PROJECT CONTROLS & DATA ANALYTICS IN THE ERA OF INDUSTRY 4.0

Practical Risk for an Owner’s Organization

AACE Election Results Announced
AACE INTERNATIONAL’S CONFERENCE & EXPO CURES PROJECT CONTROLS DYSFUNCTION.*

*USE AS DIRECTED:
Once you are back from the Conference & Expo, if productivity lasts longer than 9 hours daily, it is working as intended.

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How failure cultivates resilience

In his research for NASA, clinical psychologist Raphael Rose discovered that failure is key to creating resilience. He explains how leaning into trials and setbacks builds the emotional callouses that help us value what’s good in life.

Dr. Raphael Rose is a clinical psychologist, and serves as the Associate Director of the UCLA Anxiety and Depression Research Center (ADRC). He is a Researcher in the UCLA Department of Psychology, and a Clinical Associate Professor in the Department of Psychiatry and Biobehavioral Sciences at UCLA. For over the past 10 years Rose has been principal investigator on several NASA-funded studies involving the development and evaluation of a self-guided computer-based stress management and resilience training program called SMART-OP, and related investigations examining novel ways to implement technology in the delivery of behavioral health interventions. Raphael completed a post-doctoral fellowship at Dartmouth Medical School and received his Ph.D. from Hofstra University.

Source: www.ted.com
President’s Message
Battling Organizational Half-Life

Technical Board Spotlight
Practical Risk for an Owner’s Organization

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Understanding the Purpose and Autonomy of the Certification Board

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AACE International Online Store

For additional industry news and updates, you can always visit us at web.aacei.org.
The Top 10 Reasons To Join AACE International

Ready to advance your career and begin enjoying the advantages that our members enjoy? Whether you are an experienced cost engineer or a student, we have a membership ready for you.

1. **Time**
   Gain access to a wealth of resources that will save you time and money! You’ll stay informed about the complexities of the cost and management profession - plus you’ll have access to discounts on educational programs, publications, and more!

2. **Information**
   Locate thousands of technical papers and publications in the Virtual Library. AACE’s database is keyword searchable for quickly locating appropriate reference articles.

3. **Career**
   Members can post resumes at no additional cost in our Career Center and keep your career on track through information sources such as our annual Salary and Demographic Survey of Project and Cost Professionals.

4. **Learning**
   We offer numerous online learning courses on estimating and project management. The Approved Educational Provider program helps maintain high quality development courses and providers. AACE also holds many seminars throughout the year.

5. **Resources**
   Starting with the TCM Framework and Recommended Practices that are available for free only to members to our bi-monthly publication Cost Engineering featuring articles for cost professionals around the world. Through the AACE International website, the Cost Engineering journal is a great current resource for members and as a member, you gain access to an archive of past issues.

6. **Technical Development**
   Increase your knowledge and expertise by joining one of AACE International’s many technical subcommittees, subcommittees, and Special Interest Groups (SIGs) at no additional cost to members. Discuss industry problems with your peers or help experts develop new and improved techniques and practices for the profession.

7. **Networking**
   By attending a local section or our Annual Conference & Expo for interesting speakers, informational tours, social dinners and much more. The online Membership Directory is an excellent source for a list of contact information on thousands of members. Join one of our many technical subcommittees and participate in the AACE Forums - a great way to tap into the collective wisdom and experience of our world-wide membership.

8. **Excellence**
   Our certification programs are independently accredited by the Council of Engineering & Scientific Specialty Boards. AACE certifications are a recognized credible standard in the cost management field. A recent study shows that individuals with an AACE Certification earn 17.4% more than their counterpart without a certificate.

9. **Discounts**
   On products and services ranging from AACE International Conference & Expo registration fees, archived webinars and presentations, certification examination registrations, and more!

10. **You!**
    We are your professional partner bringing you information and support you can trust. Join and become part of a unique network of individuals who are dedicated to improving the cost and management profession.

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Organizations have a lifecycle and, as such, a half-life and mortality. A half-life is the time in which the radioactivity of an isotope disintegrates to half its original value. The concept can, and has, been applied in many ways completely unrelated to radioactivity. Training is said to have a half-life, in which the knowledge learned decays and is lost, requiring refresher training. Innovation, skills, digital footprint, medication, publications, classified information, data, and intellectual property also have half-lives. Even professional association presidents have a half-life (I reached mine in January/February), in terms of their ability to influence.

The half-life concept can also be used to describe the lifespan, health, and sustainability of an organization. According to an article in Inc. magazine, in 1965 the average tenure of companies on the S&P 500 was 33 years and shrinking rapidly. AACE International was founded in 1956, which puts us well past our theoretical half-life. We have progressed from start-up to growth and maturity, and now to our current phase of sustaining the organization.

The next two phases of an organization are revival/renewal, and death. The death of organizations (usually corporations) is sometimes conceptualized as the liability of senescence, in which bureaucracy and stagnation render organizations less agile and resilient. We all have had clients like this, the ones enmeshed in power struggles, cronyism, and cliques, where new ideas are rejected or subjected to so much red tape that they never see the light of day, where diversity, succession planning, and term limits simply do not exist. Organizations also die as external factors, such as industry changes, affect them.

