Town Hall

Data, Benchmarking, and Validation

Baqun Ding (Independent Project Analysis, Inc.)
John Hollmann (Validation Estimating, LLC)

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Town Hall

Data, Benchmarking, and Validation

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BAQUN DING

Capture, Analysis and Use of Historical Project Data for Reliable Benchmarking

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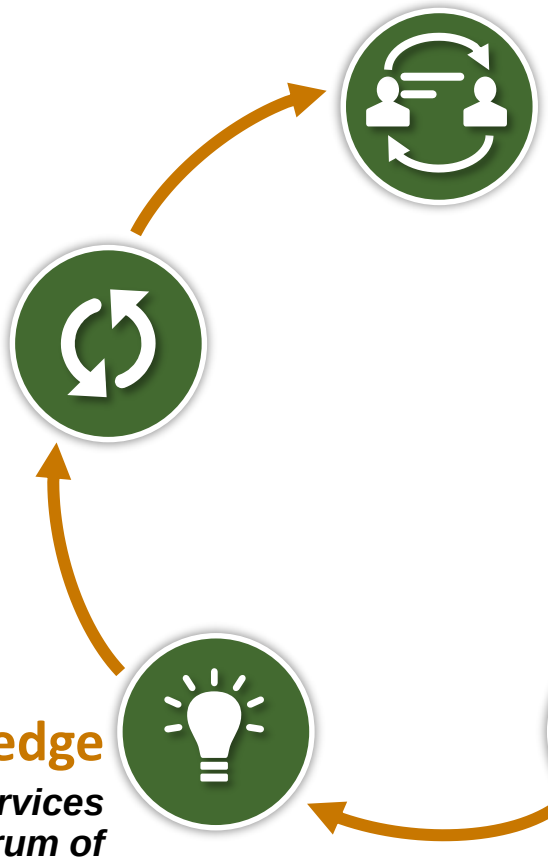
Topic

- *IPA Model*
- What To Benchmark
- How to Benchmark
- What Is Critical

IPA's Unique Model



Collect Data

Actual data direct from the project teams

Carefully Normalize Data

Make fair comparisons for benchmarking and research

Research

Use statistical models to analyze data to link practices and results and identify trends

Transfer Knowledge

Develop products and services that span the full spectrum of project system improvement

Enrich Database

Data and client feedback to update database and tools

Cost Engineering

Helping Understand Capital Cost

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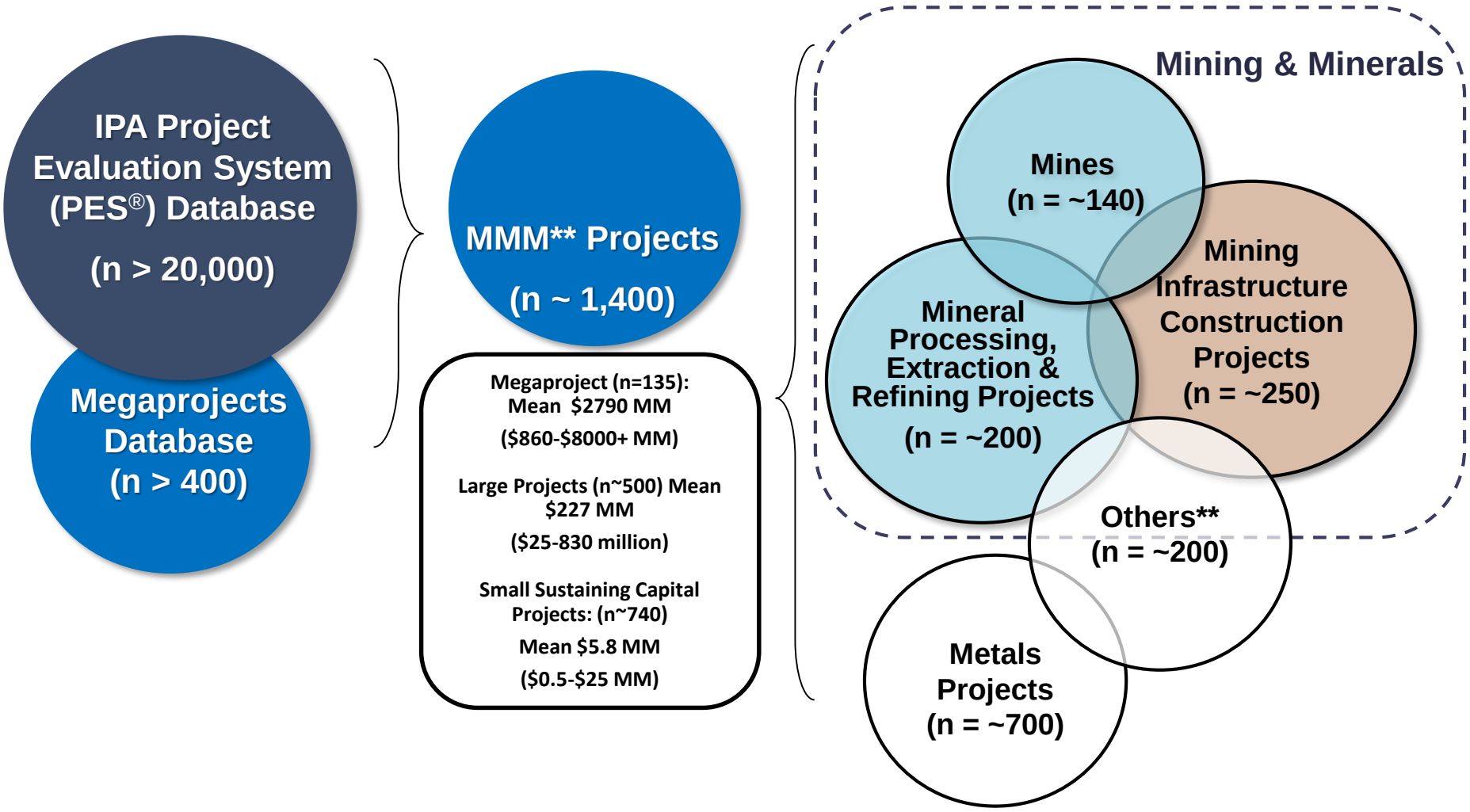
Outline

