The AACE International Journal of
Cost Estimation, Cost/Schedule Control, and Project Management

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Forecasting - What a Responsibility
James E. Baar and Stephen M. Jacobson, CCC

One of the most prevalent ways of assessing and asserting claims is to analyze time delays suffered on a project. There are a number of methods by which this can be done. This article will touch on definitions of several of these methods. The thrust of this article, however, focuses on a method called the "collapsed as-built" schedule analysis, also known as the "but-for" schedule analysis. This type of analysis begins with creating or refining an as-built schedule, identifying delays and caused by a particular party, and then removing those delays from the schedule to illustrate how work on the project would have progressed, but for those identified delays.

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Featured Articles

Forecasting - What a Responsibility
James E. Baar and Stephen M. Jacobson, CCC

This is the first in a series of articles that will look at forecasting. They are being presented in a non-peer-reviewed format by James E. Baar and Stephen M. Jacobson, CCC.

Claims Schedule Development and Analysis:
Collapsed As-Built Scheduling for Beginners
Vera A. Lovejoy, CCC

One of the most prevalent ways of assessing and asserting claims is to analyze time delays suffered on a project. There are a number of methods by which this can be done. This article will touch on definitions of several of these methods. The thrust of this article, however, focuses on a method called the "collapsed as-built" schedule analysis, also known as the "but-for" schedule analysis. This type of analysis begins with creating or refining an as-built schedule, identifying delays and caused by a particular party, and then removing those delays from the schedule to illustrate how work on the project would have progressed, but for those identified delays.

Economic Justification of a Data Acquisition System:
A Case Study
Sameer Kumar and Jon. M. Benusa

The study describes the basic need for an automated data acquisition system for use on a custom thermoplastic extrusion shop floor operation. The purpose is to serve as a proposal for the purchase of this system which satisfies the financial threshold. It also demonstrates that an economic analysis is a necessary element of capital investment justification, but is not sufficient to justify the final selection of a proposed system. On many occasions, non-economic considerations dominate the ultimate selection of a feasible alternative, as is the case presented in this study. A detailed itemization of the potential cost savings involved with the selection and implementation of such a system is also demonstrated. Five feasible system combinations are identified along with each system's basic hardware and software components.
THERE’S A WRECKING BALL AND TWENTY GUYS WITH BLOWTORCHES OVERHEAD. AND YOU’RE SUPPOSED TO BE WATCHING THE BOTTOM LINE?
The Secret of Global Success in 2004

"The secret to succeeding in the global economy in 2004 is AACE International’s almost 50-year record of performance in the management of cost and schedules.”

During the Diversity Summit II, sponsored by the American Association of Engineering Societies and hosted by the National Academy of Science in September 2003, Dr. Joseph Bordogna, deputy director of the National Science Foundation asked, “What does AACE International mean?” I replied to this question that we are the Association for the Advancement of Cost Engineering International and that we are the association for “promoting the planning and management of cost and schedules.” Dr. Bordogna smiled and said he was very aware of the importance of AACE International, and that we are a discipline society that is very important to the strategic mission statement of many other engineering societies. Dr. Bordogna’s statement recognizes AACE International as the leader in, “the management of cost and schedules.”

The success of many projects is judged by a simple formula outlined by Andrew W. Prescott, AIA, emeritus founding partner of EYP, and guest lecturer at numerous colleges and universities. Speaking at the Building Museum, in Washington, DC, Mr. Prescott said, “After a project meets its program criteria, project quality is equal to the project cost and schedule management.” AACE International is the only non-profit organization with a primary strategic plan consisting of a six-point blueprint that emphasizes, “the management of cost and schedules.” For additional insight, please visit our website at, www.aacei.org/administrative/stratplan.pdf.

Our blueprint consists of promoting education, achieving recognition of members, promoting certification, growing internationally, developing technical products, and promoting diversity. Every level of AACE International’s strategic plan emphasizes the vision synonymous with our name, “Association for the Advancement of Cost Engineering International.” Our strategic plan blueprint, our marketing plan, and our tag line of, “Promoting the Planning and Management of Cost and Schedules,” are each geared toward the same goals.

Other organizations are beginning to emphasize their non-existent record of performance, as compared to AACE International. They want to show their organization’s value in helping you and your company succeed in an ever expanding global economy. In many cases, they do not mention, “the management of cost and schedules” as an integral part of their strategic plan. They leave this out for a very good reason, since “the management of cost and schedules” does not appear as a first level initiative for them. These organizations were not developed with a strategic mission statement of, “the management of cost and schedules,” nor do they have an almost 50-year record of performance in this special area.

The question now is where can you find a proven record of performance to help your organization succeed in the global economy of 2004? AACE International’s members know its offerings include, but are not limited to, section meetings, corporate sponsorship, expert publications, salary surveys, service want ads, help wanted ads, special interest groups, recommended practice guides, great practical journal articles, distance learning, on-site training, on-site certification exams, on-line library, custom training, continuing education points, and global leadership in, “the management of cost and schedules.” Now, help us spread the word.

AACE International continues to be a global leader and resource. A few of our global initiatives include the continued development of our website, including a new expert witness area where court-recognized experts can list individual and corporate qualifications; development of a planning and scheduling professional certification designation; continued development of...
our online and distance learning training, plus many other exciting offerings in the developmental stages.

The AACE International website is growing and is currently experiencing over 600,000 hits a month. AACE International has an internationally recognized record of performance that offers continued training and development for your organization’s personnel, to enhance their organizational value. AACE International members, who are also the project managers in many organizations, are generally recognized as being able to provide their organization’s management with cost and schedule estimates along with recommended project solutions.

I urge that you take the AACE International challenge and visit our website, online library, call our headquarters office, or contact AACE International to find out how AACE International can help your organization develop its record of performance in the management of cost and schedules. “The management of cost and schedules” is a vital part of any organization’s blueprint for succeeding in today’s global economy.

Ozzie Belcher
President AACE International
President Belstar Inc.

The Diversity Summit II was hosted by, The Academies; which consist of the: National Academy of Sciences, National Academy of Engineering, Institute of Medicine and National Research, and the American Association of Engineering Societies (AAES).

RECOMMENDED READING
1. Dunlop, James J. Leading the Association, American Society of Association Executives.

Mark Your Calendar
for AACE International's 48th Annual Meeting
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Washington, DC
info@aacei.org / www.aacei.org

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**Bill Porter-Carlton — 3D/1**

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**Joe Bandza - President, Bandza Construction**

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Editor’s Note: Clarification
Ebere Sam Nwansi, CCE, should have been listed with the CCE designation in the November 2003 issue of the Cost Engineering journal, in a list of those who passed the Second Quarter (2Q) Certification Examination.

Giving Appropriate Credit
Dear Editor:

One of our engineers provided me with Cost Engineering journal—Vol. 45, No. 10 October 2003 earlier last week. I was surprised to see pictures and a three page article concerning my speech at AACE International 47th Annual Meeting in June, 2003 in Orlando Florida. I did not expect to be in print.

Nevertheless, please note that certain of the examples quoted in the last paragraph on page 39 and the first two paragraphs on page 40 of the journal were taken from the staff at Beloit College in Wisconsin who annually put together a list to try and give the faculty there a sense of the mindset of the current year’s incoming freshman. I recall mentioning this during the speech; however, I did not see it in the article as written. The appropriate credit should go to the proper people and place.

Regards,
Harry W. Zike
Vice President & CFO
Siemens Westinghouse Power Corporation
4400 Alafaya Trail
Orlando, FL 32826

Comments on September Article
The following comments were not received in a standard letter format, so the text has been modified and edited to bring it into a more of a letter format.

Dear Editor:

In reference to the September, 2003, Cost Engineering journal article (Vol. 45, # 9) Schedule Delay Analysis, Modified Windows Approach, by Kirk D. Gothand—I would like to say that this is an excellent article that gives a concise explanation of various delay analysis practices and why they are faulty. However, I would offer the following comments:

Figure 1 does not exactly match the text of the article. In fig. 2, I wonder why the activities are sequentially numbered in the fragment?

The article states that, “The contract between the claimant and defendant needs to be reviewed to determine that all project work to achieve completion has been included as schedule activities and in the work breakdown structure.” This would imply that there are 'activities' in the WBS. This is incorrect. The lowest level of a WBS is the work package for a sub-deliverable. ‘Activities’ are included within the individual work packages only.

The article also states that, “Updating the schedule includes applying progress to activities worked during the period analyzed, making necessary logic revisions . . .” This is not a good 'practice' for 'hard' mandatory sequences. Discretionary logic or 'soft' logic can be changed if indeed. It must be verified that the contractor really does plan or did re-sequence his work flow.

The article states, “The end of the analysis, for any given period analyzed, is to note any improvement or loss along the project critical path . . .” I would delete the words, “along the critical path.” In a properly resource-based schedule, the 'critical path' is invisible. I would replace these words with, "to the completion date" because the status of the completion date is what we are concerned with.”

On page 23, I’d replace 'schedule' with 'project' so the text would read, “Project completion improvement may be the result of . . .” Finally, the article states, “By following the modified Windows schedule technique . . .” What has been modified ? Did I miss something ?

Earl Glenwright

Comments on October Article
Dear Editor:

I just read the article titled, "How to Befuddle a College Professor (Without Really Trying)" Vol 45, 10 Oct. 2003, and appreciate the debate that the manual calculation of CPM forward and backward passes caused.

At issue is the long-standing (and likely never resolved) debate about the existence of a 'day zero.' Using your terminology, the Aggie method uses a day zero, the AACE International (and mine, and I taught CPM in university settings) method does not. I introduced both methods, then persuaded the students to adopt the AACE International method.

If a project begins "on the morning of day 1," and workdays start in the morning and end in the evening, the AACE International method makes sense. If you believe there is a day zero, then you can use zero in your math and the Aggie method works. The Aggie method is simpler, as you don't have to adjust for the one day not evident numerically (-1, +1 in the formula) due to the AACE International morning/evening convention (a one day activity starts and finishes on the same day, for example), but you have to accept a day zero.

In my opinion, the AACE International method is more accurate from a scheduling standpoint. The Aggie method relies on the accepted use of zero in mathematics, but we are dealing with calendar and working days and, in my opinion, should remain loyal to the form of output (dates, working days) we are generating. You will not find a day zero on any calendar, so you cannot equate the Aggie calculation to real time. Morning and evening terminology makes sense to the users; I have taught manual calculations to lots of people and they pick up on the reason for (-1) on the forward pass and (+1) on the backward pass calculations with ease. My problem with the Aggie method is the lack of an adequate definition or, even, existence of a day zero. Where is this day zero? How would I define it contractually (often a good test), or even graphically? What number is the working day prior to day zero?

All projects start, contractually, on some date. There is no day zero in a contractor's contract; the project begins on the
morning of day one, and so should the CPM schedule.

This will not end the debate. The math works either way, and has something of a romantic attachment for those who care (dreadfully few users of CPM systems these days know how the dates are arrived at). As I write and negotiate contracts, I try to align contracts and schedules and concepts, and it is this thinking that causes me to prefer the AACE International method. Plus, I can explain the morning of day one. I cannot explain day zero, and nobody has been able to explain it to me, and I did pass statistics (barely). Perhaps I am not deep enough to allow the day zero concept into my thinking.

I was going to take the AACE International Scheduler Certification test, but perhaps will not, as I, too, would fail this section. Let me suggest, instead, that the AACE International allow the use of either method and be happy that the correct result is generated.

Ted Ritter

And Another Response to the October Article

Editor’s note: This letter was sent to Ron Winter, author of the article.

Dear Ron:

First, let me qualify where I am coming from. Like you, I am a long term practitioner from the field with a fair amount of claims experience and a former Primavera dealer and authorized trainer. For the past 11 years, I have a consulting company (APMX www.getpmcertified.com) that teaches PMP prep classes, as well as CCC/CCE prep classes to the English as second language professionals in Asia Pacific and Europe. We also do a fair amount of work for the World Bank, Asian Development Bank and UN Projects Office, in applying earned value management to monitor and control projects funded by them. I hold an undergrad degree in construction management, my MS in project management from GWU, and am currently working on my Ph.D. in PM at ESC-Lille University.

I really enjoyed your article in the October issue of Cost Engineering journal, but I am not sure if you cleared up confusion or made it worse. First, in areas of agreement, there are two methods and they do cause confusion, therefore clarification is not only warranted, it is well past due.

However, I think arbitrarily naming these methods the "AACE Method" and the "Aggie Method" is not accurate, nor is it helpful. From my understanding, the two methods derived from ADM (Activity on Arrow) and PDM (Activity on Node) methodology. Back in the "old days" "BP" (Before Primavera) there was only ADM, (MSCS) where the "day" started at time 00:00 and ended at time 24:00. Thus, the convention requiring duration calculations to start at time 0. This can be evidenced in just about any major textbook that features ADM. However, once Primavera came on the scene that allowed for scheduling by the hour, (finest hour) and used PDM, the picture changed. Now instead of time starting at 00:00, time (work) started the "morning of day one, and continued through to the end of day 1, then work recommenced the morning of day 2, etc, etc, with the activity ending at close of business on day n. In PDM, time could start at any point in the day you determined.

As I understand it, any software that uses ADM will have the clock starting at time 0, and any software that uses PDM (including not only Primavera, but Artemis, Open Plan, Microsoft Project and most other software packages today using PDM) time starts on day 1, however it is you may define the actual time (using calendars). (I qualify that by stating that I am only intimately familiar with Primavera and Microsoft Project).

An interesting side note is that the last time I used ADM in a "real life" schedule was the Negev Airbase project, Ovda, Israel, for Perini in 1979-1982, using MSCS. Since that time, not once have I used ADM. To my knowledge, there is not a single major software package that supports ADM. Why? Because only PDM has the flexibility to allow for start to start and finish to finish activities. ADM does not. Now some people argue that the use of start to start and finish to finish is not a good practice, that leads to abuse, but from a pragmatic perspective, it is highly unlikely to ever get people to plan a job in such level of detail as to be able to use ADM. Which is why it has died in the marketplace.

My long standing recommendation has been (to PMI and AACE International) to kill off ADM as a dinosaur.

Several other statements you made also are a cause for some concern:

On page 25 in your review, you state "the only accurate way to determine percent complete is to estimate remaining duration". That is a very dangerous practice, as you are assuming a direct link between physical percent complete and the activities duration. If you subscribe to the concept of using earned value, the only valid way to ascertain percent complete is by demonstrating physical percent complete, measured using one of the six methods shown in Chapter 11 of AACE International's Skills and Knowledge. Remaining duration may or may not reflect the actual progress to date. Thus remaining duration has a legitimate role to play, but not in calculating physical percent complete. Therefore, what Dr. Feigenbaum was advocating is perfectly accurate. Duration and physical percent complete have no direct correlation.

Also on page 25, you state that update forms "should never contain late dates and total float." "Never" is a very powerful word, and while I would tend to agree with you that it can cause problems, assuming your work force is adequately trained and has been involved with the schedule development rather than having it thrust upon them, showing a foreman all his/her work activities sorted (prioritized) by total float can be an effective tool to help the field supervisors deploy their resources most effectively.

Regardless, your article brings up a very good point that is well worth putting on the table, not only for the CCC/CCE exam but also for PMI's PMP exam. (Which contains both ADM and PDM examples)

Thanks and I hope I have not caused you more befuddlement. But at the same time, I think clarification on this topic is something well worth collaborating on by AACE International.

Best Regards,
Paul D. Giammalvo, CCE ♦

Comments and Suggestions

If you have any comments or suggestions about anything you have read in the Cost Engineering journal, letters to the editor may be sent to Marvin Gelhausen, AACE International, 209 Prairie Avenue, Suite 100, Morgantown, WV 26501 or e-mailed to mgelhausen@aacei.org.
12 Lessons from the Football Field that Will Lead Your Company to Victory


Libertyville, IL —Author Maribeth Kuzmeski has been in her element since the leaves began changing colors, and as the old song goes, the frost was on the pumpkin. All of this meant that football season was well underway.