There are, certainly, professional societies that are older than AACE International, some dating back to the 1830’s (such as the American Statistical Association). These societies are proof that organizations can survive or even reverse their own decline, that obsolescence need not occur. The core of our membership, cost engineering, seems more relevant and imperative today than ever. However, stalling or dodging organizational death requires change and effort, especially in a day and age where online interaction, data gathering, and learning are booming and face-to-face interaction is declining. No organization can survive long-term without reinventing itself and breaking free of organizational inertia (such as embedded mindsets and processes).

What do you envision as the AACE of the future? What collaboration has taken place with other organizations, and what new knowledge has been created and captured? How has the profession, as a whole, and you (the individual member) benefited? I invite you to engage with other members at upcoming section and regional events, and the Conference & Expo in New Orleans, to help shape and evolve AACE. Volunteer on the committee and/or section, of your choice, and put your name in as a candidate for elected positions or to serve on an associate board. The future of AACE is created by you, for you.

If you would like to contact our current president with questions or comments about The President’s Message please address your e-mail to president@aacei.org. To engage in other discussions, check out AACE International’s online Communities at communities.aacei.org.
Practical Risk Analysis for an Owner’s Organization

BY JEFFERY BOROWICZ, CCP CEP PSP FAACE
EDITING ASSISTANCE BY THOMAS HREN PE

Practical risk analysis starts with a strong project team consisting of management, engineering development, estimating, scheduling and project controls.

All projects should follow a governance plan that controls project development. Many companies follow a gated or staged process that progresses the project through increasing levels of scope maturity to determine an appropriate risk-based estimate and schedule. There can be three or four gates including the project approval or funding gate. This article will focus on the use of the three gate approval process. The purpose of the gated or staged process is to ensure owners only fund projects that meet their business requirements and reject those that do not. The gated or staged process provides the company opportunities to make “go” or “no go” decisions prior to final project approval.

A new project, at the beginning of a three-gate process, will develop “concept screening” or AACE Class 5 cost estimate(s) for one or more alternatives that meet the business objectives. The AACE Class 5 project estimate includes the Basis of Estimate (BOE) and starts the project risk register. At this phase, of project development, risk is systemic and for practical reasons accounted for parametrically, built upon historical cost data (benchmarking). Before the second gate, the scope for these business alternatives are further matured including development of “study or feasibility” or AACE Class 4 cost estimates; then one preferred option is selected during the gate review. The AACE Class 4 project estimate updates the Basis of Estimate (BOE) and project risk register, which establishes the foundation for project development prior to the final funding gate. While risks at this stage are still mostly systemic, other project-related or execution risks may surface. Both the systemic and project-related risks can be accounted for holistically in the risk analysis. During the final phase of engineering, prior to the project funding gate, the project’s requirements are further defined and matured whereby a “budget or funding” or AACE Class 3 estimate is created, the Basis of Estimate (BOE) updated and the project risk register is completed. The risk analysis at this point, should have minimal to no systemic risks remaining, and should consist only of project-related or execution risks. At the funding gate, management reviews the project scope, duration, cost and risks, then based on the company’s risk tolerance, approves a funding level “contingency” and/or “management reserve.”

The development of the project risk register occurs at the start of every project. The project team collaboratively determines as many risk events as possible. Risk register development continues during project development and should be complete prior to the funding gate. At the beginning of the project, the risks in the
register are all systemic, while at the funding or project approval
gate the risks involve project execution.

Group risks in categories – such as procurement, engineering,
construction, owner, etc. Assign individuals to manage each risk
to their conclusion, which will require them to adequately scope
the risk items, identify mitigating actions, develop the cost and
schedule impacts and assess probability of the occurrence. Usually
risk impacts and risk probabilities use a rating scale, either 1 through
5 or 0 through 4. For impacts, each integer represents an order of
magnitude of increased impact. As for probabilities, each integer represents
increasing likelihood up to 100%. This
article will illustrate using the 1 to 5 scale. The risk impact integers are usually
associated with descriptors such as:
insignificant (1), minor (2), moderate
(3), major (4), or catastrophic (5); and
likewise the probabilities of occurrence
are associated with descriptors like: rare
(1), unlikely (2), likely (3), most likely (4)
or certain (5). Identifying appropriate risk
items in the register is important however,
descriptive content is crucial. Many risk
register items tend to be very generic
in nature and are not specific enough
to allow for proper scoping, costing or
scheduling detail.

A cost estimator should evaluate the
risk events and provide an AACE Class 5
estimate on each item in the risk register.
Multiply the estimated values by their
probabilities to obtain the Expected
Values (EV). In some organizations,
the sum of the EV’s for all these risks
determine the project contingency.
The problem with this approach is no insight
or insight exists into the risk profile facing the
project. A scheduler should always assess
the durations associated with each risk,
and together with the cost estimator
determine the cost of the durations. Schedulers should establish
activities based on the risks forecasted timing during the lifecycle
of the project.

As discussed earlier, when the risks are systemic, historical
data and/or a parametric models built on historical data can
adequately determine the contingency needed for risk. As the
project matures during the stage gate process, systemic risks are
reduced significantly, while the quantity of project execution
risks increase. When multiple risks need to be analyzed and
interactions or compounding affects considered, Monte Carlo
simulation modeling should be conducted. The risk analyst should
review the project cost estimate and the risk register to determine
which “critical risks” should be in the risk model. Using modeling
tools, these critical risks along with the cost estimate will provide
calculated probability values (P-values) that the company can use
to value acceptable risk tolerance.

