Cost Engineering from an International perspective
ICEC X World Congress
The mission of the International Cost Engineering Council (ICEC) is to promote the profession and cooperation between cost management and project management societies worldwide for their mutual wellbeing and that of their individual members.

ICEC was founded in 1976 by the American, Dutch, British, and Mexican Cost Engineering Societies.

ICEC has, through its members, access to more than 300,000 cost engineers, project managers and quantity surveyors in over 120 different nations.
Major Objectives

1. To encourage, promote, and advance the sciences and arts of cost engineering, quantity surveying, and project management for the public good, worldwide;

2. To coordinate and sponsor International Cost Engineering, Quantity Surveying and Project Management Congresses (on a worldwide scale);

3. To coordinate and sponsor International Cost Engineering, Quantity Surveying and Project Management Symposia (on a continental scale);

4. To encourage cost engineers, quantity surveyors and project managers in countries where no formal association or organization exists to form a group with objectives compatible with those of ICEC and its members;

5. To participate in international events related to the practice of cost engineering, quantity surveying and project management sponsored by governmental and private organizations, national or international, whether members of ICEC or not, provided that these events are in keeping with the objectives of ICEC;

6. To further the study of cost engineering, quantity surveying and project management problems of worldwide or multinational character; and

7. To encourage the development of professional certification programs in cost engineering, quantity surveying and project management.

8. Collaborate with the United Nations and other international and regional agencies in the formulation and implementation of policies affecting construction and engineering development with respect to cost, procurement and project management at policy, strategy and implementation levels of economic and social development programmes.
International Cost Engineering Council (ICEC)

a worldwide confederation of Cost Engineering, Quantity Surveying and Project Management Societies

- Region 1: Americas
  - (AACE International, CICHonduras, CanadianIQS, GOGRCostos, IBrazilEC, SMexicoIEFC)
- Region 2: Europe and near East
  - AcostE(UK), AICE(I), CAPQS(Cyprus), DACE, DPM(DK), DVP(D), GTE, CICES(UK), PMA(A), PMG(Greece), RACE (RO), SPR (SK), SMaP(F), SPR(CZ), VSF (Iceland), ZPM (Slovenië)
- Region 3: Africa
  - ASouthAfricaQS, GhanaIS, INamibianQS, IQSKenia, MauritiusAQS, NigerianIACE, NigerianIQS, South AfricanPCI
- Region 4: Asian Pacific
  - AustralianIQS, AustralianCES, BSIJapan, ChinaECA, FijiIQS, Hang Kong IS, IPM Skri Lanka, IQS Skri Lanka, Philippines ICQS, RIS Malaysia, New Zealand IQS, PMA India, Singapore ISV
Cost Engineering (the profession)

Cost Engineering and Quantity Surveying:

• Provide independent, objective, reliable and accurate capital and operating cost assessments usable for investment funding and project control.
• Analyze investment and development for guidance of owners, financiers and contractors

Estimate of capital costs
Operating costs
Manufacturing costs
Decision analysis
Appraisals
Planning & Scheduling
Risk Analysis
Site studies
Cost management

Contract management
Quality audits
Value management
Dispute resolution
Feasibility studies
Procurement management
Trending
Cash flow management
Life cycle costing
ICEC Action Plan 2016 - 2018

1. Develop written policies & procedures for ICEC:
   a) Write policies & procedures for production of the biannual World Congress;
   b) Other administrative policies & procedures as required

2. Establish a baseline Body of Knowledge that includes both cost engineering and quantity surveying:
   b) Update global inventory of Professional Standards/Best Practices
   c) Create baseline ICEC BoK
   d) Use the ICEC baseline to map the Body of Knowledge against that of IPMA

3. Develop action items for maximizing Memorandum of Understanding and Cooperative Agreements, with a focus on research:
   a) IPMA, FIG, RICS, PAQS, WFEO, KL Pact

4. Upgrade the ICEC website

5. Maintain and grow ICEC membership
   a) Identify existing organisations that are not ICEC members
   b) Promote the formation of new member organisations in areas underserved by ICEC
   c) Focus on keeping existing members
ICEC Action Plan 2016 - 2018

6. Significant increase marketing of ICEC
   a) Identify corporate sponsors
   b) Enable ads in the published ICEC Roundup and the website
   c) Develop regional activities in conjunction with regional board meetings
   d) Develop more professional-looking promotional materials

7. Develop a strategy for the participation of younger members in ICEC activities

8. Update the online journal

9. Improve the Bi-Annual Roundup Newsletter

10. Integrate research and education programmes into ICEC activities
    a) Identify network of academicians and researchers
    b) Identify support from universities
    c) Create a list of coursework providers

11. Coalition Member of International Construction Measurement Standard

12. Continue efforts toward development and implementation of United Nations Strategy
    a) Includes Central Product Classification (CPC) with the Economic and Social Council (ECOSOC) and World Trade Organisation (WTO)
Figure 2.3-1. The Strategic Asset Management Process Map
World Congresses ICEC


1. 1998 Rotterdam, Nederland
2. 2000 Calgary, Canada
3. 2002 Melbourne, Australia
4. 2004 Cape Town, South Africa
5. 2006 Ljubljana, Slovenia
6. 2008 Toronto, Canada
7. 2010 Singapore, Malaysia
8. 2012 Durban, South Africa
9. 2014 Milan, Italy
10. 2016 Rio de Janeiro, Brazil
11. 2018 Sydney, Australia
12. 2020 Region 3 Africa
13. 2022 Region 2 Europe
• Rio de Janeiro
• 2 days ICEC meeting
• 3 days World Congress
• 500 delegates
• Panel discussions:
  – Innovative trends in Project Management
  – The reality of Cost Engineering Worldwide
  – Public Construction Bids
• 87 presentations
Why Schedule Delay Analysis Methodologies Yield Different Results

AACE RP No 29R-03

Forensic Schedule Analysis

TCM Framework 6.4
# How Many Methodologies?