Football is now wrapping up the season as people are digging out sweaters and scarves to ward off winter’s encroaching chill. Each football season gives Kuzmeski, a football fan and marketing guru, plenty of fodder for teaching her clients—businesses of all sizes and shapes in a variety of fields—how to win their own “games” and keep their own “fans” coming back for more.

"The business world is nothing but an ongoing, never-ending push for companies to survive in a dog-eat-dog struggle with their competitors—just like in football," she explains. "Especially in our economy, but even in the best of times, no company can truly afford to rest on its laurels. Either stay on top of your industry or get knocked out of the competition. It’s that simple and that brutal. Companies today have to be tough as nails to stay in the game."


Kuzmeski’s Red Zone Marketing philosophy compares the most critical and magnified area on the football field, the red zone (the final 20 yards before the goal line) to the most critical and magnified area in business (the unmarked territory where you either lose or win a prospective customer). By following her innovative and proven ideas—thoroughly documented in her book—business leaders will learn to move their sales and marketing teams into the red zone . . . and score once they get there.

In keeping with the spirit of football season, here are 12 strategies you can use to stay in the game:

Focus on Winning and Ignore the Naysayers

“My favorite example of someone succeeding in difficult circumstances is Bill Parcells, the current head coach of the Dallas Cowboys,” says Kuzmeski. “Although he was a fantastic coach with an incredible reputation, some people predicted he would not have the same success because the variables in his new environment were quite different from those he had dealt with before. But he has focused on winning and simply blocked out the criticism. And he’s ended up doing very well in an environment where many thought he would not. So my advice to business professionals would be to focus on winning and to keep a high level of confidence no matter how many obstacles you face or how much negativity you hear. That includes operating in a tough economy and any number of other circumstances that may be against you.”

Know Your Competition—and Never Underestimate Them

No question about it: there are always surprises in football. That’s what makes the game so exciting. The same is true in the business world. Don’t assume that the big names will come out on top in your industry. That little "mom & pop" operation to which you’ve never given a second thought might just have an innovative idea that’s destined to move them up in the ranks fast. So pay attention to your competitors and never stop innovating. All of which leads up to the next point . . .

Realize That When You’re on Top, You’re a Bigger Target

The teams favored to carry the season and ultimately win the Super Bowl are the ones the rest of the pack is gunning for. Perhaps your company is in the enviable position of being the industry leader. But how enviable is that, really? The sobering truth is that you have a great big bull’s-eye painted on your back. You can never let your guard down; you must strive harder than ever to give clients and customers outstanding, stupendous service. Sounds exhausting, and it is. But not as exhausting as trying to catch back up once some young upstart competitor has outsmarted you!

If Your Playing Field Isn’t Working for You, Build a New One

Football players know that an unfavorable field can mean the difference between a winning and a losing season. Witness, for instance, the complaints by kickers at Pittsburgh’s Heinz field. While teams like the Steelers may not have the luxury of changing their playing fields, businesses do. For example, if you’re a financial planner trying (and failing) to sell mutual funds to 30-something professionals, maybe you’d be better suited focusing on selling your estate planning services to seniors. So, if you’re trying and trying but keep failing, recognize that you may be on the wrong field—and get busy changing it. Agility and flexibility are absolute necessities.

Accept That Past Performance Does Not Guarantee Future Performance

Often in football, last year’s stellar team is this year’s dud. The lesson for Red Zone Marketers? Never assume that just because a strategy once worked, it will always work. Your business environment is constantly changing along with the players; therefore, your marketing tools and methods must change right along with it.
Always Keep Your Fan Base Stimulated

Except for the "die-hard loyals," football fans can be a fickle bunch. Have you ever seen Green Bay Packer fans during a losing season? Loyalty is their middle name. Usually, when a team is losing, they lose more than the games; they potentially can lose a good portion of their fans. The same is true of your fans, i.e. your clients. They have short attention spans, and, unless you’ve consistently worked to earn their loyalty, they will desert you for the first competitor that offers them a price discount. That’s why Kuzmeski devotes a good portion of Red Zone Marketing to creating compelling client experiences and marketing to existing customers. If you don’t work hard to keep your "fans," an on-the-ball competitor will gladly take them off your hands.

Pay Attention to Your Bench: There May be Some Real Talent There

Remember last year, when quarterback Kurt Warner of the St. Louis Rams was injured and everyone was stunned to discover that his back-up, Marc Bulger, rose to the calling? There is a moral to this story for business people. Don’t assume that your "stars" are the only players who can lead your company to victory. Sometimes a tremendous talent is sitting, undiscovered, on your bench. Make an effort to cultivate all employees—someone you’ve never considered just might have an unexpected skill or a brilliant idea that revolutionizes your company.

Block and Tackle for Your Clients

Every football fan knows that it takes a good offense and a good defense to make a winning team. The phrase "block and tackle" is as applicable to business professionals as it is to NFL teams. First and foremost, get to know your clients’ business and anticipate their problems. That way you can "block" potential problems from occurring, which is the "prevention" part of the equation. The other, more obvious, part involves "tackling" existing problems they’re experiencing. Essentially, you’re giving them what they want (the solutions they’re paying you for), plus something extra (a dose of preventive medicine they didn’t even know they needed)!

Embrace this credo: If You Can Touch it, You Can Catch It

This phrase is often used by football coaches attempting to get their receivers to reach out and grab the ball whenever it is close. What it means to business leaders is more inspirational: if you can see an opportunity, you can win it. Nothing is out of reach! If you can imagine your company winning that big client, then go for it. This spirit of optimism, this unfailing passion, is part & parcel of the Red Zone Marketing philosophy. It’s the "extra point" that makes the difference between winners and losers.

Create an Experience That Keeps ’em Coming Back for More

Some Green Bay Packers players are known for running out on their field during icy December days in short sleeves. Not only does this intimidate their rivals, it gets their fans wildly pumped up. Great football teams go all out to give their fans an incredible, exhilarating, unforgettable experience—one that convinces them to come back again and again. You should do the same. Kuzmeski calls this “creating client delight,” and her book offers many examples of how to do so. Your clients may not stand out-side in ten-below-zero weather waiting for you to show up like the Packers’ fans do, but they should find every interaction with your company memorable and exciting. Remember, every interaction with a client is another opportunity for you to gain a loyal fan and all the positives that go along with that.

Remember: Last-Minute Turnarounds Can Win a Game You Thought Was Lost

Every football fan knows the exhilaration of seeing a sudden turn of events change the outcome of a game that everyone "knew" was over. Think about one of the biggest comebacks in football history: Early in the season, Indianapolis came back from a 21-point deficit going into the fourth quarter to defeat Tampa Bay 38 - 35 in overtime. How exciting—and how inspiring! Business leaders, too, must embrace the "it ain’t over ’til it’s over" philosophy. As Kuzmeski reiterates throughout Red Zone Marketing, the secret to success is to adopt and live by a "never give up" attitude. Keep your eyes on the prize and give it a 100 percent effort until the game is really and truly over.

Always Stay Mentally "in the Game"

Now consider the example in the last tip from the perspective of Tampa Bay. When you put yourself in the shoes of the Buccaneers, you realize that the last-minute-turnaround principle is a double-edged sword. You can never let your guard down, in football or in business. You leave the game mentally when you think you’ve already won it. So always, always, always stay focused on the task at hand. One victory at a time is how a team gets to the Super Bowl. One client at a time is how a business gets to the top of its industry.

Give It Your All

"This last thought—giving it your all—is truly the cornerstone of Red Zone Marketing, says Kuzmeski. And it's the only way a company can ever reach and stay at the top of its industry.

"The whole point of my philosophy is to assume that you’re always playing in the red zone," she concludes. "You must live in the red zone, knowing that your competition is unpredictable, the rules are forever changing, and only by being agile and flexible can you win consistently. And remember, a one-time win doesn’t cut it. There’s always the next game, and the next, and the next after that. You must display toughness and commitment with every business decision and every client interaction—but the rewards are well worth the effort." ◆

About the Author

Maribeth Kuzmeski, MBA, is an accomplished speaker, marketing consultant, and business owner. She has done extensive research into marketing strategies. She speaks across the US on topics relating to successful marketing, presents workshops and Marketing Bootcamps for financial advisors, organizations and entrepreneurs and is a member of the National Speakers Organization. Under her guidance, one of the nation’s top financial advisors built a business from $10 million to $200 million in money under management in five years. She is the president and founder of Red Zone Marketing™, a cutting edge system proven to bring businesses winning seasons year after year.
About the Book

Red Zone Marketing: A Playbook for Winning All the Business You Want (Facts on Demand Press, 2002, ISBN 1-8891-50-34-7, $17.95) is available at bookstores nationwide, major online booksellers, or directly from the publisher by calling (800) 929-3811.

DUES REMINDER

2003 AACE International Membership Expired
Dec. 31, 2003

Please renew your 2004 dues now. If you are moving, be sure to let AACE Headquarters know your new mailing address.

Education Board News

Charla Miller, Staff Director-Education and Administration

ACM Becomes the First Approved Education Provider

The AACE International Education Board is pleased to announce that Administrative Controls Management of Ann Arbor, Michigan, has been recognized as the first AACE International Approved Education Provider under the new program introduced recently.

This program is designed to provide cost and management professionals and their companies with a means of identifying suitable professional development courses and providers, by giving trainers the ability to promote their courses on the AACE website, in print media, and by awarding AACE International professional development hours (PDHs) to attendees.

If you are a trainer, consider becoming an AACE International Approved Education Provider. As such, you will have the ability to list your approved courses on AACE International’s searchable database, promote your company as an AEP, and use the official AACE International Approved Education Provider logo in your promotional materials. Your company will be listed as an Approved Education Provider on the AACE International Education web page, and will be included in an annual listing in Cost Engineering journal.

If you are looking for quality training, AACE International’s Approved Education Providers should be your first choice, because you can be confident that the courses they offer have been through an independent review process. Before a training company, consultant, AACE International section, or other professional organization can be approved as an AEP, they must demonstrate that their programs are relevant to the fields of cost and/or management and address one or more of those skills, and are taught by qualified instructors who are experts in the topics they are presenting.

Whether you are a trainer or a potential client, you can get complete details on the AEP program from the AACE International website, www.aacei.org, or by calling Headquarters at 1-800-COST for further information.

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2003 AACE International Membership Expired
Dec. 31, 2003

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Cost Track™ is the integrated cost and project controls software package designed to give you the competitive edge. This unique and affordable mini-enterprise system efficiently links procurement, planning, material tracking, and inventory control, invoice processing and payment, and provides complete cost and financial reporting. With Cost Track, clients, engineers, and contractors always have instant accurate project status enabling timely decision-making. Use Cost Track and your projects will be on time, on budget, and OnTrack!

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Corner Your Costs Like Never Before
Cost engineering at the New Jersey Institute of Technology (NJIT) is offered as one of the concentrations in the Engineering Management Masters Degree Program. As will be seen subsequently, it is a broad-based interdisciplinary curriculum that includes courses from both NJIT’s College of Engineering and School of Management to enable the inclusion of their respective expertise.

The business-oriented courses are taught by the Management School faculty and the quantitative cost and project management courses by members of the Industrial and Manufacturing Engineering Department, who possess extensive practical experience in these fields.

This degree is intended for individuals with a technical undergraduate education who want to prepare themselves for advancement into management, and for those already functioning as managers desiring to obtain a formal management education. The cost engineering concentration is a natural fit since this combination gives the student both the managerial training they are seeking, as well as specific cost and project management skills that they will be able to use in practice. (It should be pointed out that other schools are offering cost engineering in the framework of an M.S. in project management, M.S. in construction management or M.S. in technology management).

Eligibility for the MSEM degree at NJIT requires the completion of 10 courses, or 30 graduate credits. Six of these are specified and required to be taken by all students enrolled in the program. The purpose being to provide the students with broad-based management fundamentals that are relevant no matter the particular industry or organization. The other four courses are electives to be selected by the student, the only condition being that they must relate to the specialized area that they want to concentrate in and that they be approved by their advisor.

The decision which elective courses should be offered in the cost engineering concentration was influenced by what AACE International has determined the needed skills a cost engineer must have in order to function effectively and by what AACE International’s annual membership survey indicates they do. The latter has shown that the majority of the respondents are engaged in cost estimating, scheduling, project control, and project management. Consequently, specific courses relating to these topics are available. Thus, the course of study for the MSEM, with a concentration in cost engineering, would necessitate taking the following six courses:

- EM 602 Management Science
- EM 636 Project Management
- IE 673 Total Quality Management
- ACCT 615 Strategic Cost Analysis
- MIS 648 Decision Support Systems
- HRM 601 Human Resource Management

Plus, any four courses from those listed below:

- EM 691 Cost Estimating of Capital Projects
- EM 637 Project Control
- IE 618 Engineering Cost and Production Economics
- EM 631 Legal Aspects of Environmental Engineering
- EM 632 Legal Aspects of Construction
- FIN 624 Financial Management
- ARCH 650 Economy of Building
- IE 653 Facility Maintenance
- ENG 620 Proposal Writing

For a more detailed description of the program, admission requirements, and the individual course specifics, the reader is referred to the NJIT website, www.njit.edu. While not the intent, completion of this degree can be considered good preparation for AACE International’s certification exam.

To be noted is that the courses can be taken in the conventional classroom setting or via distance learning. This allows individuals living far from Newark, and those who cannot regularly attend class, to obtain the degree as long as they have access to a computer connection. More detailed information about the distance-learning format can be obtained from Ms. Ellen Schreihof, who is NJIT’s Director of Distance Learning.

Having described cost engineering education at NJIT, I would also like to discuss the rationale underlying its present structure. Like all other educational institutions, the goal is to offer a program that meets the needs of students who are enrolled in it, introduces them to material that represents the state-of-the-art, and is one which has enough sustainable demand to allow its continued offering. To be able to construct such a curriculum the first requirement is to know the needs and anticipate the direction a discipline is taking. With respect to cost engineering, many opinions have been expressed. I would like to now state mine.

When compared to the other occupations (management science, micro economics, accounting, industrial engineering, financial analysis) whose work also involves them with cost issues, cost engineering distinguishes itself when it comes to providing the financial and cost management know how necessary to successfully implement infrastructure capital projects. Given the need to deal with the non-technical (i.e., commercial, economic) aspects of the engineering activity should assure that the demand for cost engineers and preparatory education will continue. What has and is continually changing is the manner, level of sophistication, and the economic environment in which this work is done. Perhaps the greatest change driver being the computer. Many calculations, take-offs, schedules, formerly done by hand are now produced with sophisticated software in more
detail, variety, and in less time than before. Not only did this technology cause the productivity of an individual cost engineer to increase, necessitating fewer numbers to be required, it has also led to components of cost engineering, particularly project control to be done by non-technical degree holders with limited experience at a lower wage cost. Furthermore, because it affords an opportunity to save money, an increasing amount of the work is outsourced to places where salaries are lower. Despite recognition that such actions by organizations to reduce their cost engineering costs could have a negative impact and result in a higher, rather than lower total project cost, competitive pressures make it unlikely that the outsourcing trend will be reversed. One possibility to offset this situation is for cost engineers to expand the scope of their activities. Also, perhaps even more importantly to actively promote wider awareness of their unique capabilities, which are presently underused. For example, it is widely acknowledged that the increased technically complex environment has made investing in capital projects more risky. At the same time, management is pressured to increase the rate-of-return obtained with the resources at their disposal. This holds whether the firm is an owner or contractor. Top management should be made aware that cost engineers, for example, by knowing the right questions to ask, could provide important input to prevent cost overruns and decisions to commit to non-economic projects. Also, that this methodology can be relevantly applied to improve the efficiency of technical operations and facilities management. As cost engineers bring an additional needed perspective that cost accountants cannot, the demand for their services should increase and provide the opportunity for a larger number of cost engineers to work at the operating level.