Other risk modeling data can be obtained from the Monte
Carlo simulation in addition to the probability values. Systemic
and project execution risk quantifications can be produced
collectively or individually. Risk outputs with the Probability
Density Functions (PDF) or a Cumulative Probability
Distributions (CPD) can be produced to show the contingency
values and their expected P-values. Tornado diagrams can rank risk
events in an ascending order of increasing impact on contingency.
The risk simulation results can be used by upper management
during the funding gate to select the
appropriate risk P-value that represents
the company’s risk tolerance for that
each specific project to achieve the
company’s objectives. After the project
has been approved for funding, the
“Bid/Tender Estimate” or AACE Class
2 estimate would be the next estimate
produced after detailed design is
near completion. The purpose is to prepare for release of the construction
bid packages. Once the construction
contractors are selected, the Bid/Tender
Estimate along with the risk events that have not happened should be placed
into appropriate budget categories for
project controls. Project controls will
manage the drawdown of contingency
during the execution phase. The
contingency funding for risks that have occurred are allocated to the actual
risks. Any remaining risks during this
period that have not occurred the
contingency funds can be returned
to the company for reallocation. The
“Project Controls Forecast or Check
Estimate” - AACE Class 1 estimate
should be updated on an agreed to
frequency for reporting status for the
duration of the project. The remaining
execution risks in the register should be
actively managed to closure.

As projects are benchmarked, the benchmarking database
should track actual project outcomes against the estimate history
over the project development lifecycle. This provides the ability to
determine actual P-values for similar type projects. Once this data
is mined and quantified, educating project executives on the value
of benchmarking can lead to companies making better-informed
contingency decisions using historical risk profiles from similar
projects in the company portfolio.

Lessons Learned – using benchmarking data, a company
can manage risk and make better risk decisions early in a project
consistently. ☑

Editor’s Note: This is part of a continuing series of short articles
provided by members of the AACE International Technical Board.
The Certification Board of AACE International was granted its charter from the Association Board of Directors in 1976 with the purpose to plan, direct, and administer the AACE Certification Program. The Certification Board does not determine who shall engage in or practice cost engineering; they are responsible for setting minimum eligibility requirements and program policies to ensure those who apply for certification are satisfactorily qualified and capable of being recognized as one of the eight designations it offers. The certification program staff at AACE headquarters execute and enforce the requirements and policies set forth by the Certification Board.

The program has successfully evolved from one industry defining credential to a portfolio of eight distinct certifications for three levels of experience: Technician, Professional and Expertise. The program has also achieved independent accreditation by the Council of Engineering and Scientific Specialty Boards (CESB).

A key accreditation standard for certifying bodies is autonomy or self-governance. While the Certification Board exists by the authority of the Board of Directors, it remains autonomous in certification-related matters and decisions. In order to receive and maintain accreditation, a certifying body must demonstrate they are independent and impartial in all matters pertaining to granting certification. Simply put, Certification Board members and certification staff cannot succumb to undue influence from any other body, group, or person, including AACE board members, committee members, and section leaders. A certifying body can risk losing accreditation if autonomy is violated. Violation examples may consist of interceding or lobbying for exceptions, favors, or special treatment on behalf of another person, or requesting details of sensitive certification matters such as disciplinary actions or ineligibility, to name a few.

Sometimes, prospective and current candidates will reach out to other association leaders for help and assistance with certification questions or issues. We understand this approach. There are connections or established relationships with AACE leadership at all levels which create a more comfortable environment in which to share concerns, complaints and issues, and ask for their intervention. Due to the autonomous nature of the certification program, however, board and staff members are not able to provide a response to any third party advocating for, or inquiring on behalf of, a candidate or certificant, lest it have the appearance of bias and undue influence. Furthermore, certification matters are considered personnel matters and as such are subject to privacy laws.

Another accreditation standard is to provide a mechanism for candidates and certificants to report issues, file disputes, or appeal decisions. The AACE certification program is equipped to handle such matters through established channels, whether it concerns eligibility, examination results, or program policy disputes, or a complaint against a certification staff or board member. Many times, resolutions and answers are readily available, they are just not easy to find on our information-rich website. A great place to start is the Certification Hub – a centralized outlet for all things certification.

In summary, objectivity of qualified, independent subject matter experts and autonomous governance are essential in developing and maintaining a valid and legally defensible credentialing program. Our program has consistently met these requirements since our first accreditation in 2000. Each certification board and staff member annually vow to be fair, equitable, and free from outside influences in regard to the eligibility, designation, and maintenance of all candidate’s and certificant’s certification pursuits, and to be free from conflicts of interest. We exist to help candidates achieve certification, certificants to maintain certification, and for the association to proudly claim a gold-standard international certification program.

BY PENNY WHOOLERY, MANAGER CERTIFICATION AND MEMBERSHIP

CERTIFICATION NEWS

A great place to start is the Certification Hub – a centralized outlet for all things certification.
Complete Project Lifecycle Management Software

ARES PRISM is an enterprise project controls software that manages the complete project lifecycle delivering dependable forecasts, cost control, and performance measurement.

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The India Section was launched from the Indian Institute of Technology, (Delhi, India) by the Honorable Minister for Statistics and Program Implementation, D. V. Sadananda Gowda, on Dec. 1, 2018. Three prior India Sections (South India, North India, and Central India) were combined into one India Section to bring a focused approach toward growing the section in India.

