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Emirates Arsenal Stadium, London

Benchmarking:
Cost Relationship Analysis

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LANCE STEPHENSON - Biography

Executed over $35 BN of projects over my career.

Degree / Diploma:

- Bachelors of Business Administration & Diploma in Mechanical Engineering Technology

Years of Experience:

- 35 years of experience in EPC / Owner Environment

Director of Operations, AECOM

- Strategic Leader; Tactical Subject Matter Expert in Operational / Capital Program / Project Delivery...

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Background

Benchmarking:
Cost Relationship Analysis

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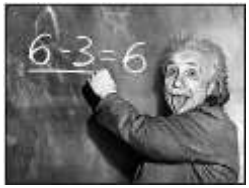
Background

Has the world gone mad…



Oil at $55 per barrel is here to stay

Oil prices will stay at $55 per barrel in 2015 before only gradually recovering to around $73 per barrel in 2020, a new report said. More

More Energy Fix stories »

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Background continued…

Due to the volatility of the oil (and all) prices in today's market, it is imperative that companies ensure that their project delivery system is utilized in order to drive improved cost competitiveness.

To further improve competitive outcomes, companies need to improve their understanding of cost drivers and behaviors through historical data collection and benchmarking.

Background continued…

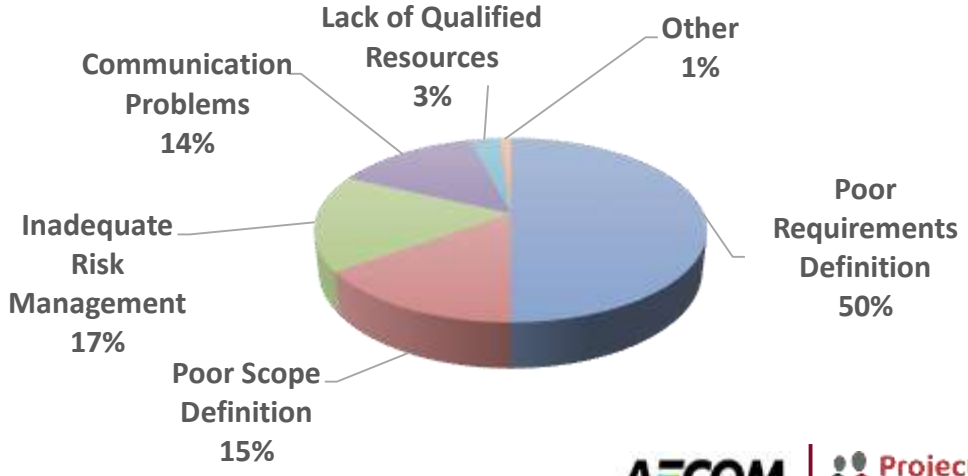
This presentation provides an understanding of some simple approaches in using a cost relationship analysis that can be used to:

- Support investment decisions
- validate the estimate
- provide a baseline for variance analysis during the project controls phase of the project
- as well as support the completion of a forensic analysis in order to understand the variances from actual costs to estimated costs

Why Do Projects Fail?

A staggering 39% of projects with budgets over US$10 MM failed.

The Standish Group, "CHAOS 2007 REX: A Standish Group Research Exchange." 2007.



Source: ESI international survey of 2000 business professionals, 2005

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Project Success Factors

1. Meet an agreed budget (Cost)
2. Deliver on Time (Time)
3. Meet quality requirements(Quality)
4. Meet the project's objectives / requirements (Scope)

What is Benchmarking?

Benchmarking:
Cost Relationship Analysis

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What is benchmarking

Benchmarking is the process of comparing one's business processes and performance metrics to:

- industry best or best practices from other companies
- dimensions typically measured are quality, time and cost

In the process of best practice benchmarking, management identifies the best firms in their industry, or in another industry where similar processes exist, and compares the results and processes of those studied (the "targets") to one's own results and processes.

Why do we need to benchmark

- Improve Investment Decision Making for the Company
- Improve Efficiency of a Business Unit
- Improve Efficiency of Overall Project System
- Improve Performance of a Single Project or a Group of Projects
- Improve Selected Performance Metrics (E.g. Productivity)

Key Benchmarking Metrics

From an Client's (Owner) perspective, there are three aspects for cost and schedule performance measures:

1. Cost & schedule competitiveness… how the project did against "similar" projects (which can be compared to industry projects & internal projects).

Cost Competitiveness	Actual Total Project Costs / Actual "Similar" Project Costs

Schedule Competitiveness	Actual Total Project Duration / Actual "Similar" Project Durations

Key Benchmarking Metrics

2. Cost & schedule factor (efficiency) and,
3. Cost & schedule growth (predictability).

Cost Growth	$\frac{\text{Actual Total Project Cost - Approved Project Cost}}{\text{Approved Project Cost}}$
Cost Factor	$\frac{\text{Actual Total Project Cost}}{\text{Original Project Cost + Approved Changes}}$

Schedule Growth	$\frac{\text{Actual Total Project Duration - Approved Project Duration}}{\text{Approved Project Duration}}$
Schedule Factor	$\frac{\text{Actual Total Project Duration}}{\text{Original Project Duration + Approved Changes}}$