It is clear from aforementioned that:

- There will be a continuing need for cost engineers to work in their traditional roles on the project management team responsible for the successful execution of capital projects.
- The specific number of cost engineers being required is contingent on the volume of infrastructure capital projects being done worldwide and by the capability of existing software.
- In addition to participating in project management, if they add to their education financial and business skills, cost engineers should be able to expand their organizational activities and also function successfully at the strategic and cost management level.
- Affordable educational opportunities, both in time and money, should be available for individuals seeking to acquire cost engineering and project management proficiency that the employment market dictates they need. Included must be opportunities that allow practicing cost engineers to maintain the currency of their expertise.
- Cost engineers should be encouraged to become AACE International certified and a continuous effort made to publicize the worth of certification for employers.

The previously expressed thinking underlies the cost engineering program at NJIT. It’s educational focus is to train the student to do "traditional" cost engineering, apply state-of-the-art methodology, and prepare them for the expanded role outlined. To keep it up to date, we conduct a periodic review of its curriculum and instructors. An important component being the students’ comments, which are both formally and informally solicited. Over time, this has led to the management science requirement, an increased emphasis on the use of IT Technology in the individual courses, and the addition of a number of electives.

Although the primary purpose of this article is to describe cost engineering education at NJIT, I have included some of my thoughts on what should be done to strengthen cost engineering’s role in the challenging and changing environment it is being applied. Any comments that AACE International members might have would be appreciated. These and any questions with regard to NJIT’s MSEM program should be addressed to me at, wolf@njit.edu.

About the Author

Dr. Carl Wolf, CCE has had a long and distinguished career at NJIT and was the recipient of the Brian D. Dunfield Educational Service Award. He is currently a Fellow of AACE International.

--- CALL FOR VOLUNTEERS! ---

Volunteers are needed for the AACE Certification Board. It’s fun, fulfilling, frustrating, satisfying, time-consuming, and rewarding - all of these adjectives describe what it is like to be a member or chair of the AACE International’s Certification Board. The Certification Board meets twice a year. For those who do not have company support for the travel, this can be a rather expensive proposition, although one of the meetings is normally held at the Annual Meeting.

Perhaps your foremost justification is the ability to have a direct influence on the content and direction of your Association’s certification operations. Additionally, you will find that satisfaction of helping to produce new materials and directions for other cost/management professionals can be very rewarding personally.

You simply need to contact the Certification Administrator at:

AACE International Headquarters
(304) 296-8444
or e-mailing: info@aacei.org.
Resolution of Ethical Issues and Complaints

Professional engineers have a legal obligation to practice in accordance with the ethical requirements of their state or territorial registration board and to report others who fail to do so. That requirement is clear. In addition, if the engineer knows of a violation, it must be reported to the registration board. Failure to report a violation is, in itself, a violation and can lead to disciplinary action and possible revocation or suspension of the license of the engineer who fails to make a report.

But what if the issue is not clear? What if it is uncertain if a violation has indeed occurred? What if all the engineer has to go on is hearsay or rumor and not direct knowledge? Should the suspicions be reported? If the engineer is not sure, is there any avenue to clarify the issue?

The answer is "Yes." Each state and territorial engineering society that is affiliated with the National Society of Professional Engineers (NSPE) has an ethics committee that can assist in resolving such concerns. The engineer can seek the assistance of the state society ethics committee directly or via their local NSPE chapter. Cases can also be referred directly to the NSPE Board of Ethical Review although the state route is preferred because it is more expeditious. The specific circumstances will then be evaluated by professional peers and, if they determine that a breach of the rules and regulations governing the practice of engineering may have occurred, they will refer the matter to the state registration board for further investigation. Throughout this process, the complaint will be held confidential, but if it is referred to the state board it is possible that the engineer who made the original report of suspected wrongdoing might be called to testify.

The state ethics committees can also assist engineers in deciding if an action they or their company is considering is acceptable. At times the issues are not clear and the state committees are willing to assist engineers in deciding upon an appropriate course of action.

In resolving ethical concerns such as these, three types of issues must be examined: factual issues, conceptual issues, and moral issues. Factual issues involve the truth or falsehood of the claim. Conceptual issues relate to the meaning or scope of a term or a concept. Moral issues deal with the relevance or application of moral principles to the issue at hand.

Consider the following situation:

An engineer leaves Company A to work for Company B. While at Company A, the engineer signed a confidentiality agreement with Company A concerning proprietary information. A new project at Company B on which he is asked to work involves emission of Compound X. Emissions of Compound X are not currently regulated but, from his experience with Company A, the engineer knows a method to change the process, thereby eliminating the emissions of Compound X. Further, the engineer’s knowledge would not harm the competitive position of Company A. Under these circumstances, should the engineer approach Company B with the proposed change?

The ethical issues which must be addressed here are:

1. Factual issue—Is Compound X really hazardous?
2. Conceptual issue—What is "proprietary information?"
3. Moral issue—Even though it is not regulated, can Compound X cause adverse health effects?

These are the issues that must be clarified prior to determining if the engineer’s anticipated actions are acceptable. The state ethics committees are a valuable resource in resolving issues such as these. Then, if the issue involves actions which have already occurred and which appear to be inappropriate, the question can be referred to the registration board for appropriate action.

As a cautionary note, the committee procedure should not be used to avoid reporting known violations or suspected violations for which strong supporting evidence is available. In such cases, the concern must be reported to the registration board without delay. It is wise, however, to report the issue to the state committee simultaneously, as it may be able to assist the board and/or the complainant in resolving the complaint.
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YOUR TECHNICAL BOARD
Editor's Note: This is the first in a series of articles that will look at forecasting. They are being presented in a non peer-reviewed format by James E. Baar and Stephen M. Jacobson, CCC. The next article in this series will be, “The Keys to Forecasting—#1 Scope.”

Forecasting: Is it more of an art or more of a science? What helps in creating a better forecast? A little bit of luck? Or maybe a few gray hairs called experience? How about a good project team in which all have excellent communication skills? Or maybe being in the right meeting? Or just the knack of asking the right questions? Maybe of course, all the time in world?

All of these issues do contribute to and improve your ability to forecast. But, in reality what does it take to provide good forecasting? While the forecasting exercise can be an overwhelming responsibility, there are key issues to focus on that can help mitigate the forecasting pressures. Let's look at six keys that will have a significant impact in helping you enhance your ability to provide better and timely forecasts, regardless of the type or size of the project. While each key issue stands alone, these keys work together to provide maximum forecasting potential. These six keys are defined as follows:

- Scope;
- Work Breakdown Structure (WBS);
- Change control;
- Data Flow;
- Timing; and
- Communications

What is forecasting?

One definition of forecasting is: the ability to predict the final cost of a unique scope of work. For example, this can be a single tagged piece of equipment, piping fabrication, electrical materials, design cost, construction indirects or a construction subcontract. All of these pieces make up a project. In essence, forecasting is the continuous review and analysis of the project cost related data so that trends can be recognized early enough to allow the project team time to react and correct these trends, in order to have a positive cost outcome on the project.

With this definition of forecasting, let us examine these six keys.

Scope:

Is there a written description of the project? What is the end result or output? Has the process been established? How will the job be executed (i.e., how will the project be engineered? Who will buy materials? What type of construction will you have, direct hire, lump sum, etc.? Is there a schedule? Do specifica-

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<th>Deliverables (I) = Issued, (P) = Preliminary Issue, (O) = Optional) and Expected Accuracy</th>
<th>Type of Estimate</th>
<th>** Estimate Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class V (Order of Magnitude)</td>
<td>≥ 15%</td>
<td></td>
</tr>
<tr>
<td>Class IV (Rough)</td>
<td>20 to 40%</td>
<td></td>
</tr>
<tr>
<td>Class III (Early Phase 2)</td>
<td>30 to 70%</td>
<td></td>
</tr>
<tr>
<td>Class II (Control)</td>
<td>20 to 80%</td>
<td></td>
</tr>
<tr>
<td>Class I (Construction)</td>
<td>≥ 95%</td>
<td></td>
</tr>
</tbody>
</table>

** Project
- Product and Plant Capacity
- Historical Data from Similar Plants

** Scope and Process
- Project Wastewater Summary & Infrastructure Requirements
- Project Scope of Work Document

** Process Data
- Block Flow Diagrams
- Preliminary P&ID’s
- P&ID’s - Rev “C” (Issues for Design)
- P&ID’s - Rev “D” (Issues for Construction)

** Equipment Selection and Layout
- Preliminary - Equipment Specifications, Fax Quotes
- Equipment Specifications, Written Quotations for Major Equipment
- Equipment Location Plans, IFD
- Final Equipment Specifications, Film Stills
- Equipment Location Plans, IFD

** Site Preparation
- Location of Site
- General Description of Site and Facilities
- Subsoil Investigation
- Description & Dimensions of Site Improvements
- Topo Maps, General Site Preparation Drawings
- Final Plant Road and Other Site Preparation Drawings

** Buildings and Structures
- Preliminary Sizes and Type of Construction
- Structural Design Sketches
- Foundation Sketches
- Architectural Drawings
- Building Plans & Elevations
- Detail Designs and Specifications

** Piping
- Preliminary Plot Plans
- Plot Plans, R-0
- Preliminary quantities on non-ressed piping
- Piping line list with LF of pipe per line
- Detailed Line, Takeoff, Valves, and Valves Lists
- Piping Layout & Sketches of Critical Lines
- Piping Layout Drawings & 3D, IFD

** Instruments
- Content Strategy
- Preliminary Process Instrument List from Historical Costs
- Procurement List from Vendor quotes

** Electrical
- Power Requirements from Preliminary Motor List
- Power Distribution Diagrams Single Lines
- Substation Designs and Specifications
- Facility Single Lines, IFD
- Electrical Design Documents, IFD

** Utilities
- Preliminary Flow Diagrams and Heat Balances
- Flow Diagram and Heat Balance IFD
- Detail Designs and Specifications

** Construction
- Direct and Indirect Cost Factor
- Direct & Indirect Cost Estimates Based on IFD Documents & Schedule
- Direct & Indirect Cost Based on Resource Loaded Schedule on IFD Documents

** Professional Service
- Percentage of TIC
- Estimate for Next Phase
- Detailed Manhour Estimates

** Schedule
- Conceptual Construction Window
- Master Schedule with Milestones
- Resource Loaded Schedule
- 

** Risk Assessment
- Risk Assessment Qualitative

** Table 1 — Estimating Deliverables Matrix

account structure is your guideline to setting up a budget control base for your baseline, the budget control aspect must be set up around the execution plan. Failure to set or reset your baseline on this principle will most likely cause you to fail in executing cost control and forecasting. Why? The answer is data flow. More will be covered on this later.

**Change Control:**

The project has been released for execution. You have your control estimate in hand. You have completed taking the control estimate and creating a baseline budget by code of accounts. Remember, this code of account oriented budget baseline is how you plan on controlling the project in terms of revised budgets, commitments, actuals and forecast. Change on a project will and is going to happen. It is therefore imperative that you understand this change in terms of change in the budget or the baseline or the control budget, as established by the scope of work and the resultant WBS. Very simply: The revised budget = original budget, plus change.

Understanding change in terms of growth, plus or minus, is of the utmost priority to insure that you fully understand the most current scope of the project. Without change control and its documentation, your ability to provide early trends and their impact to project cost will be greatly diminished.

Change control is your first line of defense. Without it, proper cost control of the project will evaporate from you extremely quickly and you will rarely get your arms around the project again, as the scope will become a moving target. Table 3 is a change flow diagram. Do you have a change procedure? Most importantly, everyone on the project team must be fully integrated into the change philosophy and work procedure. One main key concept is that anyone on the project team can start a change

**Table 2— Coding Structure Concept**

1. **Code Structure**
   - **Unit / Area**
   - **Prime Code**
   - **Sub Code**
   - **Cost Element**

   1.1 Unit / Area
      - The Unit or Area designator is used to define the general work breakdown of the particular project. The assignment of the work breakdown is based on the particular project requirement. There are no predefined guidelines. Often the unit area is used to separate individual processes until areas labor charges within an overall contract number.
      - **Example:**
        - Area 01 = Process area
        - Area 02 = Material Finishing area

   1.1.2 Prime Code
      - The primary code designates the general description of the cost item.
      - **Example:** 52 = Concrete, 62 = Piping, 90 = Engineering.

   1.1.3 Sub Codes
      - The three-digit sub code allows detailed segregation of project costs.
      - **Example:** 300 = valves, 400 = fabricated pipe, etc.

   1.1.4 Cost Element
      - A one digit cost element to determine what type of cost item the item is.

   **Current Cost Element Assignments:**
      - 1: Craft labor cost
      - 2: Material cost
      - 3: Subcontract Cost
      - 4: Not Assigned
      - 5: Professional Services Labor (Includes Salaried Field Staff Labor)

**Table 3— Change Notices/Change Orders Work Flow Procedure**
request. Why, because everyone is responsible for knowing his/her scope and identifying any deviation, change, or impact to that scope.

A common error in change control is that a change submitted for a design change is sometimes only looked at in terms of engineering impact and not for potential material, construction, and or schedule impact. Have you examined all potential cost aspects of the change request? In essence, a solid change control system not only provides well-defined scope, but provides the method for evaluating, approving or rejecting, and incorporating change.

A note of concern regarding change. Some managers look at change in a negative aspect, as it means costs are increasing, so you hear, "no change" or "all changes will come out of contingency". In this case, you have to professionally point out that change management is the only way to control cost and as such will really help the manager to avoid those large cost increases at the end of the project. A good change control system provides this visibility. Good project management then has a chance to manage it. In the end, the lack of a change control system will highly impact and impair your ability to forecast, and therefore manage the cost. So the question becomes, do you have a change procedure?

**Data Flow:**

Another way to look at data flow is to say, "Where do I go to get all the relevant cost information?" or "What are my company's work processes that provide the data I require for proper cost control?" Let's ask the questions this way, "By each baseline code of account for which a cost budget (hours, and or dollars) has been created: What will be the source of the commitments? Where will you get or obtain actual expenditures? How will you develop the forecast from this data?" Experience on TIC (total installed cost) projects has been that not all data comes from the same source, tool, or system. The key here is the word "same." TIC supported data will come from many sources, even within your company. This concept will allow you to obtain data from as close to the source of work as possible. This will help you focus on the cost drivers and who/what controls them.

**Commitments:**

Commitments are far more valuable than expenditures in terms of helping you forecast. Why? The issue is timing of data. If you only rely on expenditures, by the time you realize a problem, it is too late to control it. A good definition of commitments is: the value of purchase orders or subcontracts awarded, or services incurred, which can be paid at a later date in time. Therefore, where do your commitment values come from? Here is a sample concept on how to view this.

Purchase Orders (PO’s) for materials or fabrication are issued by the purchasing or materials management group. They are usually coded to a code of accounts, however, sometimes a PO can have one or more codes of accounts. The more you can insure that the PO, as written, contains materials specific to only one code of account, the more straight-forward your data will be and the more easily you can make detail checks, if required.

Let's assume you set your control budget up with one piping fabricator. Now, because of schedule issues, the project desires two piping fabricators. You should create another code of account for the second fabricator and then adjust your control budgets accordingly, with a change order that is really a transfer of budget, to keep the budget shifts properly accounted for and documented. You now have data coming from two unique sources, in this case two fabricators. It is easier to analyze cost looking at each of these cost sources rather than the data being combined.