The India Section was launched by the traditional Indian-style lighting the lamp which was conducted by Minister D. V. Sadananda Gowda, Prof. Balakrishnan, Deputy Director of IIT Delhi, Sudarshan Karle, Director of Karle Group, Sivakumar, President of the India Section, and Dr. Madhu Pillai, International Cost Engineering Council (ICEC) Director Middle East.

Sankar Subrahmaniyam, Chair of the India Taskforce, delivered the welcome address. In his address, Sankar said, “the India Section will not limit itself to training and development, but will work with government, academia, and industry” and complementing professional bodies to improve the project management standards in India. He said the India Section will adopt both a top-down and bottom up approach, i.e., working with policy makers and implementers, as well as training of professionals at various levels, to simultaneously achieve the desired results.

Mr. Balakrishnan, Deputy Director of IIT Delhi, welcomed everyone on behalf of IIT Delhi. He said IIT Delhi, identified as an “Institution of Eminence” by the government of India, should play active role and is looking for suggestions from professional bodies, like AACE International, to improve the schedule and cost efficiency in management of large capital projects.

Mr. Sadananda Gowda, Minister of Statistics and Program Implementation (MoSPI), in his speech called for an innovative approach to deal with the issue of cost and schedule overruns on projects. He mentioned that at present nearly 22 percent of a project’s cost is overrun expenses according to a report published by his ministry. He said this is a great loss and there are many reasons for these overruns. He said the MoSPI has a dedicated division to monitor projects. Using online computer monitoring systems, they monitor projects from 16 government departments, including civil aviation, railways, roads, etc. He noted that 1,417 projects with a more than Rs. 1500 million outlay are being monitored by the ministry. The monitoring shows 20 projects are ahead of schedule, 386 projects are on time, 317 projects are showing a time overrun, and 362 projects are showing cost overruns. Some of the overrun reasons, (like land acquisition, shortage of labor, law and order issues, etc.), are beyond the control of the implementation agencies. Other aspects, such as poor project formulation, planning, monitoring and control, are under the control of the implementing agencies but are not being given adequate importance. He believes it is essential for government, academia, industry and associations like AACE International to jointly work together to improve the situation. He said his ministry will welcome proposals from the India Section for the betterment of project implementation within the country.
Mr. Mohammad Rafiuddin, the AACE Vice President-International Regions, introduced AACE and its certifications to the participants. He said many large projects are coming in with tight timelines and budgets. Hence, sound project management practices, continuous education, and competency enhancements are the necessities of the day and a must for project management. He also said many international organizations have successfully developed and aligned their systems and processes by benchmarking AACE International’s Recommended Practices. Rafi said the India Section will be collaborating with other professional bodies that are working for the same purposes of bringing improvements to the profession of project management within its various spheres.

Dr. K.C. Iyer, Professor and Dean of Infrastructure with IIT Delhi, spoke on the necessity for deeper learning. He said IIT Delhi has studied many projects very closely and that many of the projects were economically unviable for various reasons. He cited difficulties in getting real-time data from government and private industry and a lack of trust as reasons for not sharing data. He spoke about experiential learning and cited examples from Netaji Subhash Chandra Bose Airport, Kolkata. He believes AACE International can play a major role in helping organizations manage projects, especially ones that include greater risks, and manage these in a better manner.

A government/industry/academia roundtable was anchored by Dr. Madhu Pillai, along with Dr. Uma Maheshwari of IIT Delhi, Mr. Rajeev Jain, Director Construction Industry Development Council, Mr. KR SRKrisha, Vice President Operations of Petrofac, Mr. Puneet Narang, Partner KPMG and Mr. Laurie Bowman, Director Region 8 of the AACE International Associate Membership Board. The theme of the round table was, “Improving Cost and Schedule Efficiency in Large Public and Private Sector Projects Through Effective Project Controls.” Dr. Madhu said the session goal was to bring out actionable ideas that can be shared with the government as requested by Minister D. V. Sadananda Gowda during his speech. Dr. Madhu said projects should be looked at from a lifecycle point of view of an asset rather than from the capital expenditure angle.

Dr. Uma said industry should work with various institutions in supporting researches in order to learn from projects. Mr. Rajeev Jain briefed attendees on the role of the CIDC and the purpose behind the Indian government establishing CIDC. He said though there are many identified areas for skill development, there are no learners, and this is a major challenge before the CIDC. Mr. Krishna’s opinion is that most of the workforce for the engineering industry is coming from second tier engineering colleges in India and the focus should be on improving the skills of those engineers. While Laurie Bowman brought an international perspective and the necessity for collaboration to the table. Mr. Puneet Narang mentioned that it is time to change our mindset from project management to an asset management mindset. There was an active question and answers session with participants throwing questions to specific members of the roundtable.
Mr. Sivakumar, President of the India Section thanked all the participants who made it to the launch event. He thanked IIT Delhi for being the host and IIT Madras for their continual support, Prof. Iyer and Dr. Uma, Mr., Sudarshan Karle of Karle Group, sponsors of the event M/s. Wrench Solutions, all the speakers and panelists, Mr. Rakesh Jain for volunteering to be the MC, Ms. Bhaya Nair and Mr. Nambiappan of the India Section, Ms. Priyanka Prasar and Mr. Sreenivas, research scholars of IIT Delhi and Ms. Rajitha for Karle Group for their contributions as volunteers.