- IPA Model
- *What to Benchmark*
  - ***Database and Mining Project Cost Metrics***
- How to Benchmark
- What Is Critical

IPA Database:

Basis for Benchmarking Analysis and Researches



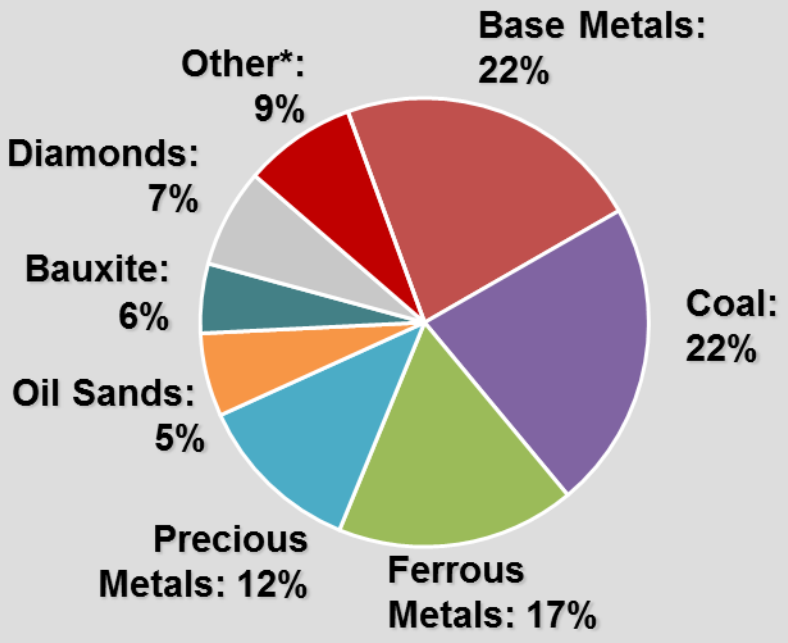
* *PES is a registered trademark of IPA*

** *Mining, Minerals, and Metals*

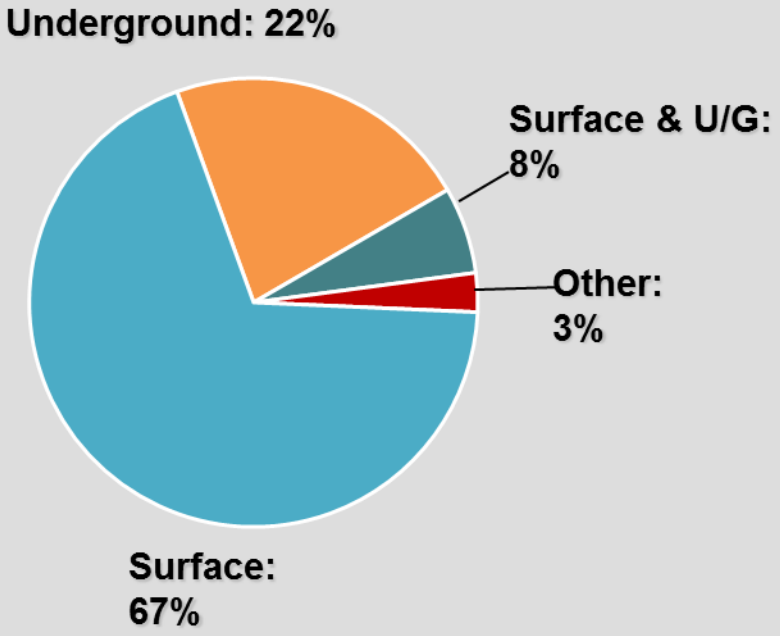
*** *Uncategorized site based small revamp sustaining capital projects, e.g., utilities upgrade projects, environment compliance projects*