Subcontracts for construction services are like a purchase order. You make an award for a certain value of services. You need to create a unique budget for that service. As in the example above, you may have to break out and transfer budgets to support this particular or unique scope of service. Again, you need to have one unique code of account for each subcontract you are monitoring and forecasting.

As for direct hire construction, how do you track on site craft expenditures, purchase orders, field staff, and construction equipment? Have you specified a specific code of account for each major tracking unit that fits the data flow? Again, ask yourself, what systems do I have and how do they process data and what reports provide this data and what will I do with the information?

Engineering services are usually a separate cost control system with their own database and unique engineering code of accounts. Where appropriate, strive for budgeting, analyzing and forecasting based on discipline, or maybe area or package. Many times this is controlled and forecasted into a single capital code of account within the TIC cost report.

Concerning owner's cost, where do you expect to get these cost commitments? To what detail can the owner supply this data? Moreover, does the owner want these costs in your report? If the answer is yes, then to what level does the owner want them identified and therefore, what reports can the owner provide on a monthly basis for you to properly have cost control visibility? It is important that you discuss and agree to the level(s) of cost detail to be reported.

**Expenditures:**

One definition of expenditures is: the cumulative value of the checks as written to date, paid to date. Again, this source must relate to the cost control code of account breakdown. Ask yourself, "from what databases can I receive the data report(s) that give me real time expenditures?" Experience tells me that some databases only give weekly data while others give monthly data. Good expenditure databases should provide you information by code of account and purchase order number (if applicable) and as a minimum, on a weekly basis. A weekly update gives you maximum potential to control your updating and how you wish to apply expenditures as part of your forecasting analysis.

Using the multi-source commitment and expenditure overview above, ask yourself, "What are all the sources of my commitments and expenditures? Can I receive this data by code of account? Do I have the flexibility to update on a weekly basis?" If you see errors, does the data source(s) allow for reconciliation to the financial system? What is the timing required to correct these errors? This may affect your reporting!

**Timing:**

The word timing is in reference to performing the proper cost work processes in a reasonable sequence, so that you have adequate time not only to prepare the different levels and types of
forecast required, but that your forecast is prepared in a sequence that allows proper management reviews, especially by the project manager. We have all heard it said many times, "I cannot make that deadline! I cannot review all aspects of the TIC cost report! I do not have time to apply the information! I cannot…! I do not have time to…!" All companies work with some sort of accounting payroll and expenditure cutoffs oriented to either a weekly and/or a monthly schedule. Further, well-run projects do establish when the project report will be issued and this includes the cost report with its best updated forecast. It is critical to have time to analyze and forecast the data as opposed to just gathering data and putting it into the reports.

Many of us have been there. It does not take anyone long to recognize that they cannot update every aspect of a full blown TIC cost report if they wait until the end of the month to try and look at all aspects of the TIC cost. See Table 4. This flow chart can help you understand how to balance the monthly cost forecasting workload. This concept works best when data can be updated on a weekly basis. Therefore, take all the cost forecasting components (engineering vs. field craft vs. field staff, etc.) and update them at different times over the course of the month.

Remember, your goal is to forecast cost. Therefore, once a month (at some point in that month) look at one aspect of the cost. Over the month you will have analyzed, adjusted, and reviewed with the project manager all aspects of the TIC forecast cost. One point to keep in mind, while it is necessary to review all project costs on a monthly basis, use your time wisely. Spend your analysis on the issues that are critical; remember the principle of diminishing returns.

What does this concept do for you? It allows you the opportunity to update, review and analyze every significant aspect of the TIC cost on a monthly basis. This in turn gives you time at the end of the month to bring the full picture together to provide final analysis and time to communicate with the project management team. In concept, focus on those non-progress type items (construction equipment, indirects, materials, equipment, etc.) that can be updated and forecasted during the mid-month cycles. This gives time to focus on the areas that are heavily dependent upon physical progress and productivity, which generally need to be updated based on the month end date (engineering design, construction hours, etc.). This progressing type of information usually gets reported on a curve in terms of staffing levels, progress and performance, therefore the focus is on end of cycle (i.e., month end) reporting. Time! How are you using yours? What does your resource and time work plan look like?

**Communications:**

Okay, you have updated your cost report and updated commitments and actuals and have accessed your analysis and adjusted your forecast. How do you communicate this information? Let's look at some, "Golden Rules of Communication":

**Rule One:** No cost report gets issued until the project manager has reviewed the suggested forecast and has provided his/her input and forecast changes. The project manager is responsible for the project and as such, must be fully ready to...
support, defend, and explain the forecast changes and trends to the client and his MOPS (manager of projects). A well informed cost engineer can really help a project manager by red flagging the key concerns and drawing focus to the right issues. Do not sandbag the project manager by issuing an unseen cost report!

**Rule Two:** Every time you make a forecast change to a code of account, write down the reasons why. Use a simple spreadsheet where you compare last month’s forecast to this month’s forecast, calculate the delta and then write in the reason, by code of account. Most code of accounts roll up to a higher level. Therefore, ask yourself, for instance, if the dollar forecast for the concrete account went up a certain value, what accounts were impacted and why? Can you tell the story? If you have written it down over the month as you reviewed, analyzed and adjusted each account, then you have a great record book to use as your support when discussing forecast changes with management.

**Rule Three:** When reviewing with managers or clients, start at the summary level with an overview by major account (i.e., concrete vs. piping vs. engineering services, etc.) and be ready to step down into an account by account overview if needed. Those forecast notes you took will be handy now! A thought to remember: you tend to develop the forecast from the bottom up and review the forecast from the top down.

**Rule Four:** Never issue a cost report without written explanation of what took place and issues raised and directions taken or to be examined, etc. A cost report without proper documentation can and will cause misunderstanding, confusion, misinterpretation, and most likely misguided management direction. Good documentation of cost forecast variances, in most cases, answers the question before it gets asked.

Consider the following:

- A project estimate does not have to accurately reflect the facility being built, as much as it must be well-defined and documented.
- Change control is essential to good cost control, thus forecasting.
- Knowing the data sources and work processes insure accuracy of the cost data.
- Manage your work processes and you will find the time to provide analysis, thus good forecasts.
- It takes both verbal and written communication to get the job done.
- Sometimes management just wants to know we are in control of the cost, and sometimes cost growth itself is not as critical as the reason for the growth, and the timing of the information.

When all is said and done, cost forecasting is an awesome responsibility. If you perform cost engineering functions, you have one primary goal - Continually providing the best practical forecast of the cost of the project as it is currently defined.

Forecasting is the real value of the services that you bring to the project team. This is what makes you a first string player. It is no different than being on a major sports team. The best players will always be in demand.

The authors hope that we have introduced some aspect from our experience that may help make your forecasting responsibility a little bit easier because you have organized and planned for success.

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**About the Authors**

James E. Baar has over 30 years of experience on total installed cost (TIC) projects. He has held positions as project scheduler, cost engineer, field project controls manager, and project manager. He is currently the manager of project controls for Jacobs Engineering Group, Inc., at Denver, CO. He can be reached by e-mail at jim.baar@jacobs.com.

Stephen M. Jacobson, CCC, has over 20 years of experience with expanding organizations contributing expertise in operations, project management, strategic planning, annual capital budgeting and cost engineering. He is an AACE International Certified Cost Consultant, and is the current Technical Committee Chair for Project and Cost Control. He has led cross-functional and multi-discipline teams throughout North America to identify and maximize investment opportunities contributing from concept through closeout. He has worked in both the public and private sectors and has experience in pharmaceutical, biotech, aerospace, forest products, and transportation industries. He has a BA from Gettysburg College and has taken graduate studies in engineering at Rutgers University. He can be reached by e-mail at jacobsons@sound-transit.org.
The Project Manager’s Partner -
A Step by Step Guide to Project Management

In this handbook, Michael Greer presents an overview to generally recognized industry standard project management terminology and concepts, which should be especially relevant for new or part-time project managers.

Greer does a good job to explain that this book is not detailed enough for a project manager tasked with a major project, such as a billion dollar construction project or landing a spacecraft on Mars. Rather, it is for those individuals with training in other fields such as accounting, engineering, or other specialties that are now challenged to produce a project, which achieved high quality results, on time and within budget. That being said, knowledge can sometimes reach a level of sophistication at which the individual can lose the simplicity of its underpinnings. For this reason, many performance professionals recommend that practitioners periodically review topics in which they are proficient, to prevent their perspectives from becoming stale. To that end, this book is a good resource, even for experts.

Greer divides this book into three main sections, each a distinct treatment of topics and tools. The introduction and part I of the book, entitled, Your Deliverables, Phases, and Project Life Cycle, goes into detail to explain such rudimentary concepts such as functional vs. matrix organizational structures, general vs. project managers skill sets, project life cycles, and essential project actions. While simplistic, I liked the way Greer cautioned young managers to guard against using the unconscious habits of highly skilled and effective project managers that don't appear to be following a "success script," but continuously produce successful projects. Instead, he recommends that budding managers practice each step and process, ensuring closure/sign-off of each step, taking nothing for granted, which should lead to a successful project completion.

The handbook wraps up part I with a worksheet called, My Unique Project Life Cycle, enabling the project manager to create his or her own custom-tailored project life cycle based on typical project phases and activities. Thinking back to my own experiences as a young project manager, I wished that I had something like this as a guide. I’m sure my learning curve would have been much shorter.

Part II of the book is entitled, Your Essential Project Actions, and it provides an opportunity for the project manager to develop actions given the project-specific deliverables and phases identified in Part I. Greer points out that all projects have five generic processes. These include the following.

- **Initiating**—authorizing the project and gaining commitment;
- **Planning**—determining the scope, activities, resources, schedule, and costs and creating essential and discretionary plans
- **Executing**—implementing the plans, developing the team, distributing information, contracting, etc.;
- **Controlling**—comparing actual to planned performance; and
- **Closing**—verifying scope, administrative items, and closing the contract.

Since every project will have these five processes, Greer developed a worksheet delineating the five, along with a list of actions that a project manager should take in order to complete a project successfully. I found the worksheet extremely valuable primarily because of a column entitled, "Results of Successful Performance" related to an action item. For example, one of the action items under planning is to close out the project planning phase. Under result, Greer points out that a successful project plan will be approved, in writing, by the project sponsor. I readily concur with this action item and personally see too many projects that do not have written approval, causing rework later.

Part III of the book entitled, Your Project Management Action Items, provides specific action items to work through each of the five phases identified in Part II. Experienced project managers will find Part III the real "heart" of this book. The beauty of this section is that it was not written in isolation from the earlier chapters. It works through each of the five processes (initiating, planning, executing, controlling, and closing) and outlines real-world tools and techniques for accomplishing project goals.

Each action item description contains an assignment, desired outputs, background information, worksheet, and/or guidelines, actions a veteran project manager might take, pitfalls and cautions, and a resource for more information. Because of my guru standing as a project manager, my eyes gravitated to the sections regarding, "what a veteran project manager might do," to see if I could learn anything or simply gloat that I already knew that. I immediately decided that the evaluating project scope action item would be my test, since I believe that many problem projects have an ill-defined scope. Also, I am currently trying to write a book called, "How to Identify Problem Projects Early" based on my eight years as a Big 5 consultant and one of my key findings was scope development and sign-off is a major problem.
in our industry. While I was pleased to see Greer's suggestions that a veteran manager might enlist expert support, conduct product analysis, conduct benefit-cost analysis, and identify alternatives as methods to combat poor scope, I felt somewhat cheated by the write-up. Fortunately, I kept reading and found the details contained under the "Pitfalls and Cautions" section of each action item to calm my fears. In fact, for experienced project managers, especially PMP's, I would highly recommend skimming most of Part III, but honing in on the veteran manager and pitfalls sections. To Greer's credit, he continually encourages project managers at all levels of experience to seek advice and networking opportunities. He also includes a resource in each tool's summary so that the reader can seek out additional information. The text description in Part III can seem complicated, but it is reinforced by graphic figures and tables that drives the information home, especially to the visual learner.

Many readers merely skim the appendix of a book or ignore it completely. I strongly encourage anyone who reads this handbook to more than skim this section. It contains a wealth of information, including: tips for managing experts outside of your expertise, a glossary of project management terms, a summary of key project manager actions and results, potential shortcuts for low-risk projects, guidelines for deciding when to kill a project, how to take charge of your project management software and selected project manager resources, such as PM-oriented websites and publications. Again, Greer provides us with tables and user-friendly advice that will not only broaden our knowledge of project management, but also help us interact and talk intelligently with others during the process.

The Project Manager's Partner is designed so that it can "stand alone" and be of immediate value to novice project managers. The tools may be used out-of-sequence, so project managers need not read through the entire book to apply a tool. For example, if you are involved in developing a schedule, you may simply turn to the tool which deals with developing a schedule and get right to work. I believe most project managers will find this handbook to be an excellent resource with forms, checklists, and practical applications. However, it does not provide the depth of information needed for those hard-to-handle projects. For instance, the handbook gives some excellent aids for cost-estimating and budgeting, but it does not address in great detail the negotiation steps or actions required to obtain critical cash flow when schedules change. Also, Greer includes many essential tools for taking those first steps and for making plans, but he does not address overcoming the all too common unforeseen obstacles.

In summary, from a people perspective, project management can be a rewarding and developmental experience or a downward slide into confusion and panic. In most of today's organizations, project managers are not professionals in this discipline, rather they accept this responsibility along with their normal job duties. Therefore, having this basic handbook as a resource can save hours of rework and avoid countless "lessons learned" meetings to discover what went wrong. I highly recommend it. ♦

About the Reviewer

David Bentley is the president of Bentley Management Group LLC, a company started in 2000 to provide project management and construction consulting services to the building industry. Mr. Bentley is a Certified Cost Engineer (not currently active). Prior to running his own company, Mr. Bentley was employed by such notable firms as Fluor, Morrison-Knudsen, Aramco Services, Parsons-Brinckerhoff, PriceWaterhouseCoopers, and Ernst & Young as a cost engineer, project engineer, construction manager, and project manager.
One of the most prevalent ways of assessing and asserting claims is to analyze time delays suffered on a project. There are a number of methods by which this can be done. This article will touch on definitions of several of these methods. The thrust of this article, however, focuses on a method called the “collapsed as-built” schedule analysis, also known as the “but-for” schedule analysis. This type of analysis begins with creating or refining an as-built schedule, identifying delays and caused by a particular party, and then removing those delays from the schedule to illustrate how work on the project would have progressed, but for those identified delays.

This article is geared toward individuals who already possess some degree of scheduling ability. The intent is twofold: to explain underlying concepts on a basic level, and to offer a step-by-step method to create a collapsed, as-built analysis of a project schedule.

**DELAY CLAIMS PRIMER**

**Delay and Blame Defined**

A “delay” is the time during which a project cannot proceed as planned. The cause of a delay, or blame, can be attributed either to a) a specific party, b) a combination of parties, or c) unforeseen and unalterable circumstances not attributable to any person or company involved in the project.

For example, if an owner neglects to obtain a permit in time for the contractor to begin work, it would be expected that the contractor would submit a change order to the owner. If the owner rejects the change order, it may evolve into a delay claim by the contractor. Regardless of where the blame lies, all delays should be included in the as-built schedule to accurately represent how the project actually progressed. After the as-built schedule is complete, only delays caused by one party will be collapsed, illustrating that party’s delay impact.

**Quality Control**

Schedules are critical to the measurement of delays. However, in order to be used in arbitration or litigation, schedules must be of a high quality to shed light on the issues at hand. A poor quality schedule will not clarify the issues at hand. Indeed, it will cast doubt on the veracity of the claim. Therefore, it is critical that the schedule be reliable and complete. It must be accurate, logically driven, and must not contradict other data or known facts.