The event was attended by professionals from Petrofac, Engineers India Limited, Larsen & Toubro, Bechtel, Turner & Townsend, Blue Star, Wrench Solutions, research scholars and postgraduate students from IIT Delhi, McDermott, AECOM, KPMG, Flour, BHEL, Technip, professors from various departments of IIT Delhi, professionals and regional directors and AACE members from Qatar, Saudi, UAE, Bahrain and from various parts of India.

There was a Section board meeting on Nov. 30, 2018, prior to the launch event. The meeting was attended by the Indian Section officers, members from India, international members attending the launch, and advisors to the India Section Board. Various strategies for expanding the section in India were discussed. The India Section board has unanimously elected Prof. K.C. Iyer and Dr. Uma Maheshwari, professors from IIT Delhi, and Mr. Devi Prasad, as advisors to the India Section.

This event required the support of an extensive cast of AACE volunteers from around the world, including Dev Tamboli, AACE Director of Region 7 from Dubai, and Laurie Bowman, AACE Director of Region 8 from Australia, who took advantage of spare time between meetings to explore the local sights and provide risk management training to some of IIT Delhi’s PhD engineering students. Hard working event organizers Sankar Subrahmaniyam and Nambiappan Sivasubramanian, who had travelled from Bangalore, also took time out to enjoy the local sights following the successful launch of the India Section. The IIT Delhi campus is surrounded by a variety of ancient monuments and tourist attractions including the Lotus Temple, Qutub Minar, Red Fort, Parliament House and the Delhi Gate to name a few.

IIT Delhi will also be host to the world’s first International Cost Management and Project Controls Conference 11-13th July 2019. Early bird registration is now available and the conference call for technical papers had an initial submission deadline of 31st March 2019.
Taymoor (TK) Khan is a project control lead who currently works for ConocoPhillips Canada and is based at the Surmont site (oilsands-asset) in Fort McMurray, Alberta (starting April, he’ll be transitioning to the Calgary head-office).

Taymoor was introduced to the oil and gas field through his father who was in the industry for over 40 years, while assigned to various countries. Taymoor grew up in the small town of Fort McMurray located in Northern Alberta and figured from a young age that his aspirations lay in the oil and gas field. Over the years, he has gained substantial experience working for various international energy companies, while obtaining his combined bachelor’s degree in accounting and finance from the University of Northern British Columbia (UNBC). In his last co-op term with Cenovus Energy, he worked as a project technician in which he collaborated with the project controls team at the head office and site. It was during this time that Taymoor gained an interest in the wide array of possibilities present in the project control field.

Following his graduation from UNBC, Taymoor joined ConocoPhillips Canada where he has held a successful career of over seven years (till date). During this time, he has been involved in multiple projects ranging from a hundred thousand dollars to billions. He’s been responsible for cost and scheduling related aspects for the Brownfield and maintenance projects that are in the execution phase of construction.

Taymoor enjoys his present role as it gives him the opportunity to communicate and collaborate with various business units such as, supply chain, finance, engineering, construction and operations. He was a key team player in the safe and successful execution of the 2017 shutdown and has collaborated with his team members at site and the home office to implement cost systems that help streamline cost tracking and project change management. He is also an active member of ConocoPhillips’ Site Cost Committee, where he takes up the responsibility of educating peers in the company on cost-conscious culture, changing individual and collective mindsets toward identifying long-term savings and promoting and implementing ideas that reduce overall cost.

Taymoor was introduced to AACE in 2015 through his former project control manager, who advised him to attend an AACE seminar, as he believed that AACE was an excellent avenue to attain career and personal development in the project control field. Taymoor joined AACE and has been glad to be exposed to the host of courses that are available to him as a result of being an AACE member, and he believes that AACE International has a wealth of courses for anyone who would like to increase or expand their professional knowledge. He is proud to be a member of an organization that focuses on the development and advancement of not only individual professionals but the entire project control sector.

In the future, Taymoor looks forward to contributing to AACE by joining the Mentorship program and helping new professionals in their career development. He is also looking to pursue his Certified Cost Professional certificate soon.

Taymoor’s view is that it does not matter whether you have been in this industry for 10 years, 10 months, or 10 days, everyone brings a unique perspective and skill set that contributes to our collective knowledge base. His key belief is that knowledge is the foundation to success, and he advises others to pursue avenues that work toward expanding their knowledge through life-long learning.

“It doesn’t matter whether you have been in this industry for ten years, ten months, or ten days, each individual brings a unique perspective and skillset that contributes to our collective knowledge base.” — TAYMOOR KHAN
Winners are being announced in the 2019 AACE International election for seats on the Board of Directors and the Membership Board. Members elected a President-Elect; Vice President-Administration; and five seats on the Membership Board for Director-Region in Regions 3, 5, 6, 8, and 10.

PRESIDENT-ELECT
Christopher P. Caddell, PE CCP DRMP, will be returning to the board as President-Elect. This is a three-year commitment, serving in 2019-2020 as President-Elect, then as President for 2020-2021, and a year as Past President for 2021-2022.

Chris is a Senior Vice President at Turner & Townsend. He holds an MBA from the University of Texas at Austin and a Bachelor of Science degree in civil engineering from Rice University. Since becoming a member of AACE International in 2004, Chris has become active in AACE International related activities. He has held elected office at the Association level, been active in standing AACE committees, written papers and presented at the AACE International Conference & Expo (formerly Annual Meetings) and has been an active member of AACE task forces.