Mine & Minerals Project Database Characteristics

Minerals



Mine Type



** Other: phosphate, uranium, industry minerals, and salt*

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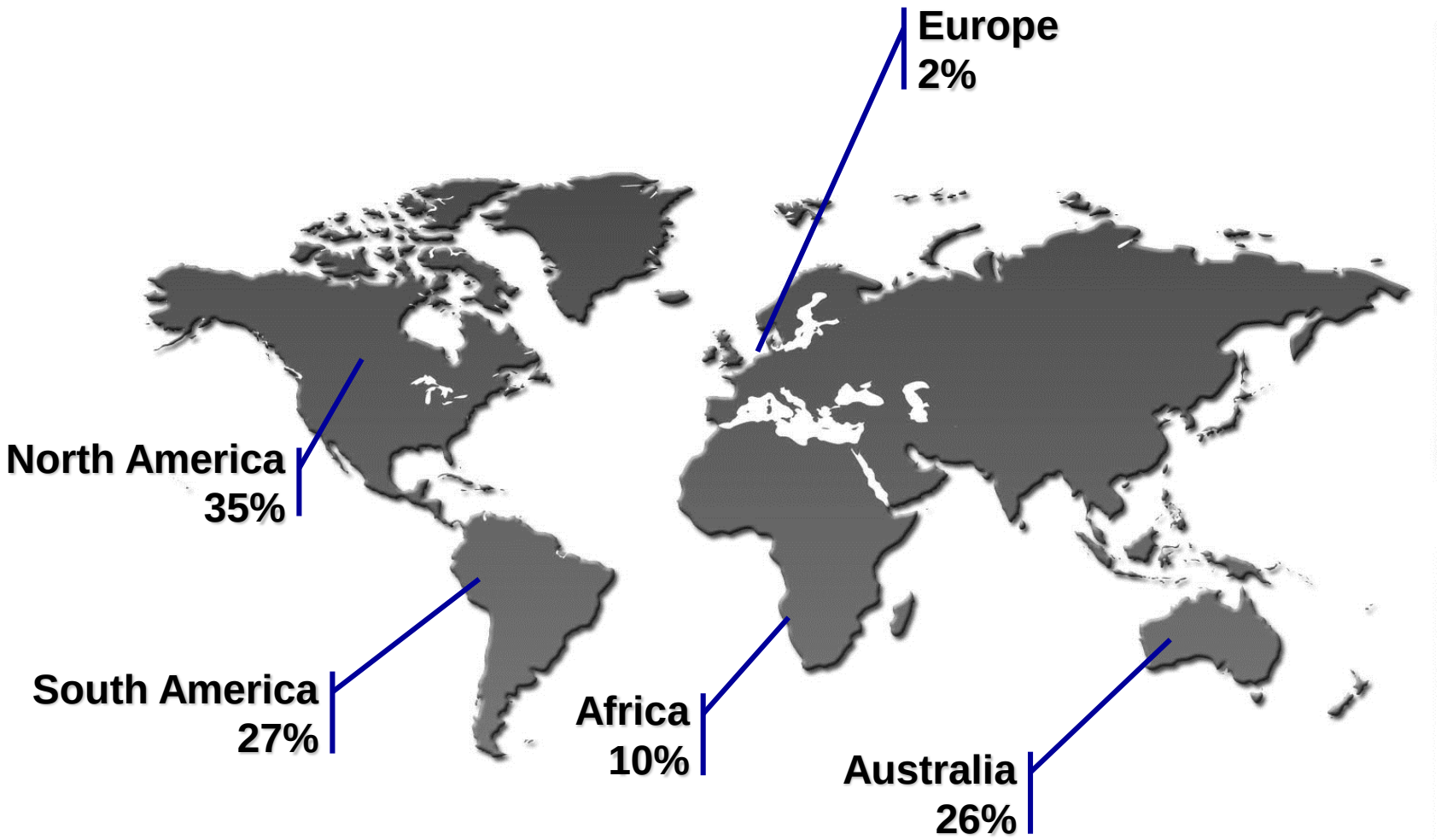
Mining and Minerals Projects Geographical Distribution



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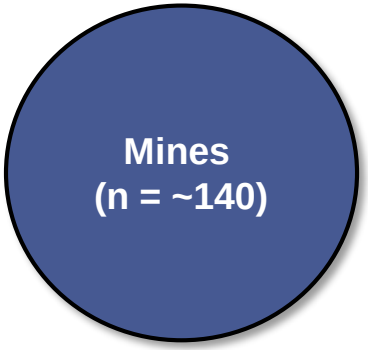
What to Benchmark – Mine Scope



- **Surface mines**
- **Underground**
  - **Shaft/ramp development**
  - **Depth 200–3,500 m**
  - **Ventilation systems**
  - **Refrigeration**
  - **Underground pumping system**

- Surface mine development cost ($/ton ore)
  - Equipment costs ($/ton of ore)
- U/G mines development cost ($/ton ore)
  - Shaft sinking costs ($/depth-dia)
  - Mining equipment costs ($/ton ore)
  - Portal construction ($/ton ore)
  - Hoist system costs ($/ton ore)
  - Lateral development costs ($/m or $/ton ore)
  - Vertical development costs ($/m or $/ton ore)
  - Refrigeration (cooling) system ($/ton ore, or $/hp)
  - Ventilation system costs($/hp)
  - Underground communication cost ($/t ore)
  - Sublevel caving development costs ($/ton ore, or $/ton reserve base)

What Metrics IPA Can Currently Provide

Concentration Plant Metrics Are Available

- Concentration
- Leach Pads
- Auxiliary process facilities

- **Cost Metrics**
  - Concentration plant cost/ton
    - Eqp cost $/ton
    - Bulk cost $/ton
    - Labor cost $/ton
    - Office cost $/ton
    - Direct cost $/ton
    - Indirect cost $/ton
  - Leach pads (including collection) cost/m^2
  - ADR facilities $/ton ore processed
  - SX-EW facilities $/ton ore processed
  - Auxiliary facilities
    - Reagent production
    - Lab
    - Maintenance
    - Other supporting facilities
    - Power
    - Water
- **Quantity metrics**

What Metrics IPA Can Currently Provide?

Most Infrastructure Scope Metrics Are Available

Mining Infrastructure Construction Projects (n = ~250)

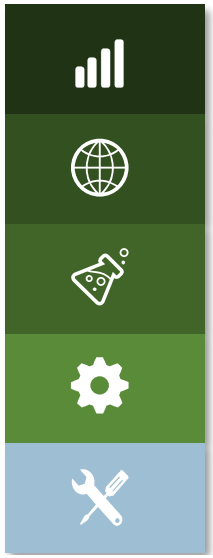
- **Cost Metrics:**
  - **Access roads $/km**
  - **Powerline $/km**
  - **Pipeline $/km**
  - **Port facilities $/ton**
    - **Storage and handling**
    - **Loading and oceangoing**
  - **Railway $/km or $/ton**
  - **Rail track construction $/km**
    - **Subcategory costs $/km**
  - **Tailings management $/ton**
    - **Initial/total**
    - **Site prep and embankment**
  - **Camp $/bed**
  - **Power generation $/KW**
  - **Water process Plant**

How Does IPA Provide Benchmarks?