Key Benchmarking Metrics

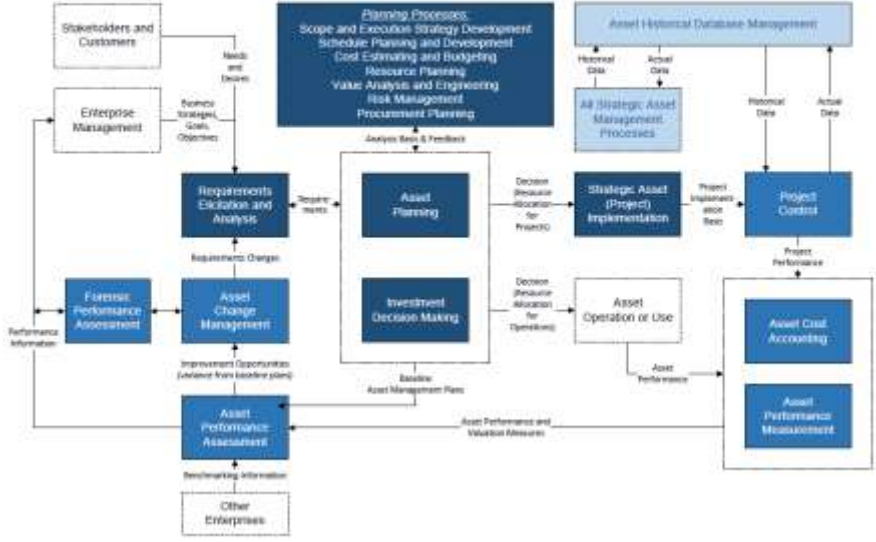
4. Safety and,
5. Quality.

TRIF (Total Recordable Incident Frequency)	$\frac{\text{Total Number of Recordable Cases x 200,000}}{\text{Total Site Work-Hours}}$
DART (Days Away & Restricted Time)	$\frac{\text{Total Number of DART Cases x 200,000}}{\text{Total Site Work-Hours}}$

Total Field Rework Factor	$\frac{\text{Total Direct Cost of Field Rework}}{\text{Actual Construction Phase Cost}}$

Strategic Asset Management

… for cost & schedule competitiveness



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Strategic Asset Management

Asset historical database management is a process for:

- Collecting; maintaining; and analyzing ***asset*** historical information

so that it is ready for use by the other strategic asset management processes and for project control.

Without empirical data, the quality of output of these types of methods is greatly diminished and it is much more likely that inappropriate investment decisions will be made.

(From TCM Framework)

Strategic Asset Management

An example, the average cost to build a SAGD Central Processing Facility project in Alberta for a production unit of 30,000 barrels per day is approximately $2.250 Billion…(excludes well pad facilities and steam / gathering lines)

ROI on a $120/barrel of WTI is different than the ROI on a $52/barrel of WTI…

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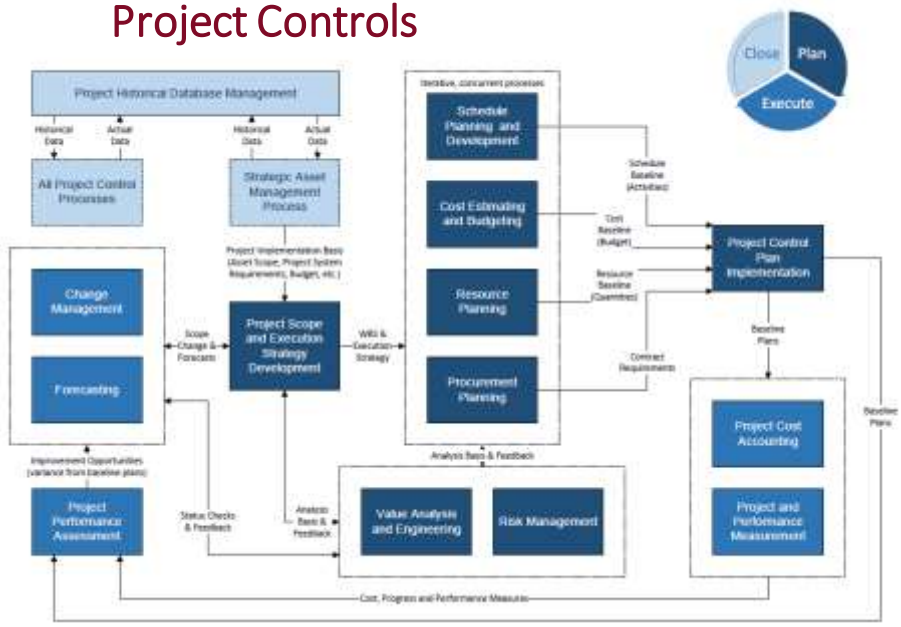
Project Controls

... for cost & schedule efficiency and predictability



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Project Controls

Project historical database management is a process for:

- Collecting; maintaining; and analyzing ***project*** historical information

so that it is ready for use by the other project control processes and for strategic asset management.