Chris became a Certified Cost Professional (CCP) in 2010 and a Decision and Risk Management Professional (DRMP) in 2013, as a result of his work on the DRMP Task Force that developed the certification. Chris has served as the Chair of the Decision & Risk Management Technical Subcommittee. Chris was elected and previously served on AACE’s Board of Directors as Director-Region 5 (2015-2017) and Vice President-Administration (2017-2019). Chris has been recognized by AACE with the following awards: Outstanding Technical Subcommittee Chair (2013), and Technical Excellence Award (2012).

All remaining Board seats serve two-year terms.

VICE PRESIDENT-ADMINISTRATION
Scott A. (Gator) Galbraith, PE CFCC, was elected to serve as Vice President-Administration.

Gator became a member of AACE in 2004 and earned the designation of Certified Forensic Claims Consultant (CFCC) in 2007. He has been an active member of the AACE Certification Board since 2016. Gator has previously authored and presented papers at the Conference & Expo (formerly Annual Meeting). Gator has previously been elected and served as a member of the North Florida Section of AACE.

FIVE ELECTED AS DIRECTOR-REGIONS
Each Director-Region provides liaison between the AACE Sections, within their respective Region, and AACE’s Board of Directors and the Membership Associate Board. Beginning terms as Director-Region will be:

- Region 3: Eric Cannon, PSP
- Region 5: Ashley Garza
- Region 6: Roger Nelson, PE PSP
- Region 8: Sankar Subrahmaniyam, EVP
- Region 10: Oscar Siles Chaves

- Eric Cannon, PSP, became a member in 2008 and obtained the designation as a Planning & Scheduling Professional that same year. He is a member of the board of the North Florida Section. Eric is the Director of Scheduling at Moss.
- Ashley Garza joined AACE in 2013. She has served as President of the Utah Section and, since moving to the Houston area, has been an active member of the Houston-Gulf Coast Section. Ashley is a Senior Project Controls Analyst for Williams.
- Roger Nelson, PE PSP, joined AACE in 2011 and obtained the Planning & Scheduling Professional (PSP) in 2018. Over the past year, he has served a one-year term as Director-Region 6. Roger is a Managing Consultant at Spire Consulting Group, LLC.
- Sankar Subrahmaniyam, EVP, joined AACE in 2012 and obtained the Earned Value Professional (EVP) designation in 2013. Sankar is the treasurer of the India Section. He is the Chief Operating Officer at Karle Infra Private, Limited.
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All elected Board of Directors and Membership Board members will officially begin their terms of office at the 2019 AACE International Conference & Expo, June 16-19, at the Sheraton New Orleans hotel.
Project Controls & Data Analytics in the Era of Industry 4.0

BY JAMES E. ARROW, DRMP; ARVID MARKHUS; VIJAI SINGH; CESAR RAMOS; AND STEFAN BAKKER

ABSTRACT
Economists predict that the fourth Industrial Revolution (i.e., Industry 4.0) will cause fundamental disruption. Within the engineering and construction sector, a proliferation of data streams will provide new levels of diagnostic and predictive insight, increasing efficiency, decreasing uncertainty and improving the likelihood of successful project delivery. New technologies promise to make the theory of risk intelligent strategies a possibility for both companies large and small. However, studies frequently highlight that the Engineering and Construction (E&C) sector is a technological laggard. Additionally, for this sector, the most significant barrier to digital progress is the lack of an overall strategy.

To prepare for disruptive change in the profession, this article will explore:

• goals for data science capability improvement
• how project controls professionals can develop and lead an effective digital strategy
• process steps for effective data science
• opportunities for employing machine intelligence throughout the investment funnel
• minimally viable metrics to support decision and risk management between entities

Ultimately, the article will advocate that the association consolidate related white papers and develop a Recommended Practice, guiding members on the skills and knowledge required to perform Total Cost Management Analytics (TCMA) and deliver effective, actionable insight that reduces capital project risk and uncertainty.

INTRODUCTION
This article will briefly address what the World Economic Forum (WEF) has described as The Fourth Industrial Revolution [22, 25] and consider how the anticipated wave of digital disruption will likely impact the Engineering and Construction (E&C) sector.

As an industry, E&C is entering an exciting period of change. Computer processing power, ubiquitous computing and the availability of cheap sensors will allow project professionals to conduct analyses and secure insight that has otherwise been beyond reach. The theory of risk intelligent strategies [1] can be employed by companies large and small.

As companies prepare for a data-driven future and seek ways to secure a competitive advantage by employing Artificial Intelligence (AI) or automation, a case will be made for project controls professionals to become data
and analytics catalysts. In addition to stressing the need for developing statistical and data literacy skills, this article will describe data science maturity levels that can be used to guide capability improvement plans and share guidelines for developing meaningful digital strategies that ultimately ensure the efficient delivery of capital projects.

Finally, thought will be given to areas of research that the AACE community may wish to explore in order to further develop the requisite skills and knowledge required to deliver effective project analyses in an era increasingly defined by AI systems.

**THE FOURTH INDUSTRIAL REVOLUTION**

In 2017, the founder and executive chairman of the World Economic Forum, released a book. His book, titled, “The Fourth Industrial Revolution” [22], is the first to explore in detail the likely impact of modern innovation. Klaus Schwab argues that, “this revolution is different in scale, scope and complexity from any that have come before.”