1. Study project characteristics
   - **Establish basis of comparison**
   - **Select cost models**
2. Normalize the cost
3. Develop benchmarks using statistical models
   - **Overall costs**
   - **Specific categories of costs**
4. Identify the drivers of the overall cost targets or final cost outcomes
   - **Cost ratio analysis**
   - **Quantity-based analysis**

1. Study of Project Characteristics

Inherent Project Characteristics Influence Outcomes



Project size

Location

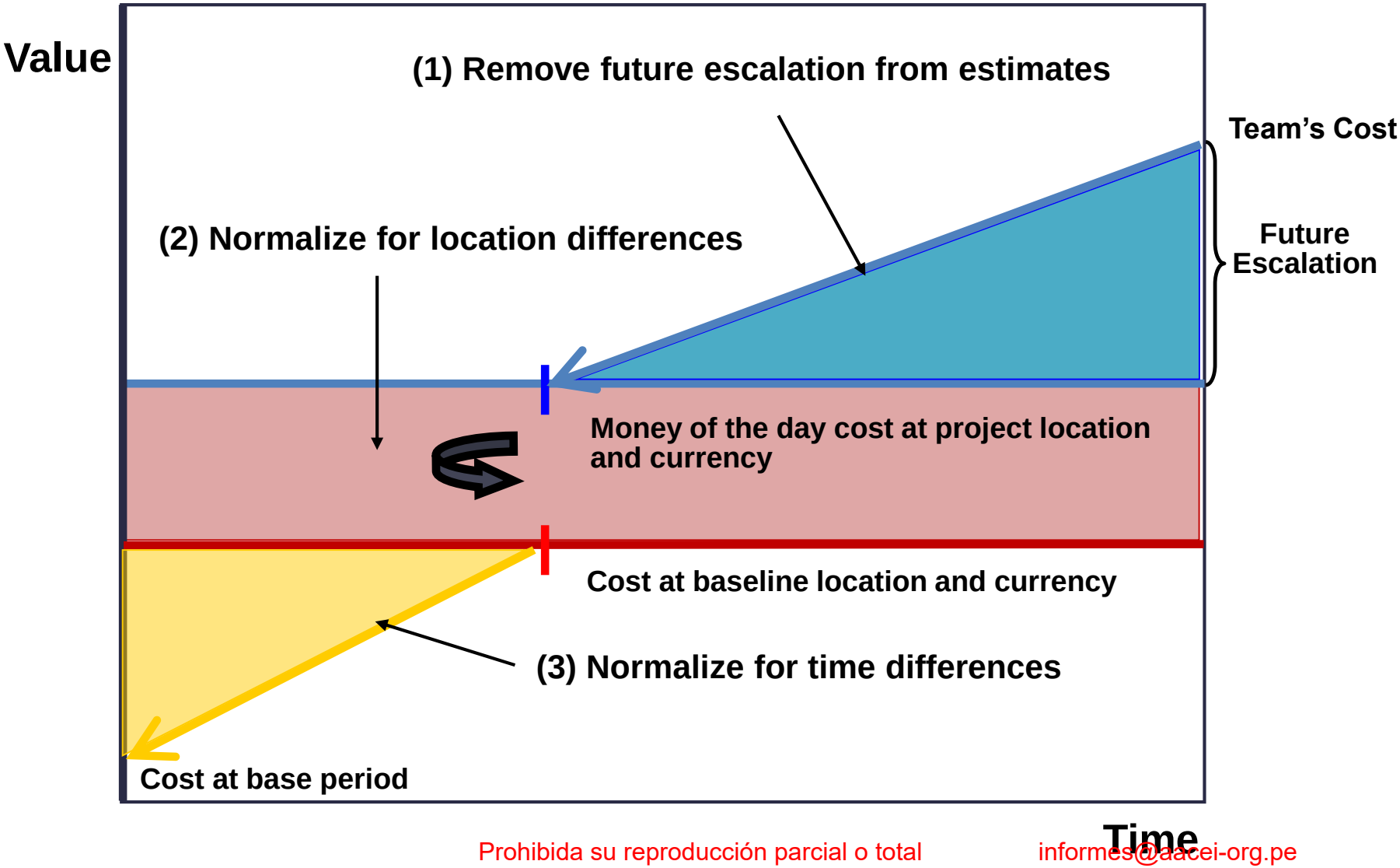
New Technology

Technical Complexity

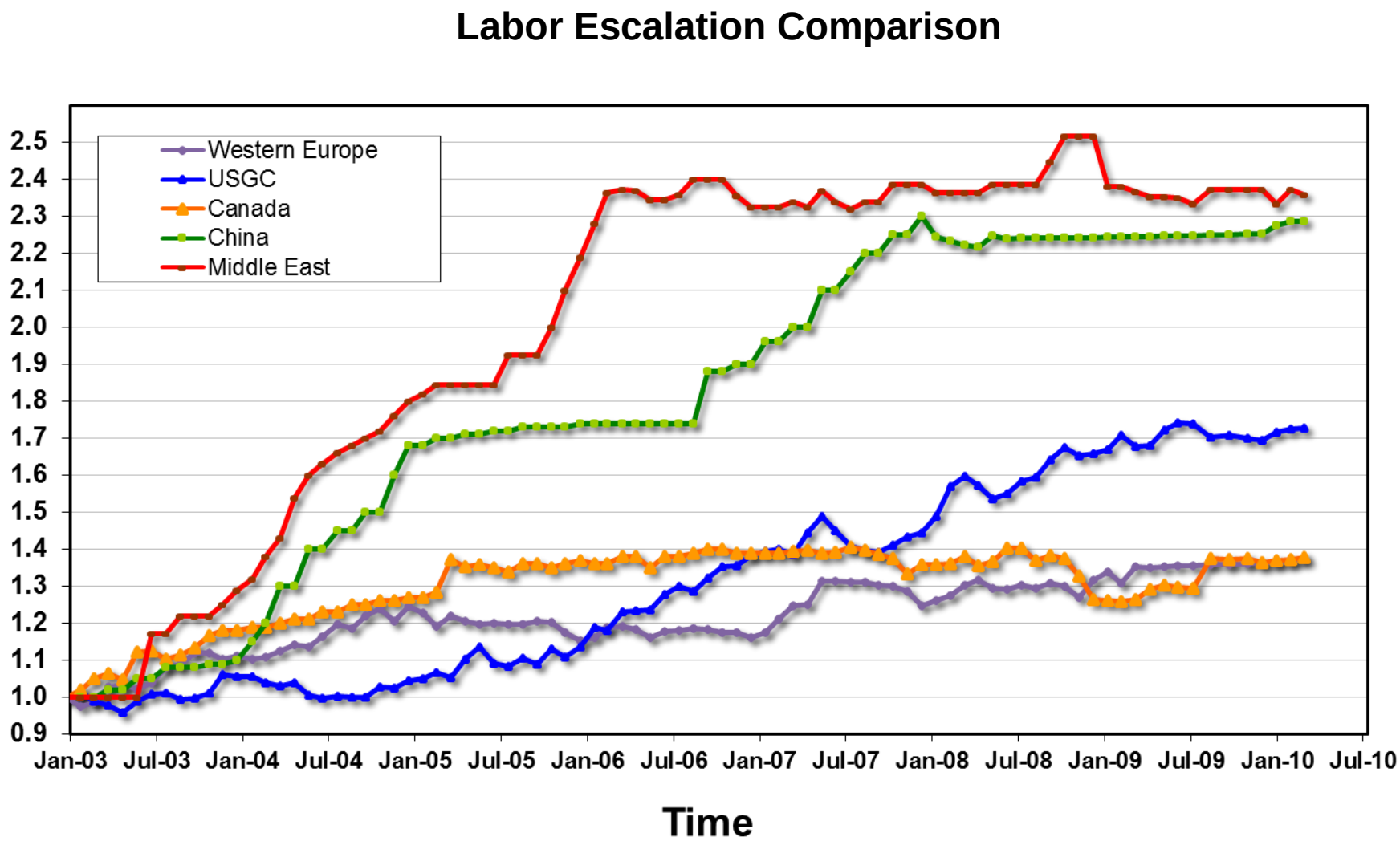
Degree of Revamp

- We extract project subset(s) from the PES® database
  - **Similar characteristics to serve as a comparison basis**