**Reliability**

The reliability of a schedule’s data will be called into question if there are other data, particularly if those data are produced by the same party, with different dates than those in the schedule. For example, if the schedule reflects that a foundation was placed on one date and the daily reports show the foundation being placed on another date, the reliability of the entire analysis may be compromised. It is essential that the actual dates reflected in the schedule are accurate.

**Constraints**

During the life of a project, a scheduler may use constraints when information is incomplete. However, constraints override schedule logic and interfere with schedule analysis. All unnecessary constraints must be removed from the claim schedule.

**Open-Ended Activities**

Open-ended activities wreak havoc on the realistic assessment of the workflow of a project. An open-ended activity is one that is missing a predecessor or successor. Sometimes an activity can be begun at any convenient point during the project—it does not have a specific predecessor or a definite successor—so the scheduler leaves it with open ends. Though this may reflect the reality of how the work can proceed, it may be seen as poor scheduling practice and can interfere with the evaluation of delays and its resultant credibility. One should aim to have only one activity with no predecessors (the project start milestone) and one with no successors (the project completion milestone).

**Errors**

Mistakes can lead to consequences ranging from a lack of credibility to outright rejection of the schedule. Care must be taken to match dates and durations to daily reports and other outside sources. Unless the scheduler who built the schedule has documented his or her sources for the actual dates as entered into the schedule, always assume that the written evidence of work progressing or being completed, such as daily reports, is more correct than the schedule itself.

**Analysis Methods**

There are several methods used to assess delay claims. A brief definition of each with its benefits and drawbacks is presented here as reference.

**Planned vs. As-Built Method**

The planned vs. as-built method is probably the oldest and most straightforward. It compares activities from the contractor’s planned schedule with actual completion dates on the “as-built.”

**Benefits**

- Easy to understand.
- Relatively simple to implement.
- Allows for mitigation of delays.

**Drawbacks**

- Takes much longer to implement.
- Assumes the baseline schedule is complete.
- Assumes the schedule has been corrected.
- Assumes the schedule is complete.
- Assumes the schedule is accurate.

**Impacted As-Planned Method**

The impacted as-planned schedule starts with the contractor’s as-planned schedule. One then incorporates delays as activities that impacted the work. The effect of these delays to subsequent activities may lead to a time extension if the completion is delayed beyond the contract date.

**Benefits**

- Takes much longer to implement.
- Relatively simple to implement.
- Allows for mitigation of delays.
- Assumes the baseline schedule logic holds.

- Assumes the baseline schedule logic holds.
Windows Method

Among the most highly respected methods of delay claims analysis is the windows analysis, also known as contemporaneous period analysis. This method assesses the schedule one reporting period at a time. One starts with the monthly schedule nearest the delay issue in question and then updates that schedule before and after the delay date to see how the critical path changes. Any changes must be included in subsequent periods, until the entire project is thus analyzed.

Benefits

• Considers dynamic nature of the critical path.
• Most often accepted as accurate.

Drawbacks

• Time consuming and costly to develop.

Collapsed As-Built Method

The collapsed as-built analysis begins with an as-built schedule, including all known or identified delays, then removes those delays from the schedule to illustrate how work would have progressed but for those delays. This process is also known as a “but-for” schedule.

Benefits

• Less costly than the windows method.
• Can provide very good accuracy.

Drawbacks

• Makes no allowance for mitigation of delays.
• Assumes that the baseline schedule logic holds.

As can be seen, there is no definite method that is always best. Sometimes a simple analysis is all that is required. Each method has both advantages and disadvantages.

The collapsed as-built method is chosen to a level of acceptability almost equal to that of the windows method, while being less costly to produce. That is why I’ve selected it for this article.

Collapsed As-Built Schedule Analysis

Step 1—Create An As-Built Schedule

The beginning point of your collapsed as-built (CAB) schedule is an as-built schedule. The scheduler must verify the as-built dates and sequencings against project documents other than the schedule itself. The entire CAB analysis rests on the premise that arbitration or litigation will eventually become necessary. In that light, one must be certain to cite references for all dates. If there is suspicion that dates were created or approximated, then all subsequent assumptions are suspect, and the analysis is strictly academic rather than useful in proving one’s case.

Document the Source for Each Date

I recommend documenting the source of actual dates outside of the schedule. A good method is to examine the contractor’s and subcontractors’ daily reports, listing all activities that relate directly to the delays for which a claim is being made. Additionally, one should list substantial activities such as the start of major work, weather delays, delivery of major equipment, and completion of major work in a spreadsheet. Even on a highly complex and expensive project, these can be limited to a few hundred dates. A good, simple method for doing this is a spreadsheet such as the one in Table 2.

Some experts recommend actually using log notes within the schedule to document the sources of the dates. This is an excellent idea, but it is time-consuming. One advantage, besides speed, of using a spreadsheet, is that one can sort or search the data. If the activity identification is recorded in the spreadsheet, it allows cross-referencing of the spreadsheet and schedule.

Reduce the Size of the Schedule

Referencing the list of actual dates, one should reduce the number of activities to a manageable number. A controllable CAB schedule typically should not exceed 500 activities. It might equate to a master- or summary-level schedule, but rather than rolling the schedule up, one should actually delete or dissolve activities so that no activities that are hidden or filtered.

A note for Primavera Project Planner (P3) users: Use the “dissolve” feature rather than deleting activities whenever possible. “Dissolve” simultaneously deletes an activity while tying its predecessors to its successors. This retains the logical flow among activities, defaulting to a FS relationship with no lag.

Multiple Calendars

Ideally, one should use a single calendar in the schedule. If the schedule is resource-loaded and one needs to track that one crew worked a five-day 40-hour week, while another crew worked six 12-hour days, this may not be possible. However, the ideal situation would allow one to use a single calendar with no non-working days except for weather delays.

Use Calendars for Weather Delays

The scheduler should make use of the features of sophisticated scheduling software to track weather delays. For example, if no work was possible because of a blizzard in mid-February, make the affected days non-working in the project calendar. In P3, the best place to do this is in the global calendar. That way, if one is working with multiple calendars, they will all reflect the same weather delays.

In Figure 2, there are three different calendars in the same schedule. In the global calendar (a), the shaded days are selected and marked as nonwork days. All other calendars (b) and (c) will automatically include changes made to the global calendar.

Ranked Preference of Logical Relationships

The best relationship for CAB analysis is a finish-to-start (FS) relationship with no lag. See figure 3.

However, it is not always possible to use an FS relationship. If an FS does not work, explore other ways to tie activities together. The ranked order of preference of types of relationship ties is as follows: 1) finish-to-start, 2) finish-to-finish, 3) start-to-start, and 4) start-to-finish. Use the type of relationship that gives the shortest lag time between activities to get the actual dates.

Step 2—Classify, Quantify and Incorporate Delays

Excusable and Nonexcusable Delays
All delays fall into two broad categories: excusable and nonexcusable. It is not safe to use past experience to judge whether a delay is excusable. If the contract contradicts one’s experience, it will still prevail in arbitration or litigation. For example, if the contract states that the Contractor assumes the risk of delayed project delivery in the event of natural or human origin that could not have been reasonably foreseen or expected and is out of the control of the contractor then those unforeseen and unalterable delays will be considered legally unexcused.

Generally, though, nonexcusable delays are those that are within the control of a party and therefore result in consequences ranging in severity from loss of profit to assessment of liquidated damages or the termination of the contract.

Compensable and Noncompensable Delays

Once a delay is identified, one asks whether it is an excusable delay. One must further ask whether it is a compensable delay. Again, the contract is the gauge by which one should judge compensability. If the contract specifically excludes a delay, stating that the risk associated with such is the explicit responsibility of one party, it will be difficult to prove otherwise.

The best candidates to pursue in delay claims are those that are both excusable and compensable (see Figure 4). Hopefully, legal minds will have determined this before the scheduler begins his or her analysis. Then and only then should a scheduler begin the process of assessing the impact of the delay to justify a change to the contract in time and/or money.

During the life of a project, this may be done several times. However, only after a project is substantially complete can a more detailed analysis of overall delays be effectively performed.

Assess Concurrent Delays

One should scrupulously avoid making claims on concurrent delays. Concurrent delays overlap each other in time, but do not depend on each other (one does not cause the other) to occur.

The concept of concurrency is simple, but one must consider where the blame for the delay lies. For example, if two concurrent delays are ascribed to the same party, then one simply deducts the overlap from the total delay. In Figure 5, these activities represent delays attributed to the same party. Rather than claiming a delay of the total 16 days, the effective delay is 10 days.

Likewise, with concurrent delays caused by two parties, assess the portion of the delay caused solely by the party against which the claim is being made. This is illustrated in Figure 6.

In Figure 6, these activities represent delays attributed to different parties. Let us assume that activity A is caused by the contractor and activity B is caused by the owner. Let us further assume that the claim is being made against the owner by the contractor. Then, only the time during which activity B occurs exclusively is considered fair to pursue.

One can only make a claim for the time during which one is not responsible for any delay.

Incorporate Delay Activities into the As-Built Schedule

Once delays have been identified and quantified, the scheduler should include an activity reflecting each delay. These activities should be logically tied to the appropriate predecessors and successors in the as-built schedule. These delay activities should have durations that reflect the length of the delay as experienced during the project.

Step 3—Collapse the As-Built Schedule

The “collapse” in collapsed as-built is achieved by dissolving the delay activities caused by a specific party. As an alternative,
rather than dissolving the delay activities, one can reduce their duration to zero such that the delay activity remains visible in the schedule even though it has a zero-day duration. Either way, the result is a schedule that reflects how work would have proceeded but for these delays.

After the as-built schedule has been collapsed, the results must be verified for reasonableness. For example, if the collapse shows that the contractor would have begun concrete work in the dead of winter, but was delayed because of the owner, an arbiter or judge might be led to conclude that the owner did the contractor a favor.

The Collapse Is An Iterative Process

Once the as-built schedule has been collapsed, the sanity check that follows will likely result in corrected logic and sequencing. Any changes to the schedule must be done to the as-built schedule, which is then collapsed again to determine the results. Do not continue in a linear fashion with the collapsed schedule. Rather, back up the file before it is collapsed and restore the backup to make changes before collapsing it again.

Critical Path and Near-Critical Path

Remember to watch near-critical activities, as well as those actually on the critical path. A good rule of thumb is to evaluate all activities with a total float of five or fewer days. If a delay occurs on a path that has more float than the length of the delay, there may be no case for a claim.

The collapsed, as-built analysis, is a thorough method. But to be truly acceptable, particularly in the adversarial climate of a claim, it must be implemented well.

Before one collapses an as-built schedule, even before one begins building an as-built schedule, it helps to realize that every choice a scheduler makes is subject to scrutiny. Document your sources, mitigate errors and omissions, and use sound logic. Above all, do not take shortcuts.

No method is immune to abuse—one should be prepared to respond to allegations of faulty implementation. Proper implementation requires consistency, diligence and skill. And most of all, the honesty to take one step back for each two forward, if needed, until the task is done.

RECOMMENDED READING


ABOUT THE AUTHOR

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Economic Justification of a Data Acquisition System: A Case Study

Sameer Kumar and Jon M. Benusa

ABSTRACT: The study describes the basic need for an automated data acquisition system for use on a custom thermoplastic extrusion shop floor operation. The purpose is to serve as a proposal for the purchase of the system, which satisfies the financial threshold. It also demonstrates that an economic analysis is a necessary element of capital investment justification, but is not sufficient to justify the final selection of a proposed system. On many occasions, non-economic considerations dominate the ultimate selection of a feasible alternative, as the case presented in this study. A detailed itemization of the potential cost savings involved with the selection and implementation of such a system is also demonstrated. Five feasible system combinations are identified along with each system’s basic hardware and software components. Details of cost estimating are unambiguously described. Familiarity with manufacturing operation and data acquisition systems’ capabilities was useful in estimating costs and benefit figures to a high level of accuracy, adequate from the point of choosing a best decision alternative. Several economic justification tools are used in order to portray each system’s feasibility for selection and approval. A number of non-economic suggestions are also described and considered. The results of this analysis will provide a clear, economically sound selection to support the proposal. The planned implementation of such a system is unique and innovative in the profile extrusion industry.

KEY WORDS: Economic analysis, decision making, information technology, manufacturing

Manufacturing plants produce an ever-growing stream of data that originates on the plant floor [10]. This data is used to optimize inventory and production, improve product quality and consistency, properly maintain equipment and ensure that plants are compliant with environmental, health and safety regulations [12]. The traditional methods of manually recording data during shop-floor operations in a manufacturing plant and later compiling and interpreting it, is very inefficient, but is still being used by many companies today.

The accuracy, timeliness, and sheer volume of data, and the fact that the data is constantly changing, makes it very difficult to obtain any benefit. Companies must be able to efficiently capture shop-floor data from a broad number of sources, aggregate it in a common format, and make it available for interpretation and conversion into knowledge (such as, labor, material usage, downtime, etc.) in a timely manner [9].

The rest of this article will discuss the current state of business operation at a leading extruder of custom thermoplastic profiles. Also outlined will be a detailed description of the proposal for the company’s management to purchase a data acquisition (DAQ) system for the shop-floor operation. The proposal includes costs of various feasible DAQ systems, along with hardware and software configurations. It then describes an itemized potential cost savings obtained from the implementation of a DAQ system. The study provides economic analyses, using various methods, such as rate of return, payback, and net present value to determine the merit of a DAQ system from among five feasible alternatives. Consideration is also given to various decision alternatives based on non-economic benefits.

The proposal is unique in that much of what is being considered is very innovative to the profile extrusion industry. It would involve the construction and implementation of a prototype system, and evaluation of the feasibility of pursuing a plant wide data acquisition system. These are not undertaken traditionally in the industry. The involvement of the vendors with the system design and the customers with the system benefits will contribute immensely to the proposed DAQ system’s probable success.

CURRENT BUSINESS SCENARIO

A leading extruder of custom thermoplastic profiles has expanded its operations by adding a new facility in a neighboring state, as well as adding a new high volume, commodity-type business, to its list of products being produced. There are three manufacturing facilities within the organization, two of them are located in close proximity of each other and the third is approximately 100 miles away. The original facilities contain the bulk of the company’s workforce, as well as industry experience. The addition of the satellite facility, located in a neighboring state, has forced the company to examine its manufacturing processes, as well as its ability to document and repeat its core knowledge base.

Since the 1960s, the company has been producing mainly short run “job shop” type extrusions for many of the country’s top window manufacturers. In the past, the company has prospered from the strength of its customers’ markets, as well as the knowledge of its employees to produce a quality product.

In light of recent changes in the nation’s economic standing, as well as expansions in plants and markets, the company is finding a more competitive environment along with a decrease in process repeatability. The increase in competition was inevitable, but the ability for the company to consistently set-up and run products was not as visible as one would think.

The highly skilled workforce would use its acquired knowledge to set-up and run each product basically from memory. With each shop order of a specific profile, the shift leaders and operators would literally “re-develop” the majority of the process, each time running slightly different than before, but still within customer specifications. The lack of a well-documented, repeatable process, was not fully revealed until the new facility was constructed and the new unskilled workforce was hired. An established set-up and operating standards for each product, as well as a consistent method for monitoring these parameters to assure a quality product was not available.

The extrusion industry itself has long been considered that of a relatively “low tech” operation with open tolerances and very little in the way of value-added services being offered. Extruders were (and for the most part still are) manufactured without automatic control systems, and unless specifically requested, no opportunity for automatic data acquisition. This is even more evident for the downstream equipment used to cool, size (set the shape of the part) and cut the profiles to shape and/or length. Extrusion was viewed as an “art” that was not demanding of close tolerances and/or precision cutting/punching.

Window manufacturers, who comprise the majority of this company’s customers, have changed. Where once “fit and function” drove the products specifications, now tight tolerances (+/- .020), shrinkage limitations, color tolerances, gloss specifications, and specialty end fabrications are the norm.

These expectations have forced the company to initiate a program of product development to establish repeatable parameters, as well as monitor these parameters for confirmation and future product development considerations.

The ability for an operator to follow an established “recipe” will greatly reduce process variations that lead to inconsistent product
qualities. The process development project is already in progress, but deviations from the standards are occurring that may be result of operational range errors. Without the aid of equipment monitoring, it is impossible to determine when and why the deviations are occurring. (Past and current methods of gathering critical process data is accomplished by manually recording via pencil and paper. This method leaves a large opportunity for error, as well as incomplete and untimely data) [18]. As a result, the manufacturing costs of various products being produced on the shop-floor are not accurately determined.

The management of the company has been keen on influencing accountability of the company's labor reporting on the employees' part. To have a grasp on the actual production job performance, it is necessary to have accurate estimates of what manufacturing costs are, wherein material usage and labor are a big portion of total manufacturing costs. The company's management really needed to reinforce the issue of accurate material and labor reporting.

This formed the basis for installation of a data acquisition (DAQ) system to capture real material usage and machine run time on the shop floor. Such a system does not capture actual labor, which is entered into company's enterprise resource planning (ERP) system by the operators. Machine run time and actual material usage are correlated with labor and material applied to the job in the ERP system to compare the two sets of data. The DAQ system uses trending of real time data to draw conclusions and prevent unnecessary machine downtime.

Proposal

A prototype system has been constructed and is being used to identify the necessary parameters to be captured for monitoring. This prototype will be used by the engineering department as a test station and should not be considered as usable hardware for permanent installation.

All of the company's existing main extruding equipment, both old and new, are not equipped with self-contained control systems. Specific process critical parameters have been identified and since there is no intention of providing control through the process parameters, sophisticated control hardware and software are not being considered [4].

The project has been separated into multiple phases, the first phase is to identify the hardware and software necessary to collect and format the process parameters, along with installing and implementing these components on four production lines at each facility.

Hardware

The manufacturing floor at each facility already contains an ethernet network that was installed during a recent ERP system installation. It was determined through discussions with the company's information systems (IS) department that capacity exists to use this network for the purposes of a "backbone" for the proposed system [16]. An alternative to the ethernet-based system is to install a dedicated network for the data acquisition collection system (DAQ). Since the ethernet network is already in place and has capacity, it will be used for the proposed DAQ system [14]. One major argument to date with regard to basing a system on an ethernet-based network is that the possibility for two-way communication to be slowed or even disrupted [5]. With the proposed system being that of acquisition only and not control, this is not an issue [15].

Next, an acquisition module must be selected. Because each production line has a desktop PC located near the end of the line, the possibility of purchasing an internal acquisition module for each PC exists [1,3]. Stand alone acquisition modules that offer more input flexibility are also available that could accommodate multiple production lines or possibly an entire facility [11]. Also, "data loggers" are an option, which are essentially industrialized input modules that can be coupled to a PC and be networked [22].

Finally, the individual inputs/sensors must be purchased. Many of the existing parameters, which are currently used as input devices for settable parameters, can be upgraded at a later date to allow for outputs with very little expense being incurred. Therefore, this decision is basically established.

Software

There are primarily two options concerning software for the data acquisition system: purchased software that will allow the user to configure the screens appearance with pre-programmed tools or, custom-written software that will allow the user to define each screen to a specific need using basic pre-defined tools. There are several advantages and disadvantages to each method.

A purchased software package, such as "Labview," by National Instruments offer the ease of building screens using a "tool kit" feature and assigning the input data parameters to these tools (such as meters, dial indicators and readouts). Custom written software using Visual Basic, or Visual C++ is the other option available. These packages also contain limited "tool kits" to allow for ease of programming.

Personnel currently employed are proficient with these languages and that will reduce the learning curve for screen construction as opposed to the package that can be purchased specifically for data acquisition.

Some of the disadvantages of using the pre-canned packages are; cost, additional software and hardware for added storage capacity and sophistication (high learning curve). The disadvantage of using Visual Basic or the like is that even though similar results can be achieved (screen appearance), the flexibility of programming the software will add to the programming time of the system. Other issues to consider include future maintenance of the system, as well as maintaining a proficient programmer on staff or at the company's disposal.

Installation

The hardware options for the system are basically identified by default with the exception of the data acquisition module. The ethernet network, which is already in place, will be used, as well as modifying the existing sensors and controllers already on the equipment. By using these existing pieces of hardware, considerable cost savings can be realized. The installation of the acquisition module, which can function with the existing ethernet network, as well as the modified sensors, in either case assumes no differential cost savings [20]. The installation costs associated with software are basically equal, neither package requires special installation considerations [19].

Implementation

Of the hardware choices being considered, the costs associated with implementing a data acquisition module with pre-manufactured software will be greater than using an acquisition module and a customer programmed interface.

Training

Training for using the system will not be dramatically different, but additional time would be consumed for maintaining the first option.

Decision Alternatives

The manufacturing engineering group, looking for viable options to satisfy a set of established criteria, has identified five alternatives. Each of the decision alternatives will be combined to formulate a separate system (labeled as Systems A-E), using the components described in the previous discussions.

The network or "backbone" as it is many times described, will be the existing ethernet system already in place. The cost of installing a dedicated network versus the benefits it would provide are obvious and the decision to move forward with its installation is not necessary. Therefore, the desired parameter for the system to be connected to a network will be defined as using an ethernet network. The project scope will include the following criteria [8].
1) Allow for a minimum of 16 discrete inputs (0-10, -5 to +5 Voltage DC).

2) Each system must be able to handle a minimum of 64 analog inputs (4-20 mA, on four production lines).

3) Must be able to be networked using an Ethernet10/100 base T protocol.

4) Must allow for software to reside on a centralized “server.”

5) Software must contain OPC, Active X architecture capabilities, to allow for integration with existing ERP system as well as other serial devices. OPC and Active X refer to sets of programming tools that were developed by Microsoft. These tools allow for universal interconnectivity between different pieces of software. These tools are fast becoming the standard for software vendors, especially industrial vendors that have been asked to provide the “hooks” into standard business software, that is, Microsoft Access, other SQL data bases, etc.

6) Must allow for portability of some or all of the inputs (movable equipment).

A breakdown of costs and total cost associated with each system alternative are described as follows:

**System A:** (Distributed I/O system with custom interface software) [17].

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed I/O communications module</td>
<td>$750</td>
</tr>
<tr>
<td>4-16 channel input modules for above</td>
<td>$1800</td>
</tr>
<tr>
<td>Power supply/connector/cabinet/cabling</td>
<td>$375</td>
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<tr>
<td>4 channel ethernet hub</td>
<td>$75</td>
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<tr>
<td>Hardware configuration (training &amp; labor)</td>
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<tr>
<td>Software</td>
<td>$2400</td>
</tr>
<tr>
<td>Interface software (Visual Basic system)</td>
<td>$0</td>
</tr>
<tr>
<td>System design</td>
<td>$2000</td>
</tr>
<tr>
<td>Programming</td>
<td>$6000</td>
</tr>
<tr>
<td>Sensors</td>
<td>$300</td>
</tr>
<tr>
<td>Extruder temperature controller upgrade (32)</td>
<td>$800</td>
</tr>
<tr>
<td>Cooling frame temperature sensors (8)</td>
<td>$300</td>
</tr>
<tr>
<td>Cooling frame infrared temperature sensors (8)</td>
<td>$600</td>
</tr>
<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$150</td>
</tr>
<tr>
<td>Installation</td>
<td>$1700</td>
</tr>
<tr>
<td>Cabling, connectors, etc</td>
<td>$1935</td>
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<tr>
<td>Maintenance</td>
<td>$21285</td>
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<tr>
<td>Software (10 percent of total project cost)</td>
<td>$2393</td>
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<tr>
<td>Cooling Frame Infrared Temperature controllers (8)</td>
<td>$600</td>
</tr>
<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$150</td>
</tr>
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<td>Installation</td>
<td>$1700</td>
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<td>Software (10% of total project cost)</td>
<td>$2295</td>
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<tr>
<td>Cooling Frame Infrared Temperature controllers (8)</td>
<td>$25,240</td>
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</table>

**System B:** (PC mounted DAQ board system with custom interface software) [21].

<table>
<thead>
<tr>
<th>Component</th>
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<tr>
<td>Communications Hardware (National Instruments)</td>
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<tr>
<td>Multifunctional DAQ 16 bit, 16 input PCI board for existing Line PC’s (4)</td>
<td>$6780</td>
</tr>
<tr>
<td>Hardware configuration (training &amp; labor)</td>
<td>$2400</td>
</tr>
<tr>
<td>Software</td>
<td>$2400</td>
</tr>
<tr>
<td>Interface software (Visual Basic system)</td>
<td>$0</td>
</tr>
<tr>
<td>System design</td>
<td>$2000</td>
</tr>
<tr>
<td>Programming</td>
<td>$6000</td>
</tr>
<tr>
<td>Sensors</td>
<td>$800</td>
</tr>
<tr>
<td>Cooling frame temperature sensors (8)</td>
<td>$300</td>
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<tr>
<td>Cooling frame infrared temperature sensors (8)</td>
<td>$600</td>
</tr>
<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$150</td>
</tr>
<tr>
<td>Installation</td>
<td>$2500</td>
</tr>
<tr>
<td>Cabling, connectors, etc</td>
<td>$2500</td>
</tr>
<tr>
<td>Software (10 percent of total project cost)</td>
<td>$26,323</td>
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<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$2000</td>
</tr>
</tbody>
</table>

**System C:** (Distributed I/O System with purchased interface software) [17, 21].

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications Hardware (National Instruments)</td>
<td>$750</td>
</tr>
<tr>
<td>Distributed I/O communications module</td>
<td>$750</td>
</tr>
<tr>
<td>4-16 channel Input modules for above</td>
<td>$1800</td>
</tr>
<tr>
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<td>$375</td>
</tr>
<tr>
<td>4 channel Ethernet Hub</td>
<td>$75</td>
</tr>
<tr>
<td>Hardware configuration (training &amp; labor)</td>
<td>$2400</td>
</tr>
<tr>
<td>Software</td>
<td>$2400</td>
</tr>
<tr>
<td>Interface software (National Instruments, LabView)</td>
<td>$6596</td>
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<td>System Design</td>
<td>$2000</td>
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<tr>
<td>Programming</td>
<td>$3000</td>
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<tr>
<td>Sensors</td>
<td>$300</td>
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<tr>
<td>Extruder temperature controller upgrade (32)</td>
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<tr>
<td>Cooling Frame temperature sensors (8)</td>
<td>$300</td>
</tr>
<tr>
<td>Cooling frame infrared temp. controllers (8)</td>
<td>$600</td>
</tr>
<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$150</td>
</tr>
<tr>
<td>Installation</td>
<td>$2500</td>
</tr>
<tr>
<td>Cabling, connectors, etc</td>
<td>$25,132</td>
</tr>
<tr>
<td>Software (10% of total project cost)</td>
<td>$27,638</td>
</tr>
</tbody>
</table>

**System D:** (PC mounted DAQ board System with purchased interface software) [21].

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications Hardware (National Instruments)</td>
<td>$750</td>
</tr>
<tr>
<td>Multifunctional DAQ 16 bit, 16 Input PCI board for existing Line PC’s (4)</td>
<td>$6780</td>
</tr>
<tr>
<td>Hardware configuration (training &amp; labor)</td>
<td>$2400</td>
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<tr>
<td>Software</td>
<td>$2400</td>
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<tr>
<td>Interface software (National Instruments, LabView)</td>
<td>$6596</td>
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<td>Programming</td>
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<td>Sensors</td>
<td>$300</td>
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<td>Extruder temperature controller upgrade (32)</td>
<td>$800</td>
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<tr>
<td>Cooling Frame temperature sensors (8)</td>
<td>$300</td>
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<tr>
<td>Cooling frame infrared temp. controllers (8)</td>
<td>$600</td>
</tr>
<tr>
<td>Haul-off puller board upgrade (4)</td>
<td>$150</td>
</tr>
<tr>
<td>Installation</td>
<td>$2500</td>
</tr>
<tr>
<td>Cabling, connectors, etc</td>
<td>$25,132</td>
</tr>
<tr>
<td>Software (10% of total project cost)</td>
<td>$27,638</td>
</tr>
</tbody>
</table>

**System E:** (Dedicated Datalogger) [22].

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications Hardware (Hioki &amp; National Instruments)</td>
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</tr>
<tr>
<td>Self contained 64 input channel datalogger with internal hard-drive and ethernet capabilities</td>
<td>$18,000</td>
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<td>Hardware configuration (training &amp; labor)</td>
<td>$2400</td>
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<td>Software</td>
<td>$2400</td>
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<tr>
<td>Included with above</td>
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<td>Configuration of Software</td>
<td>$2400</td>
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<td>System Design</td>
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<td>Software (10% of total project cost)</td>
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</tbody>
</table>
Cost estimates for various feasible DAQ systems, were provided by the hardware and software suppliers and were determined as follows. For instance, cost of communications hardware, was provided by National Instruments. Cost of configuring the software is estimated at two days worth of a process engineer time @ $100/day for a total of $2400.

This is applied to all five systems. Cost of interface software for systems A and B is the investment in a process engineer’s time to develop internally written software. It may be noted that capital expenditure authorization included an estimate of time to complete system design, training, and installation. For systems C, D, and E, the cost of interface software is the actual cost of purchased software.

Finally, the cost of programming is computed from the estimates of hours and dollars per hour charged by the software integrator (a contractor) based on scope of work furnished to the integrator. It also is the internal estimate of time, essentially, most likely the type of estimate within five to seven percent of the actual time expended on the project work. System maintenance was also included at 10 percent of the cost of the entire system. Clearly the cost of any feasible systems listed above for both hardware and software was not difficult to determine, nor were the cost savings. The estimates reference very “real” numbers and represent engineering resource requirements that were invested in order to confirm productivity/efficiencies of the satellite facility. They were based on 12 months of actual analysis. The corporate site, manufacturing engineering department specifically, was given the initiative of developing meaningful process standards for approximately 20 different products running at the satellite plant. One of the major hurdles (and it continues to be) is the lack of “real” data being reported regarding machine set-up times, actual order run time, downtime, material usage, as well as order productivity.

Of the 20 products on the initial list, only two of them have been successfully completed. 

This lack of success can be attributed to a few main problems. One of these problems is the ineffective development of process operating standards. Since the satellite plant has no engineering support staff, it must rely on data being manually fed into the system by the shop floor personnel. This practice has been proven highly unreliable. Therefore, the installation of the data acquisition system would improve the accuracy of the data coming from the shop floor without the huge investment of engineering’s time to uncover the economic shortcomings (namely material usage, standard to actual, set-up and run time labor usage and machine usage) [11].

Every shop order’s actual productivity is compared to its “standard” cost, which is generated based on the actual calculated products’ material usage, expected process waste, standard lot size, run speed, number of operations used, set-up time and run-time. These criteria are then compared to the actual reported values which are input by the operators on the shop floor. This reported data is what has been proven unreliable and inaccurate. The installation of a DAQ system would reduce the amount of time that is being consumed by the corporate manufacturing engineering group in order to investigate and “clean-up” inaccurate productivity reporting.

Estimated Cost Savings

The first issue that needs to be discussed is the need for collecting real-time operational data. One of the most important items that allow management to make timely decisions with regard to production efficiencies, as well as valuable pricing/cost data to be able to analyze production data in an accurate and timely fashion. Manually input shop floor data causes many errors that require supervisory investigation time, as well as time to correct the problems. Automated data collection will greatly reduce this wasted time.