Asset Management and Project Controls Integration…

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Requirements for Benchmarking

Benchmarking:
Cost Relationship Analysis

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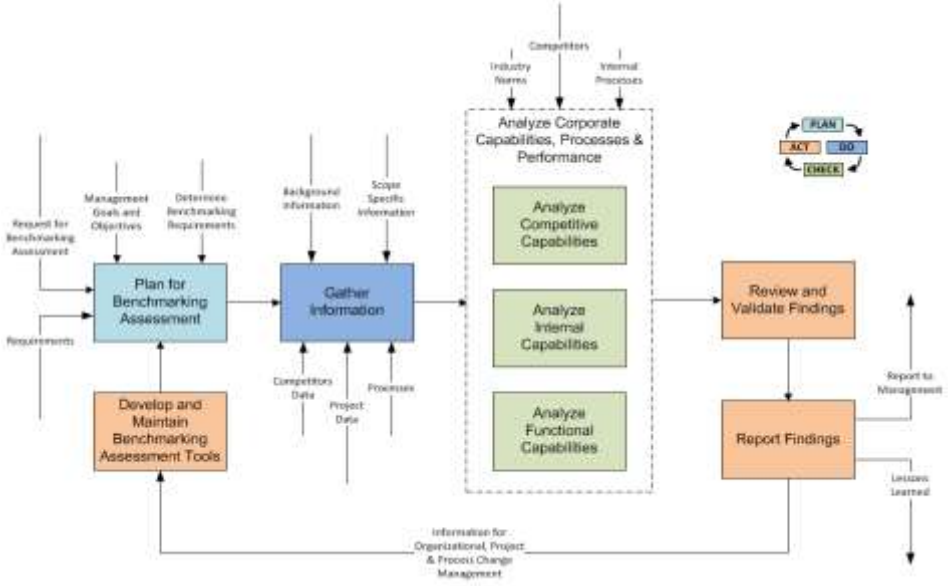
Requirements for Benchmarking

Benchmarking Plan Process Map



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Requirements for Benchmarking

Planning topics may include, but are not limited to, the following:

- roles and responsibilities
- allocated resources
- collection methods (during the project and at closeout)
- data structure and format (i.e., work breakdown or cost code structure)
- level of detail and comprehensiveness of records
- data and record quality
- storage and maintenance (tools and systems)
- access and retrieval (methods and access rights)
- analysis methods (where applicable)
- information product quality (data validation)
- legal issues (retention, claims issues, etc.)

Coding Structures

100A965	100	7200	10
Project ID	WBS Code	COA	Cost Element

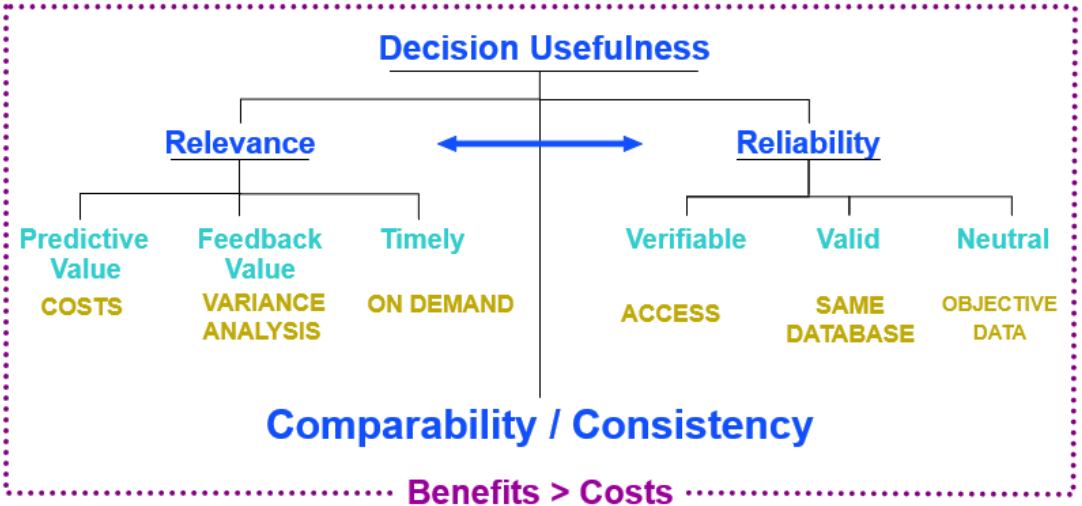
Codes can used as identifiers for client coding or WBS coding requirements

Coding Structures continued…

The communication or systems plan should include how information will be mapped throughout the systems; the data collection cut off times as well as synchronization times.

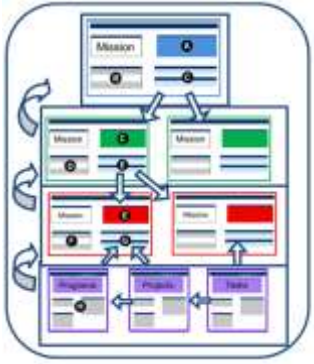
- Work breakdown structure (WBS)
- Organization breakdown structure (OBS)
- Cost breakdown structure (CBS)
- Schedule of pay value (SOPV) structure
- Project control accounts / Accounting structures
- Code or chart of accounts
- Resource classifications
    - Balance sheet / General ledger
    - Taxation and depreciation
- Cost classifications, cost types

Level of Detail



Categories

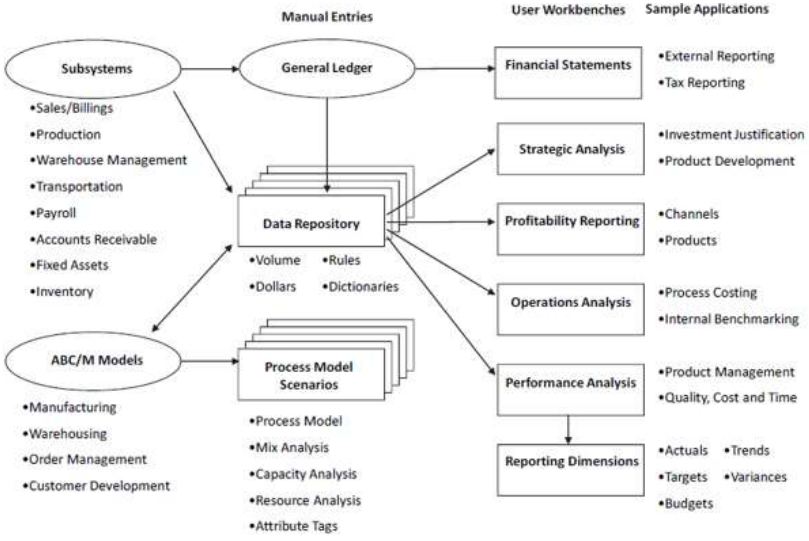
Summary ID	Description
PD	Project Definition
PM	Project Management
CM	Construction Management
DE	Detailed Engineering
BM	Tagged Equipment & Bulk Materials
CL	Construction Labour
SU	Start Up



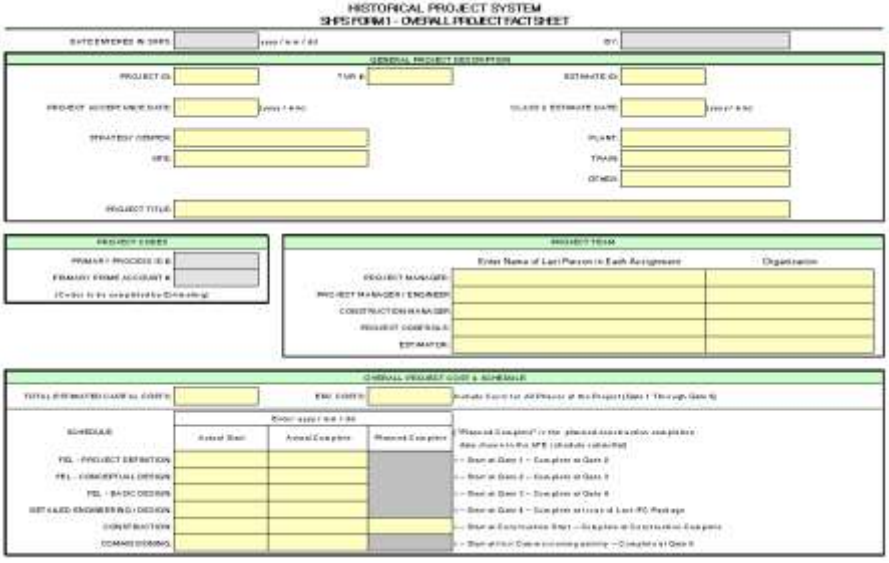
Subcategories

Code	Description	Summary ID	Deliverables / Expectations
A0.01.01	Business Development (BD)	PM	Signed Commercial Contract, Interconnection Agreement, Board / Internal Funding Memo, Financial / Economic Review
A0.01.02	Project Management	PM	Project Execution Plan, System Operability Philosophy & Review, Project Scope Definition Review, Process Hazard Assessment, KPI's,
A0.01.03	Project Controls (Cost, Planning & Scheduling)	PM	Control Budget, Basis of Estimate, Master Schedule, Basis of Schedule, Overall Cost & Schedule Reporting
A0.01.04	Construction & Quality Management	CM	Constructability Reviews, Estimate Cold Eye Review, Contract Bid Review
A0.01.05	Field Inspection	CM	Field Inspection & Reporting
A0.01.06	Site Services - Construction	CM	Site Project Controls, Change Management, Invoice Reviews & T&M Management
A0.01.07	Field Commissioning	SU	
A0.01.08	Safety	CM	Safety Plan
A0.01.09	Procurement (Material Purchasing)	PM	Procurement Plan, MR Review, Commercial Bid Tab Reviews
A0.01.10	Procurement (Contracts)	PM	Contracts Plan, Contract Formulation, Contract Bid Review
A0.01.11	Engineering Services	DE	
A0.01.12	Others (Internal)	PM	For internal cost breakdowns, includes these departments/function groups: Accounting, law, etc.
A0.01.13	Engineering	DE	Design Basis Memorandum, Engineering Design Specification, System Technical Assessment Review, Design review
A0.01.14	Construction	CL	Construction Labour, Equipment and Contractor Supplied Bulk Materials
A0.01.15	Materials	BM	Supplied Tagged Equipment and Bulk Materials
A0.01.16	Others	CM	Includes insurance, travel and meal, contingency

Typical System Schematic



Collection Forms



HISTORICAL PROJECT SYSTEM
SHS FORM 1 - OVERALL PROJECT FACT SHEET

DATE ENTERED IN SHS: (mm / dd / yy) BY:

GENERAL PROJECT DESCRIPTION

PROJECT ID: TAR #: ESTIMATE ID:

PROJECT ACCEPTANCE DATE: (mm / dd / yy) CLASS 1 ESTIMATE DATE: (mm / dd / yy)

STRATEGY OWNER: PLANT:

SITE: TRAIN:

OTHER:

PROJECT TITLE:

PROJECT CODES

PRIMARY PROCESS ID #:

PRIMARY PRIME ACCOUNT #:

(Codes to be assigned by Controlling)

PROJECT TEAM

	Enter Name of Last Person in Each Assignment	Organization
PROJECT MANAGER:		
PROJECT MANAGER / ENGINEER:		
CONSTRUCTION MANAGER:		
PROJECT CONTROLS:		
ESTIMATOR:		

OVERALL PROJECT COST & SCHEDULE

TOTAL ESTIMATED CASH OUT COSTS: EAC COSTS: (Estimate Cost for All Phases of the Project (Gate 1 Through Gate 5))

SCHEDULE	Enter appropriate Gate			
	Actual Start	Actual Complete	Planned Complete	("Planned Complete" is the planned construction completion date shown in the WBS (Module collected))
FEL - PROJECT DEFINITION				-- Start at Gate 1 -- Complete at Gate 2
FEL - CONCEPTUAL DESIGN				-- Start at Gate 2 -- Complete at Gate 3
FEL - BASIC DESIGN				-- Start at Gate 3 -- Complete at Gate 4
DETAILED ENGINEERING / DESIGN				-- Start at Gate 4 -- Complete at Issue of Last IFC Package
CONSTRUCTION				-- Start at Early Access Start -- Complete at Construction Complete
COMMISSIONING				-- Start at First Commissioning Activity -- Complete at Gate 5

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Analyze and Apply

Benchmarking:
Cost Relationship Analysis

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Typical Historical Data Formulas for Analysis

End Product/Use	Common Relationships	Example Calculations	Units
Rough Order of Magnitude Cost Estimating Relationships *Mgmt. Perf./Quality Review* *Client Perf./Quality Review* *Estimating Tools* *Est. Database Calibration* *Capital Mgmt. Forecasting*	Cost-Cost	DFL-$ / DFM-$ Total-$ / Equipment-$	%
	Labor-Cost	DFL-hrs / Equipment-$ HO-hrs / Total-$	hr / $
	Cost-Labor	DFL-$ / DFL-hrs-$ HO-$ / HO-hrs	$ / hr
	Cost-Deliverable or Output	Total Concrete-$ / Total CY Total-$ / Output Capacity	$ / unit
	Labor-Labor	Process Eng-hrs / Total Eng-hrs HO-hrs / DFL-hrs	%
	Labor-Deliverable	DFL-hrs / Piece of Equipment Eng-hrs / Drawings	hrs / unit
Rough Order of Magnitude Schedule Development Relationships *Mgmt. Perf./Quality Review* *Client Perf./Quality Review* *Planning Tools*	Time-Cost	Construction Days / TFC-$ Eng. Design Days / HOC-$	day / $
	Time-Deliverable or Output	Debug Days / No. Equipment Pieces Eng. Design Days / No. Dwgs	day / unit
	Time-Labor	Constr. Days / DFL-hrs Eng. Design Days / HO-hrs	day / hrs
	Time-Time	Front End Days / Total Days Eng. Design Days / Constr. Days	%
Performance and Quality Measurement (Indices and Benchmarks) *Mgmt. Perf./Quality Review* *Client Perf./Quality Review* *Estimating Tools* *Est. Database Calibration* *Capital Mgmt. Forecasting* *Planning Tools*	Labor Efficiency Labor-Labor	Actual-hrs / Budget-hrs	%
	Rework Cost-Cost or Time-Time	Rework-$ / Total-$ Rework days / Total Days	%
	Change Management Cost-Cost or Time-Time	Non-scope Change-$ / Total-$ Scope Change days / Total Days	%
	Capacity Achieved Output-Output	Actual Units / Name plate Units	%
	Indices Any Ratio-Process Measure	Rework-% / New Process Steps	%
	Same as ROM Est. & Sched., but mostly Cost, Labor, Time / Deliverable	Change % / FEL Index"	x / unit

Table from 1995 AACE TRANSACTIONS, Project History - Closing the Loop, John K. Hollmann, PE CCP

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Standard Summary Estimate

	Qty	UOM	Avg. Prod. Rate	Total Labour Hrs	Total Labour Cost	Expenses	Fabrication	Bulks	Equipment	Total Costs
Project Definition	1	Lot		29,760.33	$8,184,091	$1,250,000				$9,434,091
Engineering	1	Lot		107,350.02	$26,087,128	$750,000				$26,837,128
Project Management	1	Lot		62,585.25	$12,517,050	$2,125,000				$14,642,050
Construction Supervision	1	Lot		71,250.00	$14,250,000	$852,100				$15,102,100
Other Construction (Temp Fac./Equip.)	1	Lot		12,250.00	$1,347,500	$9,049,757				$10,397,257
Direct Labour & Materials										
Excavations	13,500	CM	0.04	540.00	$54,663			$851,032		$905,695
Piling	102	EA	30	3,060.00	$318,137		$306,000	$1,587,455		$2,211,592
Concrete	11,250	CM	2.12	23,850.00	$2,384,857		$632,813	$4,787,054		$7,804,723
Structural Steel	117,750	KG	0.095	11,186.25	$1,162,995		$1,177,500	$6,613,226		$8,953,721
Buildings	26	EA	200	5,100.00	$539,538		$6,001,248			$6,540,786
Equipment										
Mechanical	57	EA	300	17,100.00	$1,832,354			$815,572	$17,125,641	$19,773,567
Electrical	7	EA	150	1,050.00	$118,172			$407,786	$7,830,095	$8,356,053
Piping										
Meters	13,350	LM	5.5	73,425.00	$7,657,388			$12,464,069		$20,121,457
Avg. Diam	11,250	Dia. Inch	10	112,500.00	$11,732,464		$5,250,000			$16,982,464
Electrical										
Meters	23,625	LM	2.65	62,606.25	$7,046,013			$8,776,265		$15,822,278
Terminations	3,750	EA	1.25	4,687.50	$527,554			$301,407		$828,961
Instrumentation (I/O)	6,750	EA	1.35	9,112.50	$1,055,307				$443,247	$1,498,554
Start Up	1	Lot		7,550.00	$2,265,000	$1,035,174				$3,300,174
				614,963.10	$99,080,211	$15,062,031	$13,367,561	$36,603,866	$25,398,983	$189,512,652

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Data collection

Project Values

Total Directs % of Total Hours
Total Indirects % of Total Hours
Total Civil, Struct. % of Total Hours
Total Mechanical & Piping % of Total Hours
Total Electrical & Instrumentation % of Total Hours

Time Categories vs. Total Hours

Straight Time % of Total Hours
Overtime Time % of Total Hours
Travel Time % of Total Hours

Supervision

Total CM % of Total Hours
Total Superintendents % of Total Hours
Total General Foreman % of Total Hours
Total Trade Foreman % of Total Hours

Field Installation	Measure
Excavation	hours/m3
Backfill	hours/m3
Cut & Capping	hours/ea
Concrete	hours/m3
Steel Erection	hours/kg
Module Setting	hours/ea
Process Equipment	hours/ea
Pipe Installation	hours/lm
Pipe Hydrotest	hours/lm
Pipe Interconnects	hours/ea
Pipe Insulation	hours/lm
Glycol Tracing	hours/lm
Cable Tray	hours/lm
Cable Pull	hours/lm
Terminations	hours/ea
EHT	hours/lm
Lighting	hours/ea
Grounding	hours/lm
Instrumentation	hours/ea

Cost Relationship Analysis

		Company Data					Industry Data	
		Min	Avg	Max	Estimate	Var	Avg	Var
Total Project $	/ Material $	2.38	4.97	6.98	1.06	-35%	4.86	-37%
Total Field Costs	/ Material $	1.65	3.45	4.79	2.24	-35%	3.59	-38%
Total Office Costs	/ Material $	0.51	1.21	1.72	0.82	-32%	1.18	-30%
Project Management $	/ Total Project $	0.022	0.043	0.065	0.077	80%	0.046	68%
Project Management $	/ Total Field Costs	0.009	0.063	0.099	0.106	68%	0.064	65%
Project Management $	/ Total Office Costs	0.152	0.233	0.320	0.288	23%	0.212	36%
Project Management $	/ Material $	0.190	0.295	0.452	0.236	-20%	0.241	-2%
Engineering $	/ Total Project $	0.122	0.168	0.272	0.142	-16%	0.189	-25%
Engineering $	/ Total Field Costs	0.141	0.243	0.342	0.194	-20%	0.262	-26%
Engineering $	/ Total Office Costs	0.420	0.690	0.880	0.527	-24%	0.779	-32%
Engineering $	/ Material $	0.810	1.020	2.000	0.433	-58%	1.020	-58%
Total Office Costs	/ Total Project $	0.162	0.231	0.292	0.269	16%	0.229	17%
Total Office Costs	/ Total Field Costs	0.190	0.310	0.550	0.367	18%	0.319	15%
Total Field Costs	/ Total Project $	0.560	0.710	0.888	0.731	3%	0.783	-7%
Total Field Labour	/ Total Project $	0.272	0.362	0.523	0.182	-50%	0.362	-50%
Material - Bulks	/ Total Project $	0.302	0.481	0.691	0.595	-60%	0.419	-54%
Total Field Labour	/ Total Field Costs	0.282	0.485	0.590	0.248	-49%	0.466	-47%
Material - Bulks	/ Total Field Costs	0.291	0.550	0.817	0.264	-52%	0.534	-51%
Total Field Indirects	/ Total Field Costs				0.184			
Total Field Labour	/ Material - Bulks	0.510	1.125	1.721	3.786	237%	0.980	286%
Material $	/ Total Project $	0.096	0.223	0.572	0.327	47%	0.251	30%
Material $	/ Total Field Costs	0.125	0.304	0.632	0.447	47%	0.304	47%
Material $	/ Total Field Indirects				2.432			
Start Up $	/ Total Project $	0.000	0.034	0.158	0.017	-49%	0.033	-47%
Start Up $	/ Total Field Costs	0.000	0.051	0.111	0.024	-53%	0.047	-49%
Start Up $	/ Material $	0.000	0.171	0.632	0.053	-69%	0.169	-69%

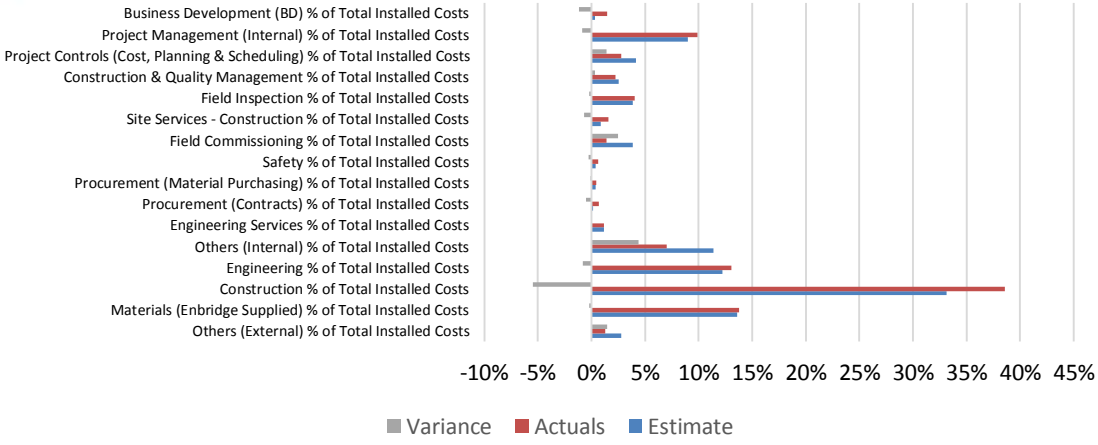
Preparing Final Project Report

- Authorization document (AFE)
- Project objectives document
- Business justification document
- Project Execution Plan document(s)
- Team Organization Chart
- RACI chart, if available
- Risk Register / Change Log & Change Orders
- Value Improving Practices documentation (Constructability review sessions, value engineering sessions, etc.)
- Process flow diagram (can be block flow), plot plans, and route map for pipeline projects

Analysis

Task Codes vs. Total Installed Costs	Estimate	Actuals
Business Development (BD) % of Total Installed Costs	0.34%	1.48%
Project Management (Internal) % of Total Installed Costs	9.01%	9.88%
Project Controls (Cost, Planning & Scheduling) % of Total Installed Costs	4.16%	2.75%
Construction & Quality Management % of Total Installed Costs	2.55%	2.24%
Field Inspection % of Total Installed Costs	3.85%	4.04%
Site Services - Construction % of Total Installed Costs	0.90%	1.57%
Field Commissioning % of Total Installed Costs	3.87%	1.40%
Safety % of Total Installed Costs	0.41%	0.65%
Procurement (Material Purchasing) % of Total Installed Costs	0.42%	0.45%
Procurement (Contracts) % of Total Installed Costs	0.17%	0.69%
Engineering Services % of Total Installed Costs	1.18%	1.15%
Others (Internal) % of Total Installed Costs	11.38%	7.00%
Engineering % of Total Installed Costs	12.24%	13.04%
Construction % of Total Installed Costs	33.14%	38.58%
Materials (Enbridge Supplied) % of Total Installed Costs	13.61%	13.79%
Others (External) % of Total Installed Costs	2.78%	1.31%

Variance Analysis



An increase in Construction costs by 5%, but only an increase of <1% in bulk and equipment costs

Why the increase?

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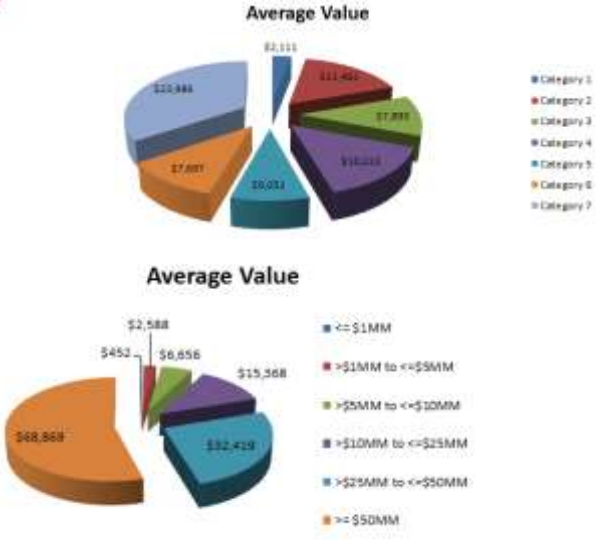
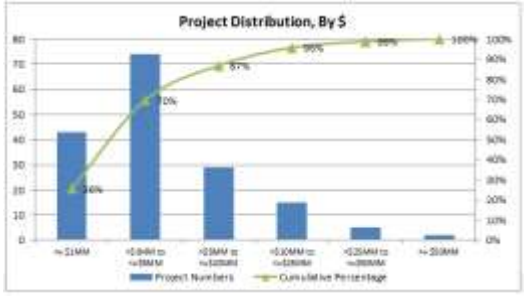
Portfolio Analysis





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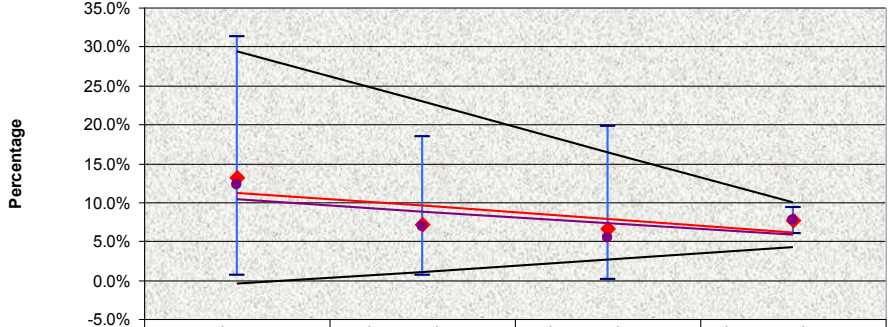
Portfolio Analysis

Project Characteristics	Number of Records	Average Value	MIN	MAX	Median		Standard Deviation		Relative Factor to Median
					Value	%	Value	%	
		a	b	c	d	e = d / a	f	g = f / a	f = line value d / overall d
Overall	168	$5,562	$24	$74,536	$2,751	49.5%	$9,580	172.3%	1.00
Project Status									
Mechanically Complete	53	$9,197	$122	$74,536	$4,198	45.6%	$14,494	157.6%	1.53
Closed	115	$3,886	$24	$33,708	$1,860	47.9%	$5,445	140.1%	0.68
Project Size									
<= $1MM	43	$452	$24	$978	$392	86.8%	$299	66.1%	0.14
>$1MM to <=$5MM	74	$2,588	$1,063	$4,852	$2,415	93.3%	$1,147	44.3%	0.88
>$5MM to <=$10MM	29	$6,656	$3,970	$9,805	$6,433	96.6%	$1,341	20.1%	2.34
>$10MM to <=$25MM	15	$15,368	$10,562	$21,639	$14,788	96.2%	$3,695	24.0%	5.37
>$25MM to <=$50MM	5	$32,419	$29,334	$37,700	$30,771	94.9%	$3,360	10.4%	11.18
>= $50MM	2	$68,869	$63,202	$74,536	$68,869	100.0%	$8,014	11.6%	25.03
Execution Category									
Category 1	91	$2,111	$24	$7,462	$1,209	57.3%	$2,097	99.4%	0.44
Category 2	32	$11,461	$148	$74,536	$5,409	47.2%	$15,145	132.1%	1.97
Category 3	9	$7,893	$687	$21,639	$3,218	40.8%	$8,262	104.7%	1.17
Category 4	6	$10,222	$3,468	$15,875	$10,894	106.6%	$4,692	45.9%	3.96
Category 5	22	$6,032	$1,216	$37,700	$3,841	63.7%	$7,724	128.0%	1.40
Category 6	5	$7,697	$1,302	$18,095	$5,144	66.8%	$6,751	87.7%	1.87
Category 7	3	$23,986	$3,970	$63,202	$4,787	20.0%	$33,964	141.6%	1.74

Trend Analysis
Total % Engineering of TIC by Size



	<$1MM	$1MM to $5MM	$5MM to $25MM	$25MM to $100MM
Lower Limit	0.7%	0.6%	0.1%	6.0%
Upper Limit	31.3%	18.5%	19.7%	9.3%
Mean	13.2%	7.2%	6.6%	7.7%
Median	12.3%	6.9%	5.5%	7.7%

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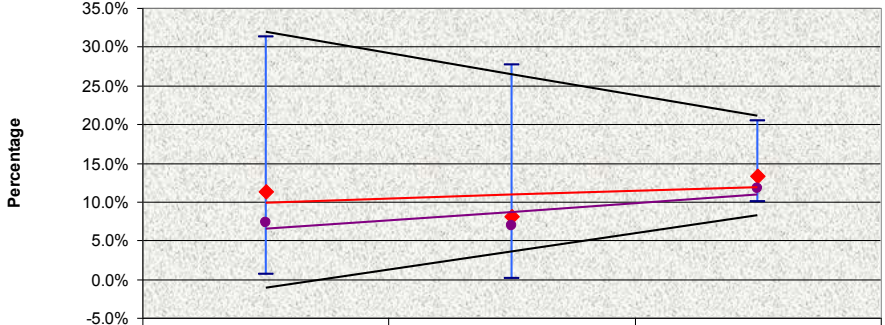
Trend Analysis
Total % Engineering of TIC by Year



	2005	2006	2007
Lower Limit	0.7%	0.1%	10.0%
Upper Limit	31.3%	27.6%	20.5%
Mean	11.3%	8.1%	13.3%
Median	7.3%	7.0%	11.8%

Benchmarking and Accuracy Ranges

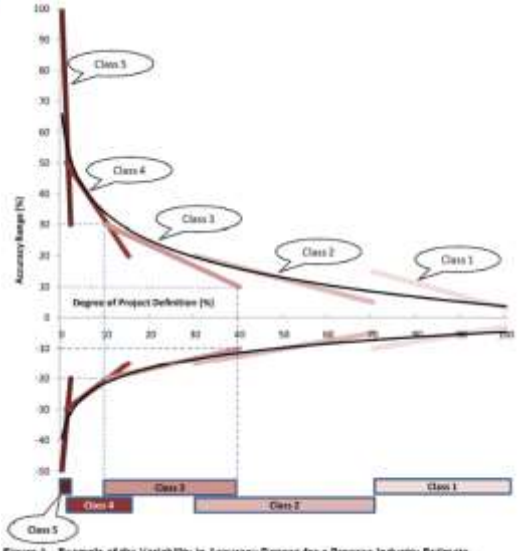


Figure 1 – Example of the Variability in Accuracy Ranges for a Process Industry Estimate

- Level of non-familiar technology in the project.
- Complexity of the project.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the organization / personnel.

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Conclusion

Benchmarking:
Cost Relationship Analysis

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Conclusion

Benchmarking improves competitive outcomes and provides companies in understanding their cost drivers and behaviors.

Benchmarking provides:

- Support investment decisions & improvement strategies
- Estimate analysis and validation
- Baseline for variance analysis during the project controls phase of the project
- A forensic analysis in order to understand the variances from actual costs to estimated costs

Learning from Experience

Learning from Experience

Learning from Experience

Become a Learning Organization through Benchmarking?

To compete successfully — achieve superior performance.

To improve your customer satisfaction / customer relations.

To improve productivity.
To improve quality.

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