  - **Used to validate model outcomes, provide a cost ratio analysis, and determine the project definition and startup durations**

2. Normalize Project Costs



We Continuously Tracks the Escalation of Different Cost Categories



Cost escalation trends are displayed in local currency

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3. Use Statistical Models to Develop Benchmarks

Conceptual Model of Project Performance

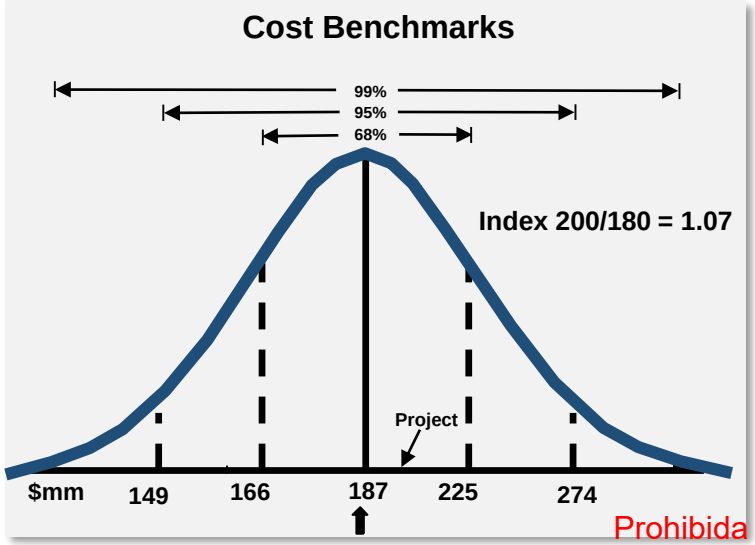
Basic Characteristics + **Technology** + **Project Practices** → **Project Outcomes**

- **Size**
- **Feedstock**
- **Project Type**
- **Other**

- **Innovation**
- **Complexity**
- **Processing Issues**
- **Commercial Status**

- **Front-End Loading**
- **Value Improving Practices**
- **Team Integration**
- **Contracting Strategies**
- **Turnover**