A new initiative is concentrating on producing products to a predetermined, consistent “standard” or recipe. The engineering group has added approximately 130 target variables to the existing set-up standards and would like to be able to monitor approximately 16 of them automatically, real-time 24-hours-a-day. The system would also have the ability to store these data points for further study with regard to up-time analysis and standard verification. The thrust of this new initiative is being applied to the satellite facility and requires engineering support from the corporate office. This requires additional travel expenses to manually monitor production set-ups. Quality issues and traceability of production runs to investigate these issues is also assisted with the DAQ system.

Real-time production line monitoring to allow supervisor to quickly respond to excessive downtime or even be proactive with regard to specific critical operating parameters to allow for downtime avoidance.

Each one of these issues has an associated cost savings. Conservative estimates are listed in Table 1. But along with these cost issues, are other intrinsic issues that influence the approval of this project, which will be discussed later [7].

Estimates (of costs of five feasible data acquisition systems and the benefits accrued from installing any one of them) are critical to decide which system would be most efficient and effective for the job shop operation of the company. These estimates were either actual numbers or based on 12 months’ data collected prior to installation of a DAQ system. Benefits

<table>
<thead>
<tr>
<th>Cost Savings Initiative</th>
<th>Estimated Annual Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Production standard verification</td>
<td>$4500</td>
</tr>
<tr>
<td>(2hrs/run * 3 runs * 45 runs/yr. * $25.00/hr)</td>
<td></td>
</tr>
<tr>
<td>2) Minimization/prevention of downtime</td>
<td>$4800</td>
</tr>
<tr>
<td>(1hr reduction/week * $100 savings/hr * 48 wks)</td>
<td></td>
</tr>
<tr>
<td>3) Manually input data correction</td>
<td>$2080</td>
</tr>
<tr>
<td>(2hrs/wk * $20.00/hr * 48wks)</td>
<td></td>
</tr>
<tr>
<td>4) Raw material consumption errors</td>
<td>$1500</td>
</tr>
<tr>
<td>(1.25hr/wk * $25.00/hr * 48 weeks (Material inventory inaccuracies)</td>
<td></td>
</tr>
<tr>
<td>5) Personnel expenses to satellite facility ($140 * 26wks)</td>
<td>$3640</td>
</tr>
<tr>
<td>**$16,520/yr.</td>
<td></td>
</tr>
</tbody>
</table>

** (This estimated cost savings represents implementing the DAQ system on four production lines only. The annual cost savings are assumed to increase at a conservative annual estimated rate of four percent because of improved learning curve for employees and also the company will not have to purchase additional DAQ software requiring additional cost of development before its use.)

Table 1 — Associated Cost Savings Conservation Estimates
and costs estimates were fairly close to actual numbers and other non-economic factors were closely looked at. Sensitivity analysis was therefore not necessary. The company would realize the same cost savings, no matter which DAQ system among the five feasible ones is installed. The economic risk would be if the company did not achieve the estimated cost savings based on expenditures incurred. To satisfy that risk, cost estimates for savings were made in a conservative manner. Apparently, operations management did not overestimate savings to show that risk is met in order to sell the acceptance of the proposal to management. The director of engineering was comfortable with costs and benefits figures. Ultimately the vice president of finance, also responsible for verifying the costs and savings estimates, reviewed and approved the project proposal and also signed capital authorization to buy the proposed DAQ system.

In the next few sections, a number of economic justification tools and non-economic benefits are used in order to portray each system’s feasibility for selection and approval [2].

Rate of Return

The following graph (Figure 1) of the different systems’ internal rate of return (IRR) indicates that all the systems’ values are less than the established minimum attractive rate of return (MARR) or “hurdle rate.” The established MARR for the analysis is 18 percent. This rate was established as the percentage required for all projects to satisfy before they can be considered for approval. The company believes that it can earn 15 to 16 percent, if available funds were to be invested safely, (based on fiscal year 2000) so the established MARR is slightly higher.

IRR equals the percentage rate by which the net benefits of the project must be discounted until the point that they equal the initial costs. The formula for IRR (in this case, a five year IRR) is:

\[
\text{Initial Costs} = \text{Net Benefit Year 1} / (1 + \text{IRR})^3 + \text{Net Benefit Year 2} / (1 + \text{IRR})^4 + \text{Net Benefit Year 3} / (1 + \text{IRR})^5
\]

The chart (Figure 1) indicates that all of the proposed alternatives would provide an adequate return, but System A would yield the most favorable rate. The unusually high rate is explained by the relatively low first costs versus the high estimated cost savings (cash inflows, or cost avoidances). Both System A and System C contain the highest percentage of return, but again all the alternatives would satisfy the requirement of containing a higher rate than the MARR of 18 percent [7]. Figure 2 is a plot of IRR values for systems A through E.

Payback Analysis

The capital recovery costs, annual net savings and salvage value for each system are shown in Table 2. System A has the lowest at $6,666.69, which indicates that it has the most favorable present worth. System C has the next most favorable capital recovery cost of $7,931.41.

A graph of the capital recovery costs for systems A through E is shown in Figure 3.

Each system is also evaluated based on the duration of the payback period. Each system’s total initial costs are compared and in order to be considered for implementation, must satisfy the most advantageous period (in months). A graph of the systems is shown in Figure 4 indicating this choice. “System A” and “System C” have a payback period of less than 18 months and will be recommended for selection. Even though this method does not recognize the time value of money, nor does it consider the impact of cash flows received after the payback period, it is still a viable “first check” to be used for completing a justification.

| MARR = 18% |
|---|---|---|---|---|---|---|
| 5-yr | System A Investment | Annual CF | System B Investment | Annual CF | System C Investment | Annual CF | System D Investment | Annual CF | System E Investment | Annual CF |
| Year | $6,666.69 | $13,837 | $8,277.73 | $13,837 | $7,931.41 | $13,837 | $8,698.24 | $13,837 | $11,135.38 | $13,837 |
| 0 | $21,285 | $0 | $26,323 | $0 | $25,240 | $0 | $27,638 | $0 | $35,915 | $0 |
| 1 | $0 | $17,180 | $0 | $17,180 | $0 | $17,180 | $0 | $17,180 | $0 | $17,180 |
| 2 | $0 | $17,868 | $0 | $17,868 | $0 | $17,868 | $0 | $17,868 | $0 | $17,868 |
| 3 | $0 | $15,368 | $0 | $15,368 | $0 | $15,368 | $0 | $15,368 | $0 | $15,368 |
| 4 | $0 | $15,982 | $0 | $15,982 | $0 | $15,982 | $0 | $15,982 | $0 | $15,982 |
| 5 | 1000 | $16,662 | $1,000 | $16,662 | $1,000 | $16,662 | $1,000 | $16,662 | $2,500 | $16,662 |

Table 2 — Capital Recovery Costs for Systems A Through E
of software, due to upgrades and the fact that the payback period for at least two of the alternatives is less than 18 months, allows this method to be more reliable as one of the justification tools used.

**Net Present Value**

By using the net present value (NPV) method of determining the feasibility of a project, we are considering the present value (PV) of all the cash inflows, in this case the cost savings realized by implementing any one of the proposed alternatives. The PV along with the initial investment of each of the alternatives can be used to determine the net present value of each of the projects. The rule of thumb is that any project with a positive NPV should be considered for implementation. The formula for NPV (in this case, a five-year project time horizon) is:

\[
\text{NPV} = - \text{Initial Costs} + \text{Net Benefit Year 1} / (1 + \text{Discount Rate}) + \\
\text{Net Benefit Year 2} / (1 + \text{Discount Rate})^2 + \\
\text{Net Benefit Year 3} / (1 + \text{Discount Rate})^3 + \\
\text{Net Benefit Year 4} / (1 + \text{Discount Rate})^4 + \\
\text{Net Benefit Year 5} / (1 + \text{Discount Rate})^5
\]

The following graph (Figure 5) contains each of the alternatives NPV. Each of the alternatives contains a positive NPV and therefore should be considered for selection, however, as with every tool used earlier, System A and System C show the most favorable results. By using the NPV to evaluate alternatives, the time value of money is considered in the calculation, taking into account the cost of capital (or discount rate), which is in this case 10 percent.

**Non-Economic Benefits**

There are also non-economic benefits that need to be considered for a system selection. A personal attribute of system familiarization is such that the prototype system that was assembled for engineering testing is that of System A. This personal, and in some sense political, reason will add to the system familiarity. By using technology that is already understood, it will offer a shorter implementation time frame. A second non-economic attribute is that of the local vendor. The distributed I/O system, System A, is produced and supported by a very knowledgeable and helpful local vendor. Internal personnel that will be responsible for the system installation and maintenance have worked with this vendor before and have had successful results. Other colleagues and local system integrators have expressed their satisfaction with this type of system, as well as the vendor, and they too have offered examples of positive results [13]. The non-economic benefits were basically measured based on the ease of system integration. The distributed I/O system was purchased based on its flexibility to interface with basically any type of input/output sensor, as well as its ease of use, no requirement for additional control devices and its inexpensive price tag. The initial software to manage a prototype line was internally developed strictly because of cost and to identify the project complexity. Process engineering was able to design a prototype system that could be used to identify a long-term system. Once the actual system was justified, the manufacturing engineering group purchased off the shelf software and hired an integrator to expedite the project. It was based on the flexibility of the suggested system, utilization of internal resources, and knowledge of working with that particular manufacturer's system. Because the company was involved in their own software development for the initial prototype system, there was familiarity in the company with the suggested systems software.

All five systems offer the ability to gather data from company's existing processing equipment. Also, they have met the company's criteria for operating with multiple types of inputs, as well as interfacing with existing ERP system (although System E, the standalone datalogger, offers some challenges with this integration). A "do-nothing" option also exists, but as proven above, would not allow the company to obtain and use "real-time" shop floor data which was identified as a critical part of improving production efficiencies and product pricing/costing scenarios. Given these proven advantages of the proposed solutions, System A and System C received the most favorable results.
options, System A, which is the hardware option of the distributed I/O communications module and custom written software, is economically the best choice. It offers the best AW analysis of capital recovery, the most advantageous IRR and also the quickest return in terms of monthly payback as compared to the other alternatives. The system of this type has also been in use for the past year as the prototype engineering test station, which offers confidence with its success.

System C, which contains the same hardware configuration as System A is also a viable option. The purchased software portion is the only difference between the two systems, this difference would add additional installation costs because of the extended learning curve, but may offer future advantages with regard to standardization and future support. Care must be taken to assure that the custom software being proposed uses industry standards (Visual Basic language), as well as detailed documentation of any written code.

As described above, several economic justification tools were used in order to portray each DAQ system’s feasibility for selection and approval. A number of non-economic factors were also considered. The intent of installing a DAQ system was to be able to retrieve production data (labor and material usage) from shop floor operation to accurately determine manufacturing costs of various products. Five feasible system configurations were evaluated. They consist of different combinations of hardware and software. For instance, hardware used is same for DAQ System A and System C. Interface Software for System A would be customized and for System C, a standard purchase. Similarly, hardware used is same for DAQ System B and System D, but different from Systems A and C. Interface software for System B would be customized and for System D a standard purchase. Finally, hardware and interface software for System E are both different from the other four systems. Hardware in each DAQ system represents the brain or the central processor. Benefits from any one of the system configurations evaluated are expected to generate same cost-savings.

The case study shows that, even though each of the DAQ systems was economically viable and met the economic threshold, the final selection was based more on non-economic factors. This demonstrates that economic analysis is a necessary element of capital investment justification but not sufficient to justify the final selection of a proposed system. In real-life, on many occasions, non-economic considerations dominate the decision of ultimate selection of a feasible alternative as is the case presented here.

In order to offset the economic risks associated with investments in any one of the feasible DAQ systems, management of the company was convinced that considerable time could be saved to obtain productivity information much more quickly and accurately by installing such a system. The job-shop environment of the company made it imperative to have accurate employee productivity data to be available as quickly as possible.

REFERENCES

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- January — Information Technology
- February — Scheduling
- March — Productivity
- April — Project Controls
- May — Project Management
- June — Dispute Resolution
- July — Economic and Financial Analysis
- August — Project Management
- September — International Projects
- October — Cost and Schedule Control
- November — Planning and Scheduling
- December — Information Technology

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- Contract Documents and Construction Law
- Planning and Scheduling
- Estimating and Bidding 2

Classes - starting April 5, 2004
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- Accident Prevention & Loss Control
- Project Management for Construction Supervisors
- Construction Productivity Improvement
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Dr. Iqbal Noor, PE CCE, receives a Petrotrin gift from engineering graduate student Sharmilla Seepersad after speaking at the October Caribbean Section meeting.

Caribbean Section

During a joint meeting between the AACE International Caribbean Section and PMI Southern Caribbean Sections on Oct. 15, 2003, Dr. Iqbal “Bob” Noor PE, CCE, delivered a dynamic presentation of “Innovations in the Measurement and Analysis of Construction Labor Productivity” at the Petrotrin Learning Centre in Trinidad. Dr. Noor explained how accurate labor productivity measurements can be obtained by a daily visit method and how the results of this approach compared with traditional methods. He also showed how the daily visit method provides consistent and reliable productivity data, was simple to use, and does not require additional staffing. The theme of the presentation was based on the doctoral thesis of Dr. Noor at the University of Dundee, Scotland.

Cascade Section

December’s meeting presentation of the Cascade Section was titled, “Water Damage to Buildings is not a Life or Health-Related Issue” and “Inspection Cannot Detect Potential Leaks.” Chester Machniewski spoke about how we have always relied on the experience of designers and workers to prevent problems involving building leaks. However, as the traditional skilled craftsmen gradually become fewer in numbers, the builders must often employ less qualified tradesmen. The current requirements to prevent water intrusion are mostly performance-oriented and require experienced and skilled designers and tradesmen to achieve the required performance and durability.

Mr. Machniewski is a structural engineer specializing in building and materials failure analysis and has been involved in fixing buildings for over 20 years. Increasingly he has been concentrating on preventing the failures that are now called the “leaky condo syndrome.” As a building envelope consultant, he has been responsible for most of the new generation of buildings incorporating a cavity behind the cladding, a system known as rain-screen, in Washington and Oregon, as well as Vancouver, British Columbia.

Chicago-Midwest Section

L. Adam Winegard, vice president of claims and risk analysis for URS Corporation, was the speaker at the Nov. 6, 2003, Chicago-Midwest Section. Mr. Winegard has over 14 years of experience providing technical qualitative and quantitative risk assessment and analysis, management, marketing, and contract administration within the construction and insurance industries. Owners, contractors, design professionals and construction managers have begun to recognize that a sound understanding of risk is critical in delivering successful projects. Mr. Winegard provided a fundamental approach to identifying, assessing, and managing risk on capital projects.

Chinook-Calgary Section

A panel discussion on Oct. 15, 2003, on ‘10 key-ways to improve project performance’ was one of the best dinner meetings of the Chinook-Calgary Section with a record attendance of 56 people. The importance of this occasion was enhanced by the presence of the AACE International President Ozzie Belcher.

The AACE International president's visit was a success and included visits to various potential corporate sponsors, including: Nexen, Bantrel, CNRL, Fluor, AMEC, and SNC Lavalin, to enhance the association’s corporate membership. AACE International has potential to help these corporations in key fields of training and providing sources of employees in the cost-engineering field.

Connecticut Section

George T. Kraus, PE, currently the Director of Planning, Design and Construction Management for the University of Connecticut, spoke at the December meeting of the Connecticut Section about UCONN in the 21st Century.

In his current capacity, Mr. Kraus participates in the day-to-day management of the UCONN 2000 initiative. This is a 10-year - 960 million dollar building initiative for the University and its regional campuses. His department is responsible for managing the architectural/engineering selection process, building and infrastructure design and construction programs. The department is currently managing over 300 million dollars in projects under active design or construction.

Mr. Kraus holds bachelors and masters' degrees in civil engineering form Villanova University and a master's degree in public administration from Golden Gate University. He is a registered professional engineer in Pennsylvania and Maine.

Delaware Valley Section

The November meeting of the Delaware Valley Section was at the Philadelphia Airport Hilton. The evening opened in a festive mode with a turkey dinner including all the trimmings, that acknowledged the pre-thanksgiving day meeting date. The after dinner presentation was entitled, “Icarus - The Power Tool of Estimating.” The speaker was Harvey Welker, a long time “Icarus” user and certified Aspentech Icarus trainer, along with being an active member of the Delaware Valley Section. His overview of the background, use and format of the “Icarus” suite
of products demonstrated and justified the presentation's power tool title. Mr. Welker is currently providing Icarus consulting to various manufacturing firms in the Delaware Valley area. A report from the section’s scholarship committee recognized the receipt of scholarship applications, but reported that this year's award would be withheld based on a lack of a qualified individual.

East Tennessee Section

Armando Garza, manager of capital projects and planning with BWXT LLC Y12, presented a program on, “Forward Thinking...a Mental Challenge” at the East Tennessee Section’s September 2003 meeting. Ellis Jackson, Scholarship Committee chair, introduced scholarship winner Jonathan O’Bryant of the University of Tennessee, and recognized his achievements with a certificate of merit. Mr. O’Bryant also won an international scholarship.

Genesee Valley Section

The Genesee Valley Section hosted another very successful breakfast meeting at the Oak Hill Country Club in Pittsford, NY on Oct. 28, 2003. Chris Williams, General Chairman for the 85th PGA Championship, spoke on all aspects of preparing for such a large event. The presentation drew over 50 local contractors, firms, and corporations, all eager to hear what went on “behind the ropes!”

The Genesee Valley Section hosted a very exciting and informational tour at the new O’Rorke Bridge construction site at the Genesee River on Nov. 13, 2003. Bo Mansouri, PE, is the county bridge engineer and project manager for this project. He spoke on the bridge construction from beginning to end—with its anticipated opening in 2004. The tour was shortened because of inclement weather, but the presentation was continued in the nearby Rochester Yacht Club where Mr. Mansouri gave the attendees the ins and outs of the design, preconstruction, and execution phases of the large project. This event drew 25 local contractors, firms, and corporations.

Houston Gulf-Coast Section

Since September 2003, the Houston Gulf-Coast Section has sponsored four regularly scheduled monthly meetings, and in

November conducted a half-day seminar on, “Advanced Topics in Cost Estimating.” The programs have been well-received by the membership, with average monthly attendance exceeding 50 members. The board team has worked hard to ensure that the monthly meetings are interesting, informative, and relevant to industry.

HGCS was pleased to have Deborah Zale from Quantum Resources speak on “Searching for a Job in Today’s Market.” Ms. Zale talked about what companies are looking for, contract assignments, and trends in today’s market during the December meeting.

Kansas City Section

The September 2003 meeting for the Kansas City Section featured guest speaker Dan McCune on the topic of Dynamic Scheduling. Mr. McCune is a principal consultant with DTS Associates and provides project/program management training and consulting services. The program incorporated both the theory and practice of dynamic scheduling. The presentation included an introduction to modern project management, discussion on project time management, and an explanation of dynamic scheduling.

The Kansas City Section’s November 2003 meeting was a plant tour of the Harley-Davidson facility in Kansas City, Missouri. The plant has 900 employees who produce the Sportster, Dyna, and VRSC families of motorcycles from fabrication to finishing. The plant has the unique distinction of being the only Harley-Davidson facility to produce an entire motorcy-
The tour started with an introductory film, followed by a guide taking the group through various manufacturing and assembly processes to illustrate the individual and collaborative skills necessary to produce the motorcycles. A wide range of operations were discussed from welding, laser-cutting, and frame bending, to polishing and wheel assembly.

New Jersey

Iftikhar Madni, CCE, was the guest speaker at the Nov. 19, 2003, meeting of the New Jersey Section at On The Border Restaurant in Princeton Junction. Mr. Madni, the section's President, spoke on, "Estimating School Construction Projects." He shared analysis of data from over 80 school projects throughout the country. He demonstrated a method of factoring completed school projects costs, to neutralize the location and time of construction - creating graphs to compare the average price range for different types of construction. It has proven to be an effective way to accurately develop budget estimates. It proved to be an informative meeting for all. He is scheduled to present this paper at the Annual meeting in Washington, DC., in June.

December's "Guest Night" meeting topic, "Fuel Cells 101" was presented by Jay Eadie, of Fuel Cell Solutions. Mr. Eadie is president of Fuel Cell Solutions and is engaged in the planning, applications, and use of fuel cells in industrial facilities.

Mr. Eadie, a technical expert on fuels cells, gave a general interest presentation. Many have heard of fuels cells in various applications including cars and industry. Mr. Eadie explained the industrial types of fuels cells. Those attending heard about the different types and the industries that have installed fuel cells. He also discussed the process of considering the purchase of a fuel cell.

Rocky Mountain Section

In a non-technical program for its holiday meeting, the Rocky Mountain Section had mystery writer Linda Berry join in a discussion on how a mystery novel is created. This was followed by a live performance on the stage (the details are a mystery). Ms. Berry provided insights into plotting fictional crimes and brought with her a murderous play that was performed live by a stellar cast of actors.

In addition to novels and plays, Ms. Barry's published credits include poetry, craft articles, preschool curriculum, short fiction for children and adults, a newspaper entertainment column, and a stint as writer/editor for a tennis publication. She's a member of the Denver Woman's Press Club, the Rocky Mountain Chapter of Sisters in Crime, Rocky Mountain Fiction Writers, and Colorado Dramatists. Her three mystery novels are set in South Georgia and are built around one real character, a cousin who is chief of police in a small Georgia town. She describes these novels as “soft boiled and mixed with grits.” She lives in Aurora with her husband, Jerry. For additional information, visit the website at http://www.ogeechee.avigne.org/

San Francisco Bay Area Section

On Tuesday, Dec. 9, 2003, The San Francisco Bay Area Section kicked-off the holiday season when members gathered around the famous family dinner table of Buca Di Beppo. This family event is a vibrant, colorful, and festive feast. Between the passing and sharing of delicious Italian dishes like Macaroni Rosa, Spaghetti Aglio Olio, Rigatoni Psitano, Chicken Saltimbocca, and the like, attendees enjoyed each other's humor, laughs, and holiday stories. There were no presentations or expectations, but the occasional party toast was graciously welcomed.

St. Louis Section

November's tour was fun and a good trip for members of the St. Louis Section and their guest with the Laclede Gas building being the only self-supplied energy building left in Missouri. The host, Robert Creech, is chief building engineer of Sterling Properties for Laclede Gas Building and showed the Section an exciting time. Sterling Properties include future plans for a new 770-space garage, currently in progress.

Laclede Gas Building, standing 400 feet high with 31 stories (441,000 SF), is the fifth tallest structure in St. Louis. Laclede Gas Company is a public utility engaged in the retail distribution of natural gas. The company serves an area in eastern Missouri, with a population of approximately 2.0 million, including the City of St. Louis, St. Louis County, and parts of eight other counties. In addition to its gas distribution business, the company operates underground natural gas storage fields and is engaged in the transportation and storage of liquid propane.

Mr. Creech gave the meeting attendees a tour of the total energy plant that consists of six internal combustion engines that have a capacity of 4.3 megawatts. Exhaust and combustion heat from the generating engine is used to make low pressure steam. This steam in turns makes HVAC for the 400,000 plus square foot Laclede Gas Building. The engine-generator sets are equipped with heat-recovery steam generators, which supply low-pressure steam for heating, domestic hot water, and for chilled water. The plant includes both absorption and engine-driven chillers and houses the main offices of Laclede Gas Company, the largest gas distribution utility in Missouri. The highlight of the evening tour was the trip to the top deck of Laclede to view the city skyline from all four directions.
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Cost Engineering Journal, Volume 46/Number 1, January 2004

Pages 19-24

Forecasting - What a Responsibility
James E. Baar and Stephen M. Jacobson, CCC

This is the first in a series of articles that will look at forecasting. They are being presented in a non peer-reviewed format by James E. Baar and Stephen M. Jacobson, CCC.

Reprint 20796

Pages 27-30

Claims Schedule Development and Analysis: Collapsed As-Built Scheduling for Beginners
Vera A. Lovejoy, CCC

One of the most prevalent ways of assessing and asserting claims is to analyze time delays suffered on a project. There are a number of methods by which this can be done. This article will touch on definitions of several of these methods. The thrust of this article, however, focuses on a method called the "collapsed as-built" schedule analysis, also known as the "but-for" schedule analysis. This type of analysis begins with creating or refining an as-built schedule, identifying delays and caused by a particular party, and then removing those delays from the schedule to illustrate how work on the project would have progressed, but for those identified delays.

Reprint 20798

Pages 31-37

Economic Justification of a Data Acquisition System: A Case Study
Sameer Kumar and Jon M. Benusa

The study describes the basic need for an automated data acquisition system for use on a custom thermoplastic extrusion shop floor operation. The purpose is to serve as a proposal for the purchase of this system which satisfies the financial threshold. It also demonstrates that an economic analysis is a necessary element of capital investment justification, but is not sufficient to justify the final selection of a proposed system. On many occasions, non-economic considerations dominate the ultimate selection of a feasible alternative, as is the case presented in this study. A detailed itemization of the potential cost savings involved with the selection and implementation of such a system is also demonstrated. Five feasible system combinations are identified along with each system’s basic hardware and software components. Several economic justification tools are used in order to portray each system’s feasibility for selection and approval. A number of non-economic suggestions are also described and considered. The results of this analysis will provide a clear, economically sound selection to support the proposal. The planned implementation of such a system is unique and innovative in the profile extrusion industry.

Reprint 20797

Cost Engineering Submission Guidelines

Cost Engineering is a peer-reviewed technical journal. All technical articles undergo a blind peer-review evaluation. Certification articles are forwarded from the Certification Committee and reflect selections from among the top 10 percent of graded submittals. Feature articles are not peer reviewed and are selected by an AACE International Headquarters committee.

All submittals for possible publication should be e-mailed to editor@aacei.org.

All technical paper submissions for peer-review should be between 1,500 and 4,000 words in length. An electronic file is required and can either be an e-mail (with the text included within the e-mail or as an attachment) or on an IBM-compatible disk that is mailed.

Authors should remember that all figures, graphs, and tables will be printed black and white and should therefore avoid using color coded bar charts, etc., as the differentiating color distinctions will be lost in the printed version. Figures, graphs, and tables can be included where they should fall within the text, or reference tagged with instructions to insert here. Individual electronic copies of all figures should be included as a separate file or files.

No more than 12 small graphic items should be used with any submission. This is a combined total for figures, graphs, and tables. No item larger than 8.5 x 11 should be used and full page or multiple page figures, graphs, and tables should be avoided.

A notarized Publication Agreement, signed by each author, is required for all submittals and should be included when the submission is first sent.

If you have any questions or need additional assistance, please send an e-mail to editor@aacei.org or visit our website at www.info@aacei.org.
Calendar of Events

January 2004

6 The AACE International Second Quarter (3Q) 2003 Certification Exam, AACE International.
Contact: AACE International
304-296-8444, www.aacei.org

8-9 Mid-Atlantic Land Use / Land Cover Conference at Towson University
Townson, MD
Contact: http://cgis.towson.edu/lulc04

21-23 Buildings for Advanced Technology Workshop II
Mesa Centennial Conference Center
Mesa, AZ
Contact: achasey@asu.edu
http://create.asu.edu

31 Deadline to Submit Technical Papers for the 2004 AACE International Transactions
Contact: info@aacei.org
www.aacei.org

February 2004

2-4 2004 Six Sigma Conference, The American Society for Quality (ASQ),
Point Hilton Squaw Peak Resort, Phoenix, AZ
Contact:
http://sixsigma.asq.org/index.html

4-6 Fundamentals of Indoor Air Quality - Core Skills for the Building Professional, The Association of Energy Engineers (AEE) and The Environmental Engineers & Managers Institute of AEE (EEMI), Radisson Deauville Miami Beach, Miami, FL
Contact: 770-925-9633, fax 770-381-9865, www.aee.center.org

5-6 Leadership Development for the Engineer, American Society of Civil Engineers (ASCE), Alexis Park Resort, Las Vegas, NV
Contact: www.asce.org/conted/


24 Specifying with PVC Geomembranes, PVC Geomembrane Institute (PGI), Radisson South, Bloomington, MN
Contact: Chris Smith

31 Deadline to Submit Abstracts for Italian Society for Total Cost Management's 2004 Forum
Contact: info@aice-it.org

March 2004

12-14 Western Winter Workshop, San Francisco Bay Area and Southern California Sections of AACE International, Doubletree Hotel, Monterey, CA
Contact: Tom Clarkin, CCE
phone 415-768-3113
fax 415-768-4909
trclarki@bechtel.com

16-19 Pipeline Automation + Control Conference, Munich, Germany
Contact: info@pipeline-automation.de
www.pipeline-automation.de

April 2004

17-21 ICEC 4th World Congress 2004, International Cost Engineering Council (ICEC), Cape Town, South Africa
Contact: www.icec.com

May 2004

22-26 T Ugis Annual Geographic Information Sciences Conference, Planning, Prevention, and Response: GIS and Homeland Security, Center for Geographic Information Sciences, Towson University, Towson University Campus, Towson, MD
Contact: Susan Wooden
phone 410-704-5297
swooden@towson.edu

20 7th Annual Spring Conference, Genesee Valley Section of AACE International, Monroe Country Club, Rochester, NY
Contact: Douglas W. Leo, CCC
phone 585-722-6466
Douglas.leo@kodak.com

21-23 The TFM Show™ Building Automation Pavilion, The Continental Automated Buildings Association (CABA), co-located with the CSI Show™, McCormick Place, Chicago, IL
Contact: caba@caba.org
www.caba.org

June 2004

Contact: info@aacei.org
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Editor’s Note: Please submit items for future calendar listings at least 60 days in advance of desired publication.
Skills and Knowledge of Cost Engineering, 4th Ed
(available in paper or CD-ROM format)
Richard E. Larew, Editor, 2002
This updated and expanded guide for fundamentals is an excellent choice for anyone interested in a concise reference to all aspects of the profession. The new 4th edition includes 27 chapters on estimating, manufacturing and operating costs, scheduling, planning progress and cost control, and much more. This is a very useful book for those studying for the certification exam. 282 pages
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1542-06 CD-ROM US$28.50 member/US$42.50 nonmember

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The AACE International Certification Study Guide provides an all-encompassing reference text to prepare for the exam. The Certification Study Guide provides background information on how to become certified; gives those studying for the certification exam a single reference text that includes theory, worked problems with answers, references, and a full discussion of key topics; allows students to maximize their study time; and provides a concise overview of the fundamentals of cost and project management.
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1820-33 CD-ROM US$49.50 member/US$64.50 nonmember

Advanced Skills and Knowledge of Cost Engineering
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Control and Management of Capital Projects, 2nd Ed
John W. Hackney; Kenneth K. Humphreys, Editor, 1997
AACE is pleased to sponsor this special soft-cover edition of this classic reference for capital project management by the late John Hackney, as edited by K.K. Humphreys. This second edition has 56 chapters that range from applied theory such as Labor Productivity Analysis to practical concerns such as Selection and Management of Contracts and Contractor. 533 pages
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