

Transforming Historical Project Data into Useful Information

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How many times have each of us asked ourselves “if I only had the chance to do that over again?” Or maybe you’ve said, “if only I knew then what I know now.” All of us, whether we are 9 or 90, make decisions based on our past experiences. As a point of reference, sometimes we ask others about their experiences, especially if we don’t have our own history to fall back on. So, why do we do this? It’s because we want to take advantage of that experience in order to make our lives better.

Those same principles apply in the world of capital projects, where the goal, in most cases, is to end up with something that will give your company a competitive edge. Using historical project data to help make strategic business decisions can play a significant role in providing your company with an advantage – at times a very distinct advantage - over your competitors. Historical data can help you decide what projects are right for the future of your company. And, equally important, it can help you determine what projects are wrong for your company. Most people that perform capital projects understand the importance of having and using historical project information. The problem is that very few companies have the methodologies, procedures, and systems in place to effectively use this information to improve their project processes and to support the estimation, scheduling, and control of future capital projects.

This paper will discuss how to collect, normalize, and analyze historical project data to develop practical information that can be used to support estimating and scheduling, provide metrics and benchmarking data, develop conceptual estimating and scheduling tools, support strategic planning, and improve our project processes.

PROBLEM STATEMENT – SITUATION ANALYSIS

Because of a lull that occurred in the process industry and weak oil and commodity prices, many major projects were either cancelled or put on hold over the last two decades. As a result, many companies went through a period of employment reduction by outsourcing, layoffs, and early retirements which created a tremendous loss of project expertise in the industry. In recent years we have seen a resurgence in all types of businesses. Many of those shelved projects have been rekindled

with, unfortunately, lesser skilled project teams – in particular project controls and estimating.

The oil and gas industry is playing a large part in this explosion of new projects. In the Canadian province of Alberta alone the approximate value of oil and gas projects in the planning phases or currently in progress is estimated to be greater than \$100 billion. And, this does not include infrastructure projects within the province that are necessary to support this expansion. It has also been reported that there are over \$1 trillion of active and planned projects in the Arabian Gulf Region. It is anticipated that this trend will continue for many years into the future based on global growth and projected energy price increases.

With all of the work currently being planned, it would be great to have historical information from previous projects to use as a guide for estimating and benchmarking purposes. After all, how can you improve the execution of your future projects if you can’t analyze what has happened on previous projects? As a general statement, there appears to be very little data, or certainly very little good data, from projects that have been completed in the past 25+ years that can be used as the basis to develop more accurate benchmarking metrics. This is largely because of the loss of experienced personnel and the unwillingness of management to invest in what it came to consider being expendable “overhead”. Without these experts on hand and management commitment to properly collect, analyze, and store the historical data when projects were completed, all of this vitally important information was typically lost.

Having said that, at the present time there appears to be somewhat of a revival under way in the area of historical project data collection. And the primary catalyst for this has been the far too frequent cost and schedule overruns that have occurred on projects in the last several years, fueled by the inability to explain these deviations to management. This has driven the need for greater up-front analysis and scrutiny of project cost and schedules. Many companies are realizing that much more focus is needed in the area of benchmarking and the development of associated historical metrics that can be used to estimate and validate their future projects.

So then, how do you go about collecting all of this data? Where is it going to be stored? And the most significant question, how do you use this data to your advantage once you have it? Let’s begin with collecting and storing the data.

REQUIREMENTS FOR PROJECT DATA COLLECTION

Before beginning the data collection process, certain methodologies and systems (or enablers) must be put in place. One of the most important of these enablers is obtaining management support. Not only must company management support historical project data collection but they must understand and actively promote this effort as well. Many resources across the entire company hierarchy will be relied upon in order to retrieve and collect this data. Without the support of the highest levels of company management, it is very probable that this effort will fail to provide meaningful results.

Let's take a look at a few other necessary enablers.

Personnel

Perhaps as equally important as management support, there must be a well trained and dedicated staff of professionals on hand (even if it is one person). Depending on the scope of data to be managed, this staff can be composed of both experienced and entry level personnel and they must be trained in the area of database development, data analysis techniques, and benchmarking concepts.

Infrastructure

Regardless of what method you use to collect your project data, there is a minimum amount of infrastructure that must be in place to assist in the effort. Networking capabilities will be needed to house computer applications; communication tools are needed to store and pass information; word processing applications are required to provide training materials and user manuals; and spreadsheets will be essential for the initial project data collection and electronic backup.

Code of Accounts

When attempting to collect project cost data, there must be a systematic method of categorizing this information. In order to do this, most companies whether owner or contractor, will use a standard structure most often referred to as a code of accounts to capture project cost expenditures. So, what is a code of accounts? In simplest terms, as described in an AACE Recommended Practice, it is a "structured, coded index of project costs, resource, and activity categories [3]." The intent of a properly structured code of accounts is to "facilitate finding, sorting, compiling, summarizing, defining, and managing the project information linked to each code."

The primary purpose of a code of accounts is to clarify and reduce confusion for your project teams and within your company. In order to do this each code of account element must be clearly defined and documented in a code of account dictionary that will describe what costs should be included. To ensure that actual project costs are collected accurately, all project personnel should be trained, and have a clear-cut understanding of, the characteristics of each element within the code of account structure.

As stated in one of the original AACE International papers on historical databases, "Before you can [effectively] collect and analyze cost data you must have a standard code of accounts. Fortunately, the elements that support good cost con-

trol practices also facilitate historical project analysis functions. A code that differentiates process types, broad activity types (such as engineering and construction), and resource types (such as labor and material, discipline and trades, directs and indirects) will permit useful ratios, factors, and benchmarks to be developed [2]."

Cost Control System

Now that you have a code of accounts structure in place, the next step is to ensure that you have a means of capturing and storing estimated and actual project costs and resource data. If your company does not have an effective cost control system, it is imperative that one be implemented. There are a number of commercially available cost control systems, or one could be custom developed. Either way, having an effective cost control system in place is imperative for the success of the data collection effort.

In general, pure accounting systems are not very useful for capturing appropriate historical data. For the most part, accounting systems aggregate data in ways that expedite recording payments or capitalizing assets; this type of data is pretty meaningless for estimating and planning purposes. Implementing a cost control system for your company is not a small task, and therefore must be undertaken well in advance so as not to impede data collection efforts.

Once there is an operational cost control system in place, it must be capable of collecting and reporting costs using the predefined code of accounts. Only then can costs be rolled up into the proper categories which will facilitate the transfer of data to the historical system.

Project Classification

There must also be a method to categorize your projects in such a way that meaningful data can be identified and organized by the various types of projects. This will enable appropriate benchmark metrics to be created from the collected project data. This is the only way to ensure that dissimilar projects are not inadvertently compiled and compared. For example, you wouldn't attempt to compare benchmark metrics for a hospital project to those of a pipeline project or a catalytic cracking unit project. A properly developed project classification index and corresponding definitions will enable similar types of projects to be analyzed and compared.

COLLECTION OF ACTUAL PROJECT DATA

With all of the necessary prerequisites in place you can now begin the process of collecting and normalizing actual project cost information and data. Collecting the project data is a relatively simple process assuming that all of the enablers have been put in place and the project costs have been properly recorded. Standardized project cost collection forms should be developed to capture the data. This will ensure that the data is uniformly organized so that nothing is overlooked during the collection process.

Refer to figure 1 for an example of a project data collection form.

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PROJECT IDENTIFIER:

PROCESS UNIT:

GEOGRAPHIC AREA:

| COST BREAKDOWN BY CODE OF ACCOUNTS | | HOURS | COSTS (Round dollars as appropriate) | | |
|------------------------------------|--|--------|---|-------------|----------|
| PA | SA | Actual | Labor \$ | Material \$ | Total \$ |
| 1 | PROJECT MANAGEMENT | | | | |
| 1 | 1 Secretarial, Administrative, Misc. PM Expense | | | | 0 |
| 2 | 2 Project & Engineering Management | | | | 0 |
| 3 | 3 Project Controls & Estimating | | | | 0 |
| 4 | 4 Procurement & Contract Administration | | | | 0 |
| | TOTAL - PROJECT MANAGEMENT | 0 | \$0 | \$0 | \$0 |
| 2 | ENGINEERING & DESIGN SERVICES | | | | |
| 1 | 1 Misc. Engineering Services & Expense | | | | 0 |
| 2 | 2 Civil & Structural Engineering & Design | | | | 0 |
| 3 | 3 Architectural Engineering & Design | | | | 0 |
| 4 | 4 Process Engineering | | | | 0 |
| 5 | 5 Mechanical & HVAC Engineering & Design | | | | 0 |
| 6 | 6 Piping Engineering & Design | | | | 0 |
| 7 | 7 Electrical Engineering & Design | | | | 0 |
| 8 | 8 Process Control Engineering & Design | | | | 0 |
| | TOTAL - ENGINEERING & DESIGN SERVICES | 0 | \$0 | \$0 | \$0 |
| 3 | CONSTRUCTION FIELD INDIRECTS | | | | |
| 1 | 1 Construction Management & Field Staff | | | | 0 |
| 2 | 2 Temporary Construction Facilities | | | | 0 |
| 3 | 3 Construction Services, Supplies, Consumables | | | | 0 |
| 4 | 4 Field Office Expenses | | | | 0 |
| 5 | 5 Construction Equipment, Small Tools | | | | 0 |
| | TOTAL - CONSTRUCTION FIELD INDIRECTS | 0 | \$0 | \$0 | \$0 |
| 4 | CONSTRUCTION | | | | |
| 1 | 1 Civil & Site Preparation | | | | 0 |
| 2 | 2 Concrete | | | | 0 |
| 3 | 3 Structural Steel | | | | 0 |
| 4 | 4 Buildings | | | | 0 |
| 5 | 5 Equipment | | | | 0 |
| 6 | 6 Piping | | | | 0 |
| 7 | 7 Electrical | | | | 0 |
| 8 | 8 Process Control & Instrumentation | | | | 0 |
| 9 | 9 Coatings - Insulation, Paint, Fireproofing | | | | 0 |
| | TOTAL - CONSTRUCTION | 0 | \$0 | \$0 | \$0 |
| 5 | START-UP COSTS | | | | |
| 1 | 1 Startup & Commissioning | | | | 0 |
| 2 | 2 Catalyst & Initial Fills | | | | 0 |
| | TOTAL - START-UP COSTS | 0 | \$0 | \$0 | \$0 |
| 6 | OTHER COSTS | | | | |
| 1 | 1 Spare Parts | | | | 0 |
| 2 | 2 Demolition | | | | 0 |
| 3 | 3 International Freight & Expense | | | | 0 |
| | TOTAL - OTHER COSTS | 0 | \$0 | \$0 | \$0 |
| 7 | CONTINGENCY, ESCALATION, MANAGEMENT RESERVE | | | | |
| 1 | 1 Contingency, Escalation, Management Reserve | | | | 0 |
| | TOTAL - CONTINGENCY, ESCALATION, MGMT RESERVE | 0 | \$0 | \$0 | \$0 |
| | TOTAL PROJECT COSTS | 0 | \$0 | \$0 | \$0 |

Figure 1—Project Data Collection Form—Example Only

Normalizing the Data

After the data has been collected it must be normalized. Data normalization reduces inconsistencies and anomalies within your data. Therefore, this step is crucial in the development of your historical project database. The first step in the normalization process is to weed out any projects where the data is deemed to be unusable. There are many reasons why the data would not be acceptable:

- **Deviant Accounting and/or Project Controls** – If the project was abnormally accounted for or controlled there is a good chance that the data is corrupted.
- **Small Project** – If the total value of the project is so small in comparison to other projects typically performed by your

company, it may render the information as inconsequential.

- **Direct Equipment Purchase** – The data may be negligible if a project is primarily for a direct purchase with no other associated discipline costs, and where there is no possibility of generating any ratios or factors. However, it is still a good idea to capture the actual equipment costs for future reference.
- **Ad Hoc Project** – Sometimes projects are one-off or ad hoc, resulting in scope that is disjointed or of little value. In this case the information is probably meaningless.

After culling out the bad or inconsequential projects, the next step is to adjust the remaining data to account for typical anomalies. This could include the following:

- Making the units of cost consistent.
- Making the year of economics consistent (common time-frame).
- Account for missing cost items if possible.
- Remove cost items that are not applicable. And,
- Assigning a project classification.

Now that you have collected good project data and normalized it, where will you store it? And, more importantly, how can you use the data to your advantage?

IMPLEMENTATION OF A HISTORICAL DATABASE SYSTEM

With sufficient project cost and schedule information available, an automated system can be either purchased or developed to house all of your historical project data. This system will contain a database of historical project cost, schedule, resource, and technical data from completed projects, and should be capable of generating presentation grade reports.

The goal of the project historical database system is to collect data and convert it into a strong knowledge base that can be used to drive improvements throughout the project process [4]. It is also generally acknowledged that companies that use historical database systems can improve their overall project performance over a period of time.

Implementation of a project historical database system will allow a company to provide the following (covered in greater detail later in this paper):

- Cost estimate validation for formal estimate reviews.
- Generation of key benchmark metrics for estimate reviews.
- Cost estimate database calibration information.
- Front-end or strategic level cost estimates. And,
- Strategic level scheduling information.

So then, what types of historical database systems are available and how does your company go about implementing such a system?

Choosing the Right System

The first thing you'll need to do is determine what type of system best fits your particular company needs. To do this you will have to consider several different options that are available:

- **Purchased System** - Currently, there are a very limited number of commercially available systems that can be used for historical data collection and analysis. One such system is called Eos Advisor and is available from EosGroup. Eos Advisor is a highly customizable and configurable web based application that allows the user to capture a virtually limitless amount of historical data for both estimates and actual project costs. This system also has sophisticated reporting features that provides both pre-defined reports as well as exporting to automated Excel spreadsheets.
- **Spreadsheet** – Since the number of commercially available systems is limited, many companies opt to create their own systems using the ever popular spreadsheet. However, as

many developers know, spreadsheets come with several inherent limitations, one of which is the difficulty to dynamically create output reports. These limitations can be overcome with good spreadsheet automation, but this can be expensive, time consuming, and a maintenance nightmare.

- **Developed Software** - The other option is to develop an in-house custom system. It is important to note that this effort will require a great deal of time, effort, commitment, and highly skilled software expertise. Therefore, when making the decision to develop software, your company must have a vision of what the final product will look like, and be convinced that there are no other alternative solutions. This will typically be the most costly option to pursue.

System Implementation

Most companies today do not have the expertise in house to either develop or implement a historical database system, and it would take significant time and effort to develop the necessary skills. Instead, many companies are opting to hire professional consultants that specialize in providing these types of services. There are many advantages in hiring these specialists:

- **Software development experts** – If your decision is to create a new computer application to house your historical database, you will need to employ software developers. Many companies have very limited software development resources, if they have any at all. Hiring a consultant that understands your needs and can also provide development services is usually the answer to this problem. These service providers will help you determine your requirements, provide enhanced specification writing, and then create custom software to meet your needs.
- **Data analysis experts** – Whether you develop your system in-house or hire it out, you will need resources that can expertly analyze the data that has been collected. Once again, most companies do not have these experts on staff. Hiring a data analyst that will understand, interpret, organize, and filter the data that is collected would be a viable solution.
- **Experienced decision making** – Consultants that specialize in providing these services have considerable experience and have usually been in the project business for many years. This experience is invaluable when it comes to making decisions on any of the topics discussed in this paper.
- **Shortened implementation time** – Putting a historical database system in place requires many hours of concentrated effort. With all of the demands on your already stretched-thin work force, asking internal company resources to provide dedicated time and effort is typically impractical. In all likelihood, this is probably the time to consider hiring specialty consultants that can do the job more quickly and efficiently. Using competent consultants to implement your new system can greatly reduce the time needed for this effort.
- **Personalized training** – Of course it will be necessary to train all of the users of your new database system after it has

been implemented. The same development consultants would be the logical choice to provide this training.

areas for improving your company's overall project performance. Let's take a look at a few end uses for your system:

If chosen wisely, these professional consultants will arrive at your company with the appropriate skills and a vast knowledge base. Smart companies will encourage their employees to leverage the knowledge that these experts possess, and these consultants will be very happy to share their knowledge. After all, a primary desire of any consultant is to have satisfied customers that can be used for future work references.

END USE OF A HISTORICAL DATABASE SYSTEM

The data housed in your new historical project database system can be used for many purposes. Primary goals will be to improve current practices relating to estimating, cost control, strategic scheduling, and standard project processes. This is done by converting your historical project data into a useful knowledge base that can identify deficiencies and highlight

- **Benchmarking** - One of the primary benefits of your project historical database system is to provide benchmarking data, metrics and factors that will be an invaluable aid for reviewing and validating estimates. The estimate review and validation process should include a benchmarking report that compares ratios and factors from the estimate being reviewed with historical values from similar type projects in your database. Your system should be able to store data from external projects as well, if this information can be obtained. This will allow you to make benchmark comparisons with both external data and your own internal company project metrics. Refer to figure 2 for an example of an estimate validation metrics report [4].
- **Database Calibration** - In addition to providing benchmark data for estimate reviews, the historical data that you collect can also be used to check and calibrate your

| COST RELATIONSHIP | --- COMPANY HISTORY --- | | | EST | VAR | INDUSTRY DATA | |
|---------------------------------|-------------------------|-------|-------|--------------|------|---------------|------|
| | LOW | AVG | HIGH | | | AVG | VAR |
| TOTAL PROJECT \$ / EQUIPMENT \$ | 2.38 | 4.97 | 6.98 | 4.77 | -4% | 4.86 | -2% |
| TFC \$ / EQUIPMENT \$ | 1.65 | 3.45 | 4.79 | 3.20 | -7% | 3.59 | -11% |
| TOC \$ / EQUIPMENT \$ | 0.51 | 1.21 | 1.72 | 1.15 | -5% | 1.18 | -3% |
| TFL \$ / EQUIPMENT \$ | 1.09 | 1.99 | 2.41 | 1.80 | -10% | 1.89 | -5% |
| PROJ MGMT \$ / TOTAL PROJ \$ | 0.022 | 0.043 | 0.065 | 0.037 | -14% | 0.046 | -20% |
| PROJ MGMT \$ / TFC \$ | 0.009 | 0.063 | 0.099 | 0.054 | -14% | 0.064 | -16% |
| PROJ MGMT \$ / TOC \$ | 0.152 | 0.233 | 0.320 | 0.210 | -10% | 0.212 | -1% |
| PROJ MGMT \$ / EQUIPMENT \$ | 0.190 | 0.295 | 0.452 | 0.260 | -12% | 0.241 | 8% |
| ENGR+DESIGN \$ / TOTAL PROJ \$ | 0.122 | 0.168 | 0.272 | 0.198 | 18% | 0.189 | 5% |
| ENGR+DESIGN \$ / TFC \$ | 0.141 | 0.243 | 0.342 | 0.291 | 22% | 0.262 | 11% |
| ENGR+DESIGN \$ / TOC \$ | 0.420 | 0.690 | 0.880 | 0.872 | 26% | 0.779 | 12% |
| ENGR+DESIGN \$ / EQUIPMENT \$ | 0.810 | 1.020 | 2.000 | 1.173 | 15% | 1.020 | 15% |
| TOC \$ / TOTAL PROJ \$ | 0.162 | 0.231 | 0.292 | 0.245 | 6% | 0.229 | 7% |
| TOC \$ / TFC \$ | 0.190 | 0.310 | 0.550 | 0.341 | 10% | 0.319 | 7% |
| TFC \$ / TOTAL PROJ \$ | 0.560 | 0.710 | 0.888 | 0.682 | -4% | 0.783 | -13% |
| TFL \$ / TOTAL PROJ \$ | 0.272 | 0.362 | 0.523 | 0.341 | -6% | 0.362 | -6% |
| TFM \$ / TOTAL PROJ \$ | 0.302 | 0.481 | 0.691 | 0.419 | -13% | 0.419 | 0% |
| TFL \$ / TFC \$ | 0.282 | 0.485 | 0.590 | 0.457 | -6% | 0.466 | -2% |
| TFM \$ / TFC \$ | 0.291 | 0.550 | 0.817 | 0.598 | 9% | 0.534 | 12% |
| TFL \$ / TFM \$ | 0.510 | 1.125 | 1.721 | 0.902 | -20% | 0.980 | -8% |
| EQUIPMENT \$ / TOTAL PROJ \$ | 0.096 | 0.223 | 0.572 | 0.241 | 8% | 0.251 | -4% |
| EQUIPMENT \$ / TFC \$ | 0.125 | 0.304 | 0.632 | 0.334 | 10% | 0.304 | 10% |
| START-UP \$ / TOTAL PROJ \$ | 0.000 | 0.034 | 0.158 | 0.041 | 21% | 0.033 | 24% |
| START-UP \$ / TFC \$ | 0.000 | 0.051 | 0.111 | 0.066 | 29% | 0.047 | 40% |
| START-UP \$ / EQUIPMENT \$ | 0.000 | 0.171 | 0.362 | 0.235 | 37% | 0.169 | 39% |
| CONSTR IFC \$ / TOTAL PROJ \$ | 0.059 | 0.085 | 0.110 | 0.079 | -7% | 0.088 | -10% |
| OWNER COST \$ / TOTAL PROJ \$ | 0.105 | 0.175 | 0.219 | 0.155 | -11% | 0.186 | -17% |
| ENGR+DESIGN HRS / EQUIP COUNT | 841 | 990 | 1287 | 1120 | 13% | 1039 | 8% |
| TOT FIELD HRS / EQUIP COUNT | 3087 | 4117 | 4734 | 3884 | -6% | 4089 | -5% |
| CONCRETE CY / EQUIP COUNT | 16 | 20 | 33 | 16 | -20% | 22 | -27% |
| PIPING LF / EQUIP COUNT | 392 | 474 | 687 | 484 | 2% | 470 | 3% |
| CONCRETE HRS / CY CONCRETE | 12.1 | 13.4 | 19.2 | 12.4 | -7% | 13.8 | -10% |
| PIPING HRS / LF PIPE | 2.7 | 3.2 | 3.4 | 3.3 | 3% | 3.2 | 3% |
| CONCRETE MATL \$ / CY CONCRETE | 219 | 243 | 306 | 224 | -8% | 255 | -12% |
| PIPING MATL \$ / LF PIPE | 88 | 103 | 113 | 104 | 1% | 102 | 2% |