- **Cost**
- **Schedule**
- **Operability**
- **Achievement of Objectives**

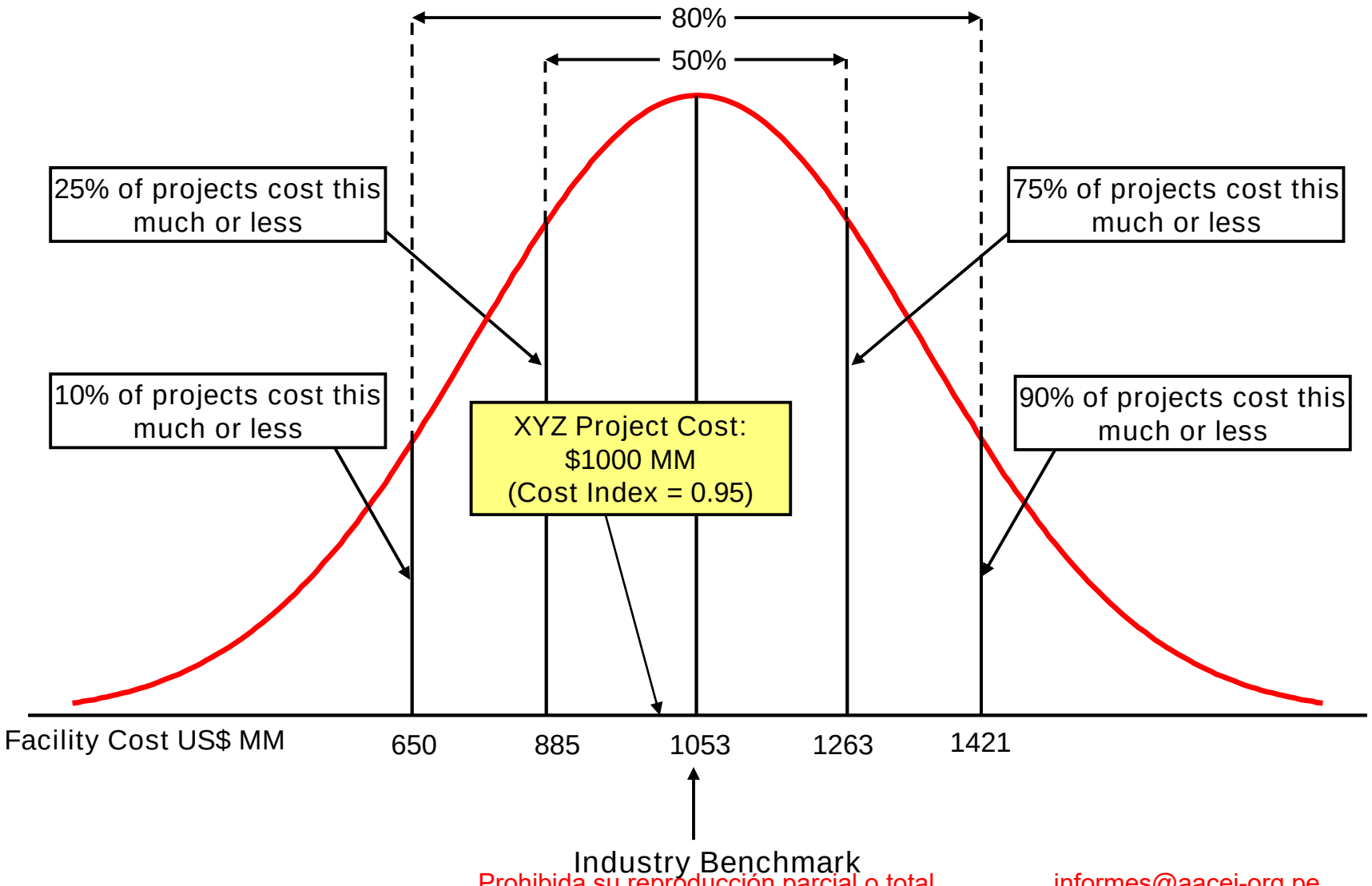


Statistical models provide the basis for:

- **Developing benchmarks with probability distributions**
- **Developing performance index:**

  Project Plan/Model Benchmark Value = Index
- **Comparing performance across projects and time**
- **Understanding what practices really work**

Benchmarks Allow Comparison with Industry



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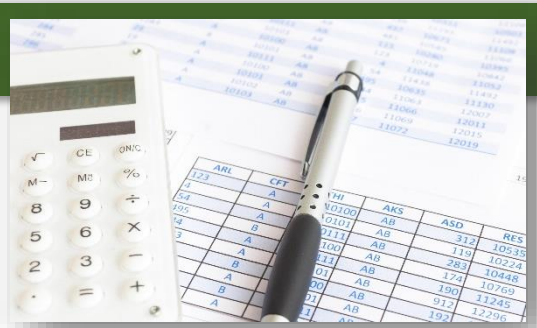
4. Identify Drivers of Project Costs Outcomes

- *Cost Ratio Analysis*

- Cost ratio analysis can help identify cost categories that drive overall cost effectiveness

Typical Ratios



$$\frac{\text{Office Cost*}}{\text{Equipment Cost}} \qquad \frac{\text{Office Cost}}{\text{Bulk Materials}}$$

$$\frac{\text{Bulk Materials}}{\text{Equipment Cost}} \qquad \frac{\text{Field Labor Cost**}}{\text{Equipment Cost}} \qquad \frac{\text{Field Labor Cost}}{\text{Bulk Materials}}$$