While academics and historians may debate exact details, for the purposes of this article, the course of industrialization can be summarized as follows:

1. The first industrial revolution used water and steam power to mechanize production.
2. The second used electric power to create mass production.
3. The third used electronics and information technology to automate production, igniting a digital revolution that began the middle of the last century.
4. A fourth industrial revolution is building on the third. This new era will be characterized by a fusion of technologies. Blurring the lines between the physical, digital, and biological spheres.

When describing the current period of rapid technological change, industry commentators also speak more specifically of digital disruption. Billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, present untold possibilities. Such possibilities will be multiplied and further extended by emerging technology breakthroughs. New fields — such as: artificial intelligence, robotics, the Internet of Things (IoT), autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing — are likely to trigger self-perpetuating waves of complementary innovation.

Change is coming to all industries and at an unprecedented rate. Industry 4.0 is evolving at an exponential rather than a linear pace. Change is also likely to be profound, affecting sectors, like construction, that have otherwise been slow to embrace new technology. The possibilities can be exciting for some, but they also risk being a threat for others who are unprepared. It is imperative that project professionals embrace this period of fundamental disruption with their eyes wide open. The profession has a fantastic opportunity to create, not respond to, their collective future.

However, project professionals cannot be complacent. A 2015 research project by MIT Sloan Management Review and Deloitte [16] highlighted that, of the 18 sectors they studied, construction and real estate had the lowest level of digital maturity. Project controls professionals have an obligation to embrace the change they want to see. This report highlighted that the power of a digital transformation strategy lies in its scope and objectives. With that as a backdrop, this article shall explore the scope and objectives of an effective digital transformation strategy within the engineering and construction sector.

**DATA SCIENCE AND COMPETING ON ANALYTICS**

Taking just one facet of the emerging, multiplicative technological breakthroughs, data science is arguably one area in which organizations can immediately develop or further enhance their capability. Within their Field Guide to Data Science [6], Booz Allen provide the following definition for data science: “the analysis of data using the scientific method with the primary goal of turning information into action.”

A 2013 study by the University of Texas titled, “Measuring the Business Impacts of Effective Data,” revealed that organizations that increase data usability by 10% can anticipate productivity improvements ranging from ~20%~50%. Additionally, increasing data accessibility by 10% can anticipate their return on assets to increase by ~10%~40% [4].

Thomas Davenport is the Distinguished Professor in Management and Information Technology at Babson College. He was among the first, in 2007, to raise awareness of the benefit to businesses who seek to use data as a means to compete on analytics [9]. Davenport remains a vocal figure in the field of advanced analytics. He highlights that, although computers today are more capable than humans when making narrow observations, they cannot consider context and remain poor at problem-solving. Tom, among others [24], suggest that the key to increased productivity is augmentation. In other words, competitive advantage can be gained by augmenting human smarts with the power of machines to make more effective, data-driven, intelligent decisions.

**DATA SCIENCE CAPABILITY IMPROVEMENT**

Maturity models are often very useful for organizations to make baseline assessment of their capability and then establish a realistic performance improvement target.

When seeking to raise the data science capability within an organization, often, the first task is to simply break down data silos and facilitate data sharing across the enterprise. As maturity increases, the ease with which data can be collected improves. Today, most organizations in the construction sector are at the second stage of data science maturity [6], represented in Figure 1 by the shaded area labeled describe. The analytics employed at
In the near-term, far greater competitive advantage, exponential or disruptive change can be enjoyed by companies that have identified repetitive tasks (such as estimating, scheduling, cost and progress reporting) to be of the most prominent tech organizations. In 2012, the Harvard Business Review, proclaimed Data Science to be the sexiest job of the 21st Century [10]. We should anticipate that the most competent data scientists will be regaled much like the Wall Street quant of the 1980s and 1990s. Today, the most prominent tech organizations (such as Google, Microsoft, Amazon, Tesla and Uber) can rarely hold on to top talent for more than a year or two. Recently, a VP in Microsoft’s Machine Intelligence (MI) research department compared the cost of acquiring a top MI researcher to that of signing a NFL quarterback [7]. Since such costs are likely outside the reach of many within the construction sector, organizations should start exploring strategic partnerships with consultants, like-minded cohorts and academia to determine how best to invest in existing capability and raise their data science capability.

For organizations that target these two higher levels of data science maturity, the field of machine learning offers the potential for artificial intelligence to support project professionals with the development of more realistic targets or accurate performance predictions. In less than a decade, AI may ultimately provide prescriptive guidance. Allowing project delivery teams to augment their experience and strategic know-how with deep tactical insight provided by state-of-the-art machines.

**LEADING AN EFFECTIVE DIGITAL STRATEGY**

To gain the most benefit from AI, it is critically important this technology is not seen as an end in of itself, but a means to an end. An effective data science strategy must have specific goals that directly complement an organization’s mission objectives. Adopting this approach, teams should consider how data-driven decision-making could better support their existing processes. How can project teams work smart, taking advantage of existing data streams, ideally learning about and improving upon past performance? The right strategy will guide an organization to, relentlessly ask the right questions and constantly search for the next one [6].

**DIGITAL STRATEGY ATTRIBUTES**

Having pinpointed the underlying value into which an organization’s data science capability must be rooted, the following five areas should be explored to help further refine an effective digital strategy:

1. **Culture**
   - Does the organization value transparent decision-making that is empowered by analysis? If so, is their appetite great enough to commit to data-driven continuous improvement?
   - Is PMO culture sophisticated enough to recognize the potential capabilities of a project controls group with access to expanded data streams (historic and real-time)?