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Recall that AACE broke down the methodologies into nine types, but they fell into four “families” of methodologies:

- As-Planned v. As-Built (APAB)
- Windows (Contemporaneous Period Analysis - CPA)
- Time Impact Analysis (TIA)
-Collapsed As-Built

This designator of four is often used because the sharpest methodological distinctions fall between these four [*]

As-Planned vs. As-Built

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Owner-caused delays
Contractor caused delays
Added, non-contractual work that is not on the As-Built Critical Path

DDO: 04 Jan 13
DDAB: 17 Dec 13
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*Windown: DD1: 04 Feb 13

*DD2: 14 Mar 13*
Prospective Time Impact Analysis (TIA)

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### Impacted Schedule (with As-Built Delay Activity)

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DD: 04 May 13
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<tr>
<td></td>
<td>J</td>
<td>F</td>
</tr>
<tr>
<td><strong>As-Built Schedule</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity B</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Owner Delay 1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity C</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity D</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Owner Delay 2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity E</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity F</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Predicted Completion</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Collapsed As-Built Schedule</strong></td>
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</tr>
<tr>
<td>Activity A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity B</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Owner Delay 1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity C</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity D</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Owner Delay 2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity E</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Activity F</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Predicted Completion</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Why Different Results?

Assume the experts mean well but still don’t agree

- Different data
- Different objectives
- Different methodologies

Do different methodologies yield different results?

- Conventional wisdom
- Expert Studies
- Attorneys’ frustration
- Unconscious bias
- Selection of data
Why Different Results?

Perceived Wisdom:

• **Different Methods Give Different Results**

Each method is a tool that has been accepted in a certain set of circumstances.

• **Proper method selection is key**
• **Some methods are not appropriate to a given set of facts on a specific case**
Combined Cumulative Delay Graph

Prospective Time Impact Analysis

Collapsed As-Built

Retrospective TIA (Windows)

As-Planned v. As-Built

Contractor Progress Delays

Owner Delay

Retrospective TIA

(Windows)
Method’s Effects on Apportionment

<table>
<thead>
<tr>
<th>Windows/ MIP 3.3</th>
<th>Windows/ MIP 3.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner: 37%</td>
<td>Owner: 52%</td>
</tr>
<tr>
<td>Contractor: 39%</td>
<td>Contractor: 13%</td>
</tr>
<tr>
<td>Weather Period: 24%</td>
<td>Weather Period: 35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>Period</th>
<th>Windows</th>
<th>TIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions - 1

• Most Common Reasons for Different Results:
  • Wrong methodology for the intent
  • Bad data
  • Different interpretation of data
  • Manipulation
  • Performing the method incorrectly

• EVEN if these are not the reasons:
Conclusions - 2

• Different methodologies produce different results because they measure delay differently
• Delay Methodologies depict the delay occurring at different times
• A learning curve is a mathematical description of workers’ performance in repetitive tasks (Wright, 1936)
• Learning (or experience) curves assume that performance (output) improves as a task is repetitively performed, which is attributed to experience that is accumulated by the individual or group performing the task. (Grosse et al., 2015)
LEARNING CURVE

• Rule-of thumb named “80% learning curve” that was widely applied in the aeronautical industry of the time.
• According to that rule cumulative assembly costs are reduced on average by 20% as the number of units is doubled.
LEARNING CURVE

• Factors contributing to this improved performance include (Salameh et al., 1993):
  • more effective use of tools and machines,
  • increased familiarity with operation tasks and work environment,
  • enhanced management efficiency

• LC assumes no major change in product design, production process, workforce composition, and interval between units.
Several models are developed to overcome this problem in the literature. Most commons are summarized below:

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning-Curve</th>
<th>Model</th>
<th>Usually measures learning as</th>
<th>Typical Learning Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WLC</td>
<td>$y_x = y_1 \cdot x^{-b}$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
<tr>
<td>2</td>
<td>PM</td>
<td>$y_x = c + y_1 \cdot x^{-b}$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
<tr>
<td>3</td>
<td>SBM</td>
<td>$y_x = y_1 \cdot (x + B)^{-b}$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
<tr>
<td>4</td>
<td>DJM</td>
<td>$y_x = y_1 \cdot (M + (1 - M) \cdot x^{-b})$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
<tr>
<td>5</td>
<td>SCM</td>
<td>$y_x = y_1 \cdot (M + (1 - M) \cdot (x + B)^{-b})$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
<tr>
<td>6</td>
<td>JGLCM</td>
<td>$y_x = p \cdot y_1 \cdot x^{-b_1} + (1 - p) \cdot y_1 \cdot x^{-b_2}$</td>
<td>reduction in time/cost</td>
<td><img src="cumulative_units" alt="Cumulative Units" /></td>
</tr>
</tbody>
</table>
According to Wright’s log-linear learning curve, a single learning rate is applied in a model for different types of Works: as the cumulative production goes to infinity the result of the model goes to zero, which is impossible.