*** Office cost comprises project definition, engineering, and project management costs**

**** Field labor cost comprises labor, construction supervision, and other construction costs**

Cost Ratio Analysis for XYZ Project *(Example)*

Cost Ratio	Project Costs	Comparison Dataset Median (50 percent range)
Overall Lang Factor (TIC to Major Equipment)	4.52	5.15 (3.80–6.80)
Bulk Materials to Major Equipment	0.83	0.95 (0.61–1.07)
Office to Major Equipment	0.81	0.84 (0.45–0.75)
Project Definition to Equipment	0.17	0.18 (0.11-0.29)
Detailed Design to Equipment	0.22	0.31 (0.15–0.39)
Project Management to Equipment	0.36	0.38 (0.20 – 0.55)
Field Labor to Major Equipment	1.88	2.29 (1.67–2.77)
Construction Labor to Equipment	1.28	1.64 (1.44–1.89)
Construction Mgnt to Equipment	0.32	0.28 (0.17–0.39)
Other Construction Costs	0.28	0.31 (0.20–0.45)

Identify What Drive Cost Category High or Low

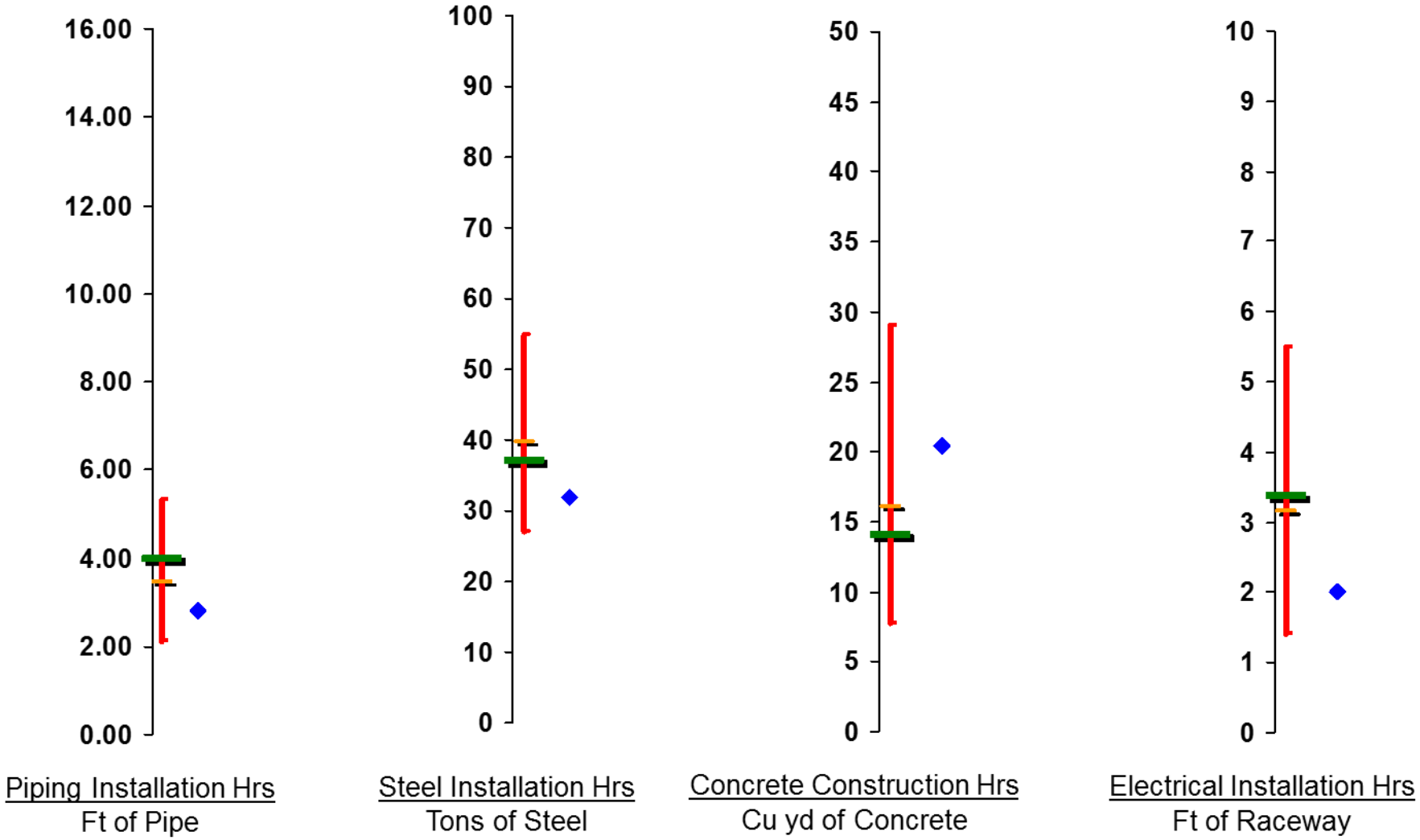
Quantity-Based Analysis

- Quantity-based analysis needs support of detailed cost breakdown with quantities provided; used to identify drivers of cost categories

Typical Metrics	Examples		
Costs per Quantity:	Office costs / Piece of equipment	Piping labor costs / Ft of piping	
Quantity per Quantity:	Ft of piping / Piece of equipment	Piping labor hours / Ft of piping	Tons of steel / Ft of piping
Quantity per Cost:	Instrument count / Cost of equipment	Foundation labor hours / Cost of equipment	
Cost per Cost:	Piping engineering costs / Piping costs	Structure steel costs / Cost of equipment	

XYZ Project Quantity Based Metrics (Example)

Labor Hours per Bulk Unit



Outline

- The IPA Model
- What To Benchmark
- How to Benchmark
- *What Is Critical*

Are Benchmarks Reliable?

Every Step of Benchmarking Relies on Clean Cost Breakdown

- Good number of projects – sufficient for developing benchmarks using statistical tools
- Good cost details
- Good benchmarking methodology
- But …. are you sure comparing apples to apples?
  - Do you consider access road as part of project development or infrastructure?
  - Do you consider village relocation as part of project-specific owner's cost or corporate business set-up costs?
  - Do you capture front end costs? from what stage on do you capture?
  - etc., etc.!