Figure 2—Estimate Validation Metrics Report—Example Only

estimating unit cost database. This is especially important during times when labor and material pricing is volatile. A check of your historical database can help you determine if these cost fluctuations are a long term trend or simply a short term spike, allowing you to calibrate your estimating database appropriately.

- **Conceptual Cost Estimating and Scheduling** - Your new database system can also be used as a cost estimating tool to create conceptual level estimates and schedules that are based on the historical project information stored in your database. Using the mechanical equipment related data and associated metrics generated by the system, you can easily prepare conceptual level estimates that will require a minimal amount of time or engineering input. Because these high level, conceptual estimates are based on actual cost data and information from similar projects, the results can be surprisingly accurate.
- **Strategic Project Planning** - Your historical database system can also be used for strategic project planning efforts. By using historical project information related to work breakdown structures, schedule logic, and account coding, the lessons learned from successful and failed projects can be applied during the front end planning sessions for the control of future projects. High level staffing requirements and durations for engineering, construction, start-up, etc., can be approximated by utilizing your historical project data.

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This paper has described methods of collecting, normalizing, and analyzing historical project data to develop practical information that can be used to support estimating and scheduling, provide metrics and benchmarking data, develop conceptual estimating and scheduling tools, support strategic planning, and improve your project processes as your company strives to become truly world class.

Improvement is the goal. Successful companies typically employ principles such as continuous improvement to help them attain and maintain the title of world class. One of the primary components of continued improvement is examining the past so that you can learn from previous mistakes as well as draw on examples of good results. But, often times we fail to use our individual and collective project experiences in a comprehensive and standardized way to improve and enhance our future project endeavors. As stated in AACE International's **Skills and Knowledge of Cost Engineering**; "the most fundamental and useful planning tool available is.....experience.....the experience gained is fed back to the company to increase its knowledge for the next planning action. This cycle represents the learning curve in action - each repetition makes planning for and achieving the next opportunity much easier [1]." Collecting accurate historical project data, in conjunction with a detailed situation analysis and reporting, will help your company achieve more effective capital projects.

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