According to the “plateau learning curve model”, learning is flattened after a certain point of production. This is also not practical in real life because learning, although in a very little rate, is observed continuously.
PROPOSED MODEL - MULTIPLE PHASE LEARNING CURVE

- Wright’s log-linear learning curve model can be used as having two or more legs and for each leg different learning rates can be applied. This means learning percent can change at some certain points of the curve. By doing so, the model can fit the data more accurately.
PROPOSED MODEL - MULTIPLE PHASE LEARNING CURVE

• Analysis of an actual data example:

\[ y = 429.15x^{-0.071} \]
\[ R^2 = 0.1442 \]
PROPOSED MODEL - MULTIPLE PHASE LEARNING CURVE

• Analysing data in three legs

<table>
<thead>
<tr>
<th>Units (Leg)</th>
<th>Learning Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st leg</td>
<td>1 - 50</td>
</tr>
<tr>
<td>2nd leg</td>
<td>51 - 150</td>
</tr>
<tr>
<td>3rd leg</td>
<td>151 - 715</td>
</tr>
</tbody>
</table>

• Actual data is divided into three legs and the learning percent of each leg is analyzed separately.
**PROPOSED MODEL - MULTIPLE PHASE LEARNING CURVE**

- **Summary of analysis**

<table>
<thead>
<tr>
<th></th>
<th>Actual Data</th>
<th>3-Legs (proposed model)</th>
<th>1-Leg (industry learning average)</th>
<th>1-Leg Trend Line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st unit</strong></td>
<td>795</td>
<td>795</td>
<td>795</td>
<td>429</td>
</tr>
<tr>
<td><strong>Learning Percent</strong></td>
<td>-</td>
<td>84%-98%-99%</td>
<td>85%</td>
<td>95%</td>
</tr>
<tr>
<td><strong>1st leg (1 - 50) average</strong></td>
<td>374</td>
<td>389</td>
<td>405</td>
<td>348</td>
</tr>
<tr>
<td><strong>2nd leg (51 - 150) average</strong></td>
<td>304</td>
<td>293</td>
<td>273</td>
<td>310</td>
</tr>
<tr>
<td><strong>3rd leg (151 - 715) average</strong></td>
<td>285</td>
<td>287</td>
<td>196</td>
<td>281</td>
</tr>
<tr>
<td><strong>All (1 - 715) average</strong></td>
<td>294</td>
<td>295</td>
<td>221</td>
<td>290</td>
</tr>
<tr>
<td><strong>SSE</strong></td>
<td></td>
<td><strong>1574803</strong></td>
<td><strong>1861078</strong></td>
<td><strong>6309765</strong></td>
</tr>
</tbody>
</table>
Contingencies for an Enterprise

Günter Banda Schulz-Nöthling
The Composition of an Investment Estimate

Direct Investments
- Engineering
- Growth Allowances

InDirect Investments
- Construction Camp Indirects
- Escalation
- Contingencies
- Risk and Opportunities
- Management Reserve
The Contingency Estimation Process

Quantitative Analysis

- Intensification of the engineering effort applied so far, in comparison with that necessary to conclude the project;
- Possibility of being associated with any project errors or omissions;
- Susceptibility to changes or updates to the project prior to implementation (excluding changes in scope);
- Qualification of the topographical survey and of geological-geotechnical investigations that support the quantitative surveys;
- Methodology for the calculations for the dimensioning of the planned structures;
- Degree of definition of the scope
The Contingency Estimation Process

• Based on the quantitative and qualitative analyses mentioned, percentage variation range groups are created. For each of these groups, subgroups with three scale levels are established.

• When the extreme and average limits for all the items listed in the estimate have been constructed and with the utilization of tools such as @Risk, it is possible to obtain the most likely probability distribution curve for the most likely values for an investment estimate, within a given confidence interval, which will lend support to the contingency values to be recommended.
Conclusion

There is no established universal methodology for estimating the total amount of provisions that should be made for a given project, let alone a single consensus regarding the concepts to be applied. However, it is of fundamental importance that there be a clear definition of the concepts and scope applied for Contingencies and Risks & Opportunities, including the clear definition of the items for which no provisions have been made, when applicable.
Alignment of Contingency Definition, Concepts and Estimate Methodology

Macedo, Helber da Cunha Ferreira, Cesar Teodoro Fonseca, Fabrizio C.R. Braga, Carlos Eduardo M.F.
Alignment of Contingency Definition, Concepts and Estimate Methodology

Motivation

- Competitive Market
- Risks and uncertainties
- Contingency
OBJECTIVE

Present a brief introduction of concepts and methodologies to estimate cost and schedule Contingencies on projects.

Differentiate contingency from other concepts such Allowance, Accuracy Range, Management Reserve.

Present an example of integrated cost-schedule risk analysis
Contingency is included in the baseline of the project, which is calculated and added to the estimated time and cost of the project.

**Schedule Contingency**
DEFINITION

Usually contingency tends to decrease with increasing maturity of the project and it is expected be consumed throughout the project execution.