2. **Data Attributes**
   - Is data appropriately curated throughout the project lifecycle or at close-out? The importance of a consistent approach to data curation cannot be overstated
   - Are there processes to ensure the right attributes are captured to answer key business questions?

3. **Data Governance**
   - Is data current, accurate and complete?
   - Is ethical reasoning employed when decisions are made?
   - Is there a process for undertaking algorithmic audits?

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect</td>
<td>Focuses on collecting internal or external data sets.</td>
<td>Gathering productivity / progress records and corresponding weather data.</td>
</tr>
<tr>
<td>Describe</td>
<td>Seeks to enhance or refine raw data as well as leverage basic analytical functions such as counts.</td>
<td>How long after a significant weather event did productivity return to a consistently stable level?</td>
</tr>
<tr>
<td>Discover</td>
<td>Identifies hidden relationships or patterns.</td>
<td>Are there causes outside the weather conditions influencing productivity?</td>
</tr>
<tr>
<td>Predict</td>
<td>Utilizes past observations to predict future observations.</td>
<td>With resources working on their current assignment, what is the likely completion date?</td>
</tr>
<tr>
<td>Advise</td>
<td>Defines possible decisions, identifies an optimal state and advises on the decision that gives the best outcome.</td>
<td>On which work fronts should resources be deployed to achieve an optimal completion date?</td>
</tr>
</tbody>
</table>

**TABLE 1 Data Science Maturity Stage Descriptions**

this stage are what Tom Davenport describes as descriptive analytics. Essentially, these comprise of standard reports, ad hoc reports and drill down queries that provide hindsight.

Much of the rote work associated with the development of these common reports can be easily performed by machines. RPA or robotic process automation is a proven and now relatively cheap means for automating, repetitive clerical work. Good examples of successful RPA tools in use today center around tax preparation. With a little imagination, it is easy to recognize that there exists a great opportunity for similar, well-defined repetitive tasks (such as estimating, scheduling, cost and progress reporting) to be automated, enabling project teams to refocus their efforts on analysis and problem-solving.

Some of the industry’s leading companies are actively working to digitize their traditional practices. However, digitizing existing practices largely restricts organizations to perform only descriptive analytics, delivering only linear change. In the near-term, far greater competitive advantage, exponential or disruptive change can be enjoyed by companies that have identified repetitive tasks (such as estimating, scheduling, cost and progress reporting) to be automated, enabling project teams to refocus their efforts on analysis and problem-solving.

Having configured the computer architecture or infrastructure to perform diagnostic analytics, it is interesting to note that, simply speaking, an organization has all the hardware needed to perform at the remaining, highest levels of the data science maturity model. The primary element, needed to perform predictive and prescriptive analytics (i.e., at the predict and advise maturity stages in Figure 1 respectively), largely boils down to an organization’s ability to code or write appropriate algorithms. Taking that into account, it is easy to appreciate why individuals with this skillset are highly sought after!

Table 1 further details the five stages of data science maturity and provides examples that help illustrate the how uncertainty in a project management or project controls environment can be more effectively assessed and controlled.

Table 1 further details the five stages of data science maturity and provides examples that help illustrate the how uncertainty in a project management or project controls environment can be more effectively assessed and controlled.
4. Talent
• Does the organization currently possess an appropriate blend of skills and knowledge?
5. Analytic Assets
• Are tools and architecture (i.e., software and hardware) adequate to deliver the needed data-driven insights? Are systems user-friendly or simply accessible to available talent? Are outputs flexible enough to suit all stakeholder needs?
• Is decision architecture adequate to ensure decision-makers receive the right information at the right time? Is there benefit in adding embedded analytics (i.e., within legacy platforms) to minimize bias and/or reoccurring error and nudge decision-makers toward better outcomes?

Companies with the operational discipline to have curated empirical records of their past performances are likely to have a head start on their competition. With structured data, organizations can take advantage of supervised machine learning. Teams can gain further insight by employing asset tagging and sensors or Internet of Things (IoT) technology to develop rich data streams, targeting systemic risks such as poor productivity [25], with the goal of discovering previously hidden efficiencies.

DATA SCIENCE AND RISK INTELLIGENT STRATEGIES
David Apgar’s 2006 book, “Risk Intelligence: Learning to Manage What We Don’t Know” [1], was among the first to raise awareness of the benefits to gained from risk intelligent strategies. Here, Apgar made the case that organizations who are most able to weigh risks effectively will secure a risk-based competitive advantage. He described that value protection and value creation are predicated by an enterprise’s ability to avoid unrewarded risk and pursue rewarded risk respectively. Additionally, he described that weighing risks effectively involves:

• classifying risk data
• characterizing and calculating exposure
• perceiving relationships (and in the inherent value thereof)
• learning quickly
• storing retrieving, and acting upon relevant information
• communicating effectively
• adjusting to new circumstances

It is exciting that data science is now helping close the gap between this theory and modern practice! Computing power, and the depth of data available, ensure techniques for data analysis are now far more capable than they were 10 years ago. Consequently, it is far easier for an enterprise to weigh risks, optimize the cost of risk management, and secure a risk-based competitive advantage.

1. Domain Expertise
• Project controls professionals are essential for helping to precisely define the problem space necessary for asking targeted questions that will most likely deliver actionable results.
• Correlation does not equal causation, so domain expertise is critical for reviewing context and validