improvement



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