Changes in Cost Estimate according to maturity
### Examples of items covered or not by Contingency

<table>
<thead>
<tr>
<th>Not included on Contingency</th>
<th>Included on Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major changes on contracting strategy.</td>
<td>Changes in the scope and development of engineering design or detailed.</td>
</tr>
<tr>
<td>Extraordinary events.</td>
<td>Changes in market conditions.</td>
</tr>
<tr>
<td>Major changes in the planning.</td>
<td>Errors and omissions in the project planning or cost estimate.</td>
</tr>
<tr>
<td>Management reserve and Allowances.</td>
<td>Variations in environmental conditions.</td>
</tr>
<tr>
<td>Exceptional Stand-by.</td>
<td>Small price fluctuations.</td>
</tr>
<tr>
<td>Escalation and exchange effects.</td>
<td>Risks associated with the selected technology.</td>
</tr>
<tr>
<td>Major changes in scope.</td>
<td></td>
</tr>
</tbody>
</table>
OTHER CONTINGENCY-RELATED CONCEPTS

Allowance - resources included in estimates to cover the cost of known but undefined requirements for an individual activity, work item, account or sub-account.

Management reserve - may include amounts that are within the defined scope, but for which management does not want to fund as contingency.
INTEGRATED COST-SCHEDULE RISK ANALYSIS

The main inputs to the analysis are listed below:

- Cost estimate free of any specific contingency, no risk impact must be included in the cost items;
- Quality resource loaded schedule. The schedule must also be updated and logically linked (the schedule should not contain open activities and lags should be avoided);
- Reliable and consistent risk data with probability and impact loaded;
- Compatibility between cost estimate and schedule. It’s not uncommon to find conflicting cost and schedule estimates. These makes the risk analysis very difficult or even impossible to be executed.
INTEGRATED COST-SCHEDULE RISK ANALYSIS

Example

Cumulative Distribution
Finish Date

Cost

Cumulative Distribution
Cost – Time Results
CONCLUSION

➢ The paper allows you to analyze the concept of contingency and related concepts from different institutions (AACE, GAO and PMI).

➢ It showed that the timing of the project can influence the choice of the most appropriate method for defining the contingency.

➢ Although organizations show contingency definition in different ways, alignment is necessary in order to eliminate misunderstandings among companies.

➢ An integrated cost and schedule risk analysis ensures that the results are consistent with project planning.
CHALLENGING THE CONTRACTING EXECUTION APPROACH FOR CONSTRUCTION PROJECTS

Qs Jennifer Musyimi, MBA
Council Member, Institute Of Quantity Surveyors Of Kenya, Board Member, National Construction Authority
CHALLENGING THE CONTRACTING EXECUTION APPROACH FOR CONSTRUCTION PROJECTS IN AFRICA

Order of Discussion:

- Contracting in Africa
- Competitive Advantages for Foreign Contractors
- Challenges Faced by African Contractors
- Reform Agenda
Foreign Contractors in Africa

- Globalization
- Africa is the next frontier
- Market demand is increasing due to the needs to build the infrastructure
- The global construction industry revenue as at 2011 - $5.8 Trillion and 60% in Africa
- And of these Foreign Contractors, the Chinese group has taken the lead in the recent years.
ESTIMATION OF CONCRETE VOLUME OF VERTICAL BUILDINGS BY MEANS OF LINEAR REGRESSION


Marcio Soares da Rocha
1 INTRODUCTION

Many real estate enterprises must have their costs estimated even before their projects are completely detailed. Most of the preliminary estimations are made based on the architectural drafts.
1 INTRODUCTION

In the parametric budgets, often the costs of the services are obtained in similar works already executed.

This type of budget has, according to the cited institutes, accuracies of approximately 80%; therefore, is more accurate than expeditious budgets.
One of the quantities that needs to be estimated in preliminaries budgets is the **volume of concrete**, once, only with the drafts, the structural project is not yet made.
1 INTRODUCTION

This work establishes an equation for estimating the volume of concrete in vertical buildings, which was deduced by means of multiple linear regression.
4 RESULTS

4.1 Estimate equation and statistics of the model

\[ V_{conct} = -189.1828879 + 27.28395776 \times N_{pvt} + 0.18296457 \times A_{pist} \]  \hspace{1cm} (5)

Where:
\( V_{conct} \) = concrete volume of the tower
\( N_{pvt} \) = number of floors of the tower
\( A_{pist} \) = paved floors area of the tower
4 RESULTS

Statistics of the model

- General Confidence level adopted = 90%
- Correlation Coefficient (R) = 0.9851
- Determination Coefficient (\(R^2\)) = 0.9704
- Adjusted Determination Coefficient (\(R^2_a\)) = 0.9664
- Standard deviation (e) = 76.1321 m\(^3\)
4 RESULTS

4.2 Limits for application of this estimating parameter

- Minimum number of floors: 04
- Maximum number of floors: 25
- Minimum floor area: 1,000.00 m²
- Maximum floor area: 13,300.00 m²
5 CONCLUSIONS AND SUGGESTIONS

5.1 General paper conclusion

The statistics and the results of the tests demonstrate the accuracy of the estimating equation deduced in the present study and its suitability as an preliminary estimator parameter of concrete volumes of the towers of vertical buildings whose physical characteristics are within the limits set out in 4.2.
Forecasting Engineering Design Project Errors

Authors:

• Otto M. Machado Filho
• Nelson F. F. Ebecken
Forecasting Engineering Design Project Errors

**Objective:** Improve the performance of engineering design projects, with the help of an expert system, which enables to anticipate potential design mistakes.
An expert system have been designed to capture the checklists answers and apply rules in order to present alerts with potential design errors.
METHODOLOGY - Gathering the Raw Data

Engineering design workflow (basic):

- Creation
- Verification
- Checklist Answers
- Errors?
- Yes ➔ Revision
- No ➔ Release

Expert system creates a database with all checklists answers.
METHODOLOGY - Rules Definition

Expert system will segregate the most frequent design errors by:
- **Professional profiles**: discipline (civil, piping, electrical…), experience (senior, junior…), sector (oil&gas, infrastructure…)
- **Documents characteristics**: type (drawing, datasheet, calculation…) discipline (civil, piping, electrical…), project…

Before a document elaboration, system will present an alert with the most frequent errors for specific professional and document features.

In case there are no representative checklist records in the database, system will reduce the constraints, considering errors for similar
IMPLEMENTATION

The Expert System was implemented in an Electronic Document Management System (EDMS), called SAPROD. EDMS are frequently used in engineering market. Some characteristics:

**MOBILITY:**
Access documents from any computer, tablet and smartphone with internet.

**AUTOMATIC VERSION CONTROL:**
Professionals share the latest version of the document. Prevents simultaneous edition.

**DOCUMENT WORKFLOW:**
Manage document lifecycle, enabling status and activities control.

**DOCUMENT CHECKLIST:**
Create documents checklist. Present most frequent errors ranking.

**COST AND TIME CONTROL:**
Assign document workhours and track documents budget and deadlines.

**REPORTS AND INDICATORS:**
A set of reports and indicators allows online management of project performance.
IMPLEMENTATION

Verifier must fill up the electronic checklist, embedded in the system.
IMPLEMENTATION

Before document elaboration, an alert will present the most frequent errors. The designer must confirm by clicking on the button “Ok, I’m aware”.
RESULTS

Real Scenario:
- Design engineering company - Rio de Janeiro - Brazil
- Two similar projects undergoing simultaneously (buildings)
- One project used the design errors methodology

As less workhours were spent in verification and revising stages, it has been verified a reduction of approximately 6.4% in the design cost.
International Measurement Standards: Space, Cost and Technology

Martin Darley, AACE – Trustee of ICMS
Alan Muse, RICS – Vice-Chair of ICMS SSC
Peter Smith, ICEC
Introduction

Problems applying BIM in construction:

• Data and decision-making
• Consistent professional processes
• Symbiotic relationship between standards and technology
Decision-making in construction

Generally:
• Recent trends and their influence
• More focus on technology to assist decision-making
• Accounting for complexity – space and cost
Decision-making in construction

Decision-making gateways:
- Plans of work
- Proceed in steps through gates
- Simplifies decision-making
Decision-making and BIM:

- Data drops
- Defining the requirements
- Compliance with space and cost
Technological Change

BIM:

- Opportunities and benefits
- Lack of standards
- UK experience
- Global imperatives
Technological Change

Big Data:

- Waste in construction
- Prediction and machine-learning
- Advanced analytics
Technological Change

Smart Cities:

• Urbanisation
• Utilising the data
• Opportunities and challenges
International Standards

• Global rules in professional services through coalitions

• Space - IPMS
  – Consistent floor area measurement and classification
  – Global deviation of 24%
  – Valuation, property management and construction

• Cost - ICMS
  – Consistent cost comparisons
  – High level cost presenting and reporting
  – Buildings and civil engineering

ICMS
INTERNATIONAL CONSTRUCTION MEASUREMENT STANDARDS
International Standards

Current progress:

- **IPMS**
  - Office buildings – Nov 2014
  - Residential buildings - Aug 2016
  - Industrial buildings – End 2016
  - Further sectors/mixed - use

- **ICMS**
  - Private consultation until mid-October 2016
  - Public consultation November 2016
  - Publication 2Q17
Industry Perspective

Example – Oil and Gas industry:

• Industry drivers and the need for standards
• Sector challenges and new paradigms
• Embracing new technologies
Industry Perspective

Construction generally:

- Comparison-resistant
- Problems in practice
- Simple, high-level, data required

Cost of building wind farms falls to new low

By Emily Gosden

THE cost of building offshore wind farms has fallen to a new low, with Sweden’s Vattenfall winning contracts to build two projects in Danish waters for just over €60 (£51) per megawatt-hour (MWh).

That undercuts the record set by Denmark’s Dong Energy, which in July won a contract for a Netherlands project at €72.70/MWh.

Although the prices are not directly comparable with those awarded in the UK, because they exclude grid connection costs which can be up to €30/MWh, they are nevertheless substantially cheaper than the most recent UK deals, awarded last year for about £120/MWh.

Magnus Hall, Vattenfall chief executive, said the deals showed it was “able to reduce the costs of offshore wind faster than had been expected”.

The award was also seized upon by critics of the Hinkley Point nuclear plant – provisionally been offered £92.50/MWh for 35 years – as fresh evidence the EDF-led project is too expensive.

Doug Parr, Greenpeace chief scientist, said: “We can expect more and more offshore wind bids to break records with falling prices in the coming years. This will make the price of electricity guaranteed for Hinkley look even more ill-advised.”

Despite the low price of the new contracts, the Danish government may scrap the projects because of concerns over subsidy prices.

(Source: Daily Telegraph - August 2016)
Conclusion

• Standards need technology – and technology needs standards
• Space and cost – critical to design and construction decisions
• IPMS and ICMS are important developments which all stakeholders need to adopt
International Construction Measurement Standards (ICMS) – Get Involved!

www.icms-coalition.org
Using EVM – Earned Value Management as a tool for monitoring the trend of time & cost in projects.
• What the Project status is, in regards the contractual completion date?