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JOHN HOLLMANN

The application of historical metrics for estimate validation as a precursor to risk analysis

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Validation as a Step in Risk Quantification

Validation – a step in estimate and schedule review processes whereby the end result is evaluated for its conformance with business cost and schedule strategy

Project Risk Quantification – integrated project cost and schedule risk analysis practices focused on providing probabilistic cost and schedule values for decision making and control purposes

They go together

Validation Starts with Establishing Strategy

Cost and Schedule "Strategy" – in the Basis of Estimate and Basis of Schedule, one must define what the base cost and duration estimates represent:

- Define the target: Are the base cost and duration estimates to be aggressive or conservative? (or do we let the estimator and scheduler do what they please)
- Validation: assures the strategy is achieved
- Bias: Defining a strategy is defining an intentional bias rather than accepting an accidental, uncertain one

Base Estimate Bias Drives Contingency

- Contingency = Value at Confidence Level – Base Estimate
- Therefore, any bias in the Base Estimate directly adds to or deducts from the contingency
  - i.e., Validation is a step in contingency estimating
  - Corollary: No validation = Lousy contingency estimate

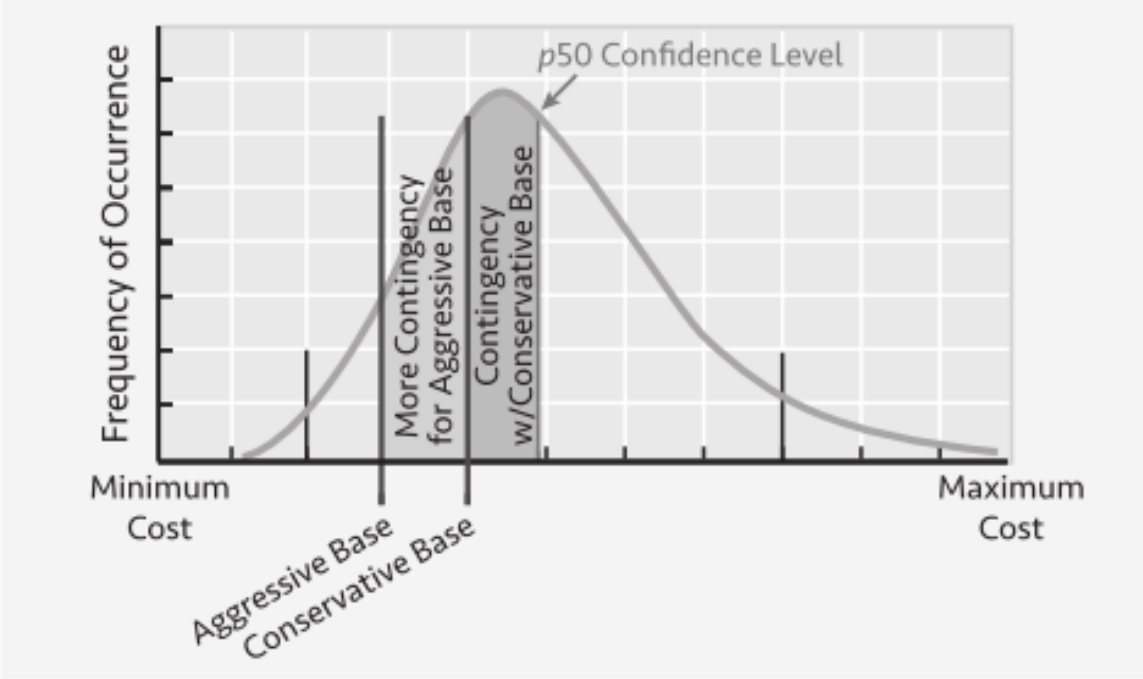

Figure 9.1: How Base Estimate Bias Relates to Contingency Determination

Re: PRQ book page 167

Simple Validation Example

- History of CIP concrete hours/CM
  - 5 records = 6, 7, 9, 13 and 18 hrs/cm
- Base Estimating Strategy options:
  - Aggressive: use p20 = 7 hr/cm
  - Conservative: use p50 = 9 hr/cm
  - Mediocrity: use mean = 11 hr/cm
  - Meh: use whatever feels right at the time = 13ish
- If your company funds at the mean, an *aggressive* strategy implies a contingency of 4 hours (11-7); while a *mediocrity* strategy implies no contingency (of course, there is a lot more to risk analysis; this is just one risk)

Validation Methodology

- Validation uses multiple “metrics” or ratios
- Use a structured approach such as “ratio-to-driver” (one cost is *driven* by another cost or resource)
  1. Quantity/Quantity (e.g., concrete cubic meters/steel tonnes)
  2. Bulk Materials/Equipment ($/$)
  3. Direct Field Labor/Bulk Materials ($/$)
  4. Field Indirects/Directs ($/$)
  5. Engineering Hours/Quantities (e.g., structural engineering hours/steel tonnes)
  6. Engineering Hours/Direct Field Hours (hours/hours)
  7. PM and Owner’s Costs/Field and Engineering Labor ($/$)

Closing the Loop

- Tying back to Mr. Ding's topic, I hope you can see the importance of historical data analysis for reliable benchmarking as well as validation….and risk analysis
- PS: my June 2018 AACE paper in San Diego will be on *Estimate Validation* (potential AACE RP)

QUESTIONS/COMMENTS? (PLEASE USE INTERACTIVE POLLING TURNING SYSTEM)

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