• What is the current Project cost situation and therefore its trend of profitability?
### Planned S Curve, summarized by the planned direct working hours

| Activity | Quantity | Control Unit | Planned Hours | Relative weight | Month 1 | Month 2 | Month 3 | Month 4 | Month 5 | Month 6 | Month 7 | Month 8 | Month 9 | Month 10 | Month 11 | Month 12 |
|----------|----------|---------------|---------------|-----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| activity 1 | 1500 | meter | 1.050 | 0.11% | 525 | 525 |
| activity 2 | 100 | unit | 70 | 0.01% | 70 |
| activity 3 | 250 | m³ | 3.000 | 0.30% | 600 | 600 | 600 | 600 | 600 |
| activity 4 | 500 | gallon | 350 | 0.04% | 350 |
| activity 5 | 10000 | Ton | 350.000 | 35.00% | 50000 | 50000 | 50000 | 50000 | 50000 | 50000 |
| activity 6 | 2000 | m² | 12.000 | 1.20% | 4000 | 4000 | 4000 |
| activity 7 | 5000 | meter | 1.250 | 0.13% | 625 | 625 |
| activity 8 | 500 | unit | 4.500 | 0.45% | 9000 | 9000 | 9000 | 9000 | 9000 |
| activity 9 | 3000 | m³ | 54.000 | 5.40% | 5750 | 5750 | 5750 | 5750 |
| activity 10 | 2000 | liter | 23.000 | 2.30% | 61875 | 61875 | 61875 | 61875 | 61875 | 61875 |
| activity 11 | 15000 | Ton | 495.000 | 49.50% | 2195 | 2195 | 2195 | 2195 |
| activity 12 | 2000 | m² | 8.780 | 0.88% | 800 | 800 |
| activity 13 | 4000 | meter | 1.600 | 0.16% | 400 |
| activity 14 | 800 | unit | 400 | 0.04% | 11250 | 11250 | 11250 | 11250 |
| activity 15 | 3000 | m³ | 45.000 | 4.50% | 525 | 10120 | 15320 | 286240 | 413660 | 564355 | 133735 | 124625 | 125425 | 50800 | 400 |
| **monthly** | | | | | 525 | 3595 | 70875 | 71825 | 133420 | 133420 | 145235 | 133735 | 124625 | 125425 | 50800 | 400 |
| **cumulative** | | | | | 525 | 10120 | 15320 | 286240 | 413660 | 564355 | 698750 | 623375 | 546800 | 393600 | 1000000 |
Progress & efficiency monitoring
Cost & Productivity Monitoring

\[ \text{PH (Planned hours)} = \sum \text{Planned Productivity} \times \text{Planned Quantities} \]
\[ \text{EH (Earned hours)} = \sum \text{Planned Productivity} \times \text{Actual Quantities} \]
\[ \text{AH (Actual hours)} = \sum \text{Actual Productivity} \times \text{Actual Quantities} \]

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>PH</strong></td>
<td></td>
<td>DEC 04/jan</td>
<td>11/jan</td>
<td>18/jan</td>
<td>25/jan</td>
<td>01/feb</td>
<td>08/feb</td>
<td>15/feb</td>
<td>22/feb</td>
<td>29/feb</td>
<td>07/mar</td>
<td>14/mar</td>
<td>21/mar</td>
<td>28/mar</td>
<td>04/apr</td>
<td>11/104</td>
<td>18/1pr</td>
<td>25/apr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EH</strong></td>
<td>3%</td>
<td>7%</td>
<td>20%</td>
<td>25%</td>
<td>35%</td>
<td>45%</td>
<td>87%</td>
<td>92%</td>
<td>95%</td>
<td>96%</td>
<td>97%</td>
<td>98%</td>
<td>99%</td>
<td>100%</td>
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</tr>
<tr>
<td><strong>AH</strong></td>
<td>3%</td>
<td>7%</td>
<td>20%</td>
<td>25%</td>
<td>35%</td>
<td>45%</td>
<td>87%</td>
<td>92%</td>
<td>95%</td>
<td>96%</td>
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</tr>
</tbody>
</table>

Graph showing the progression of Planned Hours (PH), Earned Hours (EH), and Actual Hours (AH) from December 2015 to April 2016.
PROJECT AUDIT AND PROJECT GOVERNANCE TO IMPROVE RESULTS

Walther Krause, MSc., PMP
PROJECT AUDIT AND PROJECT GOVERNANCE TO IMPROVE RESULTS

- Introduction
- Organizational Governance
- Project Governance
- Audit
- Project Audit
- Quality Management
- Conclusion
PROJECT AUDIT

- Identify the effectiveness of the organizational structure of the project management system;
- Identify the effectiveness of the project management;
- Identify the relationship between the limits of authority in decision-making for the project management;
- Identify the degree of adoption, applicability and effectiveness of policies and strategies used;
- Identify adherence, applicability and effectiveness of processes, best practices
PROJECT AUDIT

- Identify the adequacy, applicability and effectiveness of the controls used in the project management;
- To provide clarity of the application of regulatory frameworks relevant to the project;
- Evaluate the provision of project accounts, according to the audit the applicant's needs;
- Identify opportunities for improvement in the management and execution of projects.
PROJECT AUDIT

- Definition of the project management structure
- Policies, processes and methodologies to be used
- Authority limits for decision-making
- Business case
## PROJECT AUDIT

<table>
<thead>
<tr>
<th>TYPE</th>
<th>AUDIT SCOPE</th>
<th>EVALUATION ORGANIZATIONAL</th>
<th>EVALUATION CLIENT REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project responsibilities audit</td>
<td>Decision making process and results</td>
<td>Achievement of project objectives</td>
<td>degree of customer satisfaction</td>
</tr>
<tr>
<td>Strategic application audit</td>
<td>Alignment of projects with organizational strategies</td>
<td>Achievement of the organization's strategic objectives</td>
<td></td>
</tr>
<tr>
<td>Procurement audit</td>
<td>Use of resources in purchases needed for project</td>
<td>Level of efficiency in procurement</td>
<td></td>
</tr>
<tr>
<td>Performance audit</td>
<td>Evaluation of financial results in terms of competitiveness</td>
<td>Level of performance in relation to financial results</td>
<td></td>
</tr>
<tr>
<td>Conformity audit</td>
<td>project management excellence</td>
<td>Degree of effectiveness of service level agreements</td>
<td>compliance with contractual clauses</td>
</tr>
</tbody>
</table>
PROJECT AUDIT
QUALITY MANAGEMENT

Total Integration in the process

Excellence in Management

Client Satisfaction

Team compromised with the quality

Continuous Improvement

Quality
CONCLUSION

High Performance

Continuous Improvement

Organizational Governance
Project Audit
Cost Control
Client
Audit: A Path to Project Performance

Dr. Alexia Nalewaik FRICS CCP CCA
October 2016
There are many different philosophies and methodologies for ‘successful’ project management
  – … but there are no guarantees

Following detailed project management and project controls policies and procedures does not mean a project will be successful
  – … they are a best practice, and do contribute to improved chances of project success

There are many variables in projects and project management that are difficult to capture
  – … especially the ‘people’ part
One of the most common statutory and regulatory oversight mechanisms required on projects is audit.

When most people think of audit, financial audit comes to mind:
- Financial auditing focuses on accounting and fiscal regularity.
- Expenditure audit focuses on where and how funds were spent, with a strong focus on compliance.

Performance evaluation grew from financial auditing, amidst concerns that adequate accounting, controls, and compliance were not sufficient to guarantee success.
The objectives of performance review are continuous improvement and stakeholder assurance.

Projects, departments, and entire organizations can be evaluated.

A performance audit examines the process by which an entity is achieving its objective.

- **Economy** – undertaking the work with least wastage of physical and financial resources (inputs)
- **Efficiency** – performing work productively, with a high ratio of inputs to outputs
- **Effectiveness** – extent to which business and stakeholder objectives are met (outputs)
• Client experiences:
  – Audits of the same entity (performed in different years or at a different point in the project lifecycle) did not use the same methodologies or achieve the same depth, even if the teams came from the same consulting firm
  – There was often a difference between scope and stakeholder groups’ perception of the audit function (expectations gap)
  – Almost anything can be called a ‘performance audit’
  – Most audits generated findings that focused on compliance, not performance

• Resolution of performance review findings is imperative
  – No change means no improvement
Defining the audit scope is the most important part of procurement.

Different kinds of audit (scope) yield different types of findings.

<table>
<thead>
<tr>
<th>Type of Finding</th>
<th>Expenditure Audit</th>
<th>Performance Audit</th>
<th>Risk / Assurance Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of Expenditure Support</td>
<td>23.28%</td>
<td>1.03%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Incorrect Math</td>
<td>1.32%</td>
<td>0.26%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Contract Compliance</td>
<td>32.01%</td>
<td>1.79%</td>
<td>14.29%</td>
</tr>
<tr>
<td>Incorrect Rates</td>
<td>16.67%</td>
<td>1.28%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Excessive or Unallowable Charges</td>
<td>27.25%</td>
<td>2.31%</td>
<td>42.86%</td>
</tr>
<tr>
<td>Duplicated Scope of Work or Payment</td>
<td>0.26%</td>
<td>0.51%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Inadequate Controls or Accounting</td>
<td>7.41%</td>
<td>11.79%</td>
<td>28.57%</td>
</tr>
<tr>
<td>Program Management Best Practices</td>
<td>0.00%</td>
<td>23.33%</td>
<td>28.57%</td>
</tr>
<tr>
<td>No issues</td>
<td>33.86%</td>
<td>72.56%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Audit Objectives

- Facilitate continuous improvement
- Support a learning culture
- Provide assurance to stakeholders
- Ensure accountability
- Strengthen controls
- Enable transparency in reporting
- Contribute to good governance
- Empower critical questioning
- Provide external validation, not biased self-assessment
- Create a culture of best-for-project decision-making
- Cost-benefit (cost of review vs. value provided)
- Focus on leading measures instead of lagging measures
# Nalewaik-Mills Performance Review Model

<table>
<thead>
<tr>
<th>QA/QC Modules</th>
<th>1. Project Planning: Matching objectives with long-term strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Stakeholder Identification: Defining success</td>
</tr>
<tr>
<td></td>
<td>3. Risk Assessment: Optimizing opportunities</td>
</tr>
<tr>
<td></td>
<td>4. Compliance: Responding to internal and external requirements</td>
</tr>
<tr>
<td></td>
<td>5. Resource Analysis: Focusing on economy and efficiency</td>
</tr>
<tr>
<td></td>
<td>6. Management Controls: Improving effectiveness</td>
</tr>
<tr>
<td></td>
<td>7. Post-Project Concerns: Customer satisfaction and future planning</td>
</tr>
<tr>
<td></td>
<td>8. Special Issues: Targeted review of specific concerns and risks</td>
</tr>
</tbody>
</table>
Module 1 – Project Planning

• Intended to address the politics and challenges of project approval
  – Gap between project needs and available funding
  – Design for success

• Review of the project initiation process
  – Project objectives / organizational strategic objectives
  – Financing model, cash flow
  – ROI, operating costs, value for money
  – Development of scope, specifications, and requirements
  – Asset planning
  – Contracting and procurement mechanisms
  – Project organization structure and team
Module 2 – Stakeholder Identification

- Definition of success depends on stakeholders
- Multiple levels of stakeholders and their influence create a network of interdependencies and obligations within the project hierarchy
- Identify and understand stakeholders
  - Levels of interest and influence
  - Definitions of success and concepts of value
  - Motivations of profit, power, and achievement
  - Level of tolerance for risk and change
- Know the project audience
  - Design communication plans to address them accordingly
Module 3 – Risk Assessment

- Project reviews are limited by constraints of politics, cost, and time
- Assessing risks enables project reviews to be focused for best results
- Identify risks, and prioritize them based on probability and impact
- Develop a risk management and mitigation plan
- Repeat
Module 4 - Compliance

• Why test for compliance?
  – Legislative or regulatory requirement for evaluation of compliance
  – Stakeholder concerns about compliance with internal policies or contract
  – Noncompliance with policies & procedures may identify opportunities for improvements or streamlining of procedures
Module 5 – Resource Analysis

• Any and every activity that consumes project resources has the potential to be evaluated
• Critical questioning of why things are done a certain way, in order to reduce risk, increase value to stakeholders, and assure performance
• Focus on the best and most appropriate use of resources: cost, schedule, people, departments, materials, equipment, IT systems, tools, etc
  – Overlaps, overburdening, and gaps in available resources may be identified, creating opportunities for reallocation and streamlining of resources.
Module 6 – Management Controls

- Reviews project management and related processes, goal is appropriateness for the project
  - Total Cost Management (www.aacei.org) and quality assurance
  - Other areas of review: environmental sustainability, change management, procurement and contracting, project controls, accounting, safety, product quality, document control, commissioning, and data management
  - Softer elements: lessons learned, decision-making processes, levels of authority, ethics and conflicts of interest, innovation, training, communication, and reporting
Module 7 – Post-Project Concerns

• Projects create products that live on beyond the project lifecycle, and have a lifecycle of their own
  – Maintenance and operations of the project product
  – Asset management, capitalization & depreciation
  – Funds accounting
  – Customer satisfaction
  – Future market conditions
  – Lessons learned
  – Product performance
  – Historical data and benchmarks
Other concerns that require consideration and were not included above, but which would not be conducted as a separate engagement

YES
- Forensic review
- Special issues (systems, departments)
- Expenditure review
- Resolution of previously identified audit issues
- Building performance

NO
- Financial audit
- Value engineering
- Technical reviews
- Inspector general investigation
- Monte-Carlo style risk modeling
- Claims analysis
- LEED / BREEAM
Examples

- Largest school district in the country
  - Knew they had monies in contingency & reserves for old projects
  - Wanted to fund new projects

- Issues
  - Quantify needed contingency and reserves
  - Formalize processes
  - Find existing contingency, reserves, & other monies

Modules:
- Module 3: Risk Assessment
- Module 4: Compliance
- Module 5: Management Controls
- Module 6: Post-Project Concerns
- Module 7: Special Issues
- Module 8: Targeted Review of Specific Concerns and Risks
Examples

• Major transportation agency
  – Bids received were over budget

• Issues
  – Estimating
  – Budget
  – Stakeholders
  – Contingency

Module 1: Planning
  Matching objectives with long-term strategy

Module 2: Stakeholder Identification
  Defining success

Module 3: Risk Assessment
  Optimizing opportunities

Module 4: Compliance
  Responding to internal and external requirements

Module 5: Resource Analysis
  Focusing on economy and efficiency

Module 6: Management Controls
  Improving effectiveness
COST GROWTH AND SCHEDULE SLIP ANALYSIS
A PRIVATE EQUITY FIRM’S PERSPECTIVE

10th ICEC 2016 – Rio de Janeiro

PRESENTED BY: EDWARD VAN DOORN
• Cost Growth and Schedule Slip Analysis

• 20 Studies per year
• Quality ranges from bad to great
• Start-up Capital Cost / Execution Schedule / Ramp-up
• Start-up Capital – 18% average overrun
• Execution Schedule – 10% average overrun
Key drivers of overruns: Systemic Risks and Project Specific Risks

Typical key systemic risks include:
- Level of project scope definition
- Business ownership and leadership
- Team development and skills
- Capital cost estimate and schedule quality and bias
- Project management/control effectiveness
- Level of process technology
- Level of complexity in the process and execution

Typical key project specific risks include:
- Unknown soil conditions
- Bad weather
- Land owner issues
Model Criteria:
- Incorporates systemic risks as well as project specific risks.
- Has the ability to quantify both capital cost and schedule risks.
- Aligns with AACE International Recommended Practices and the Total Cost Management Framework.
- Integrates estimate and schedule.
- Empirically valid.
- Practical for available in-house resources to apply on every project regardless of size, type, phase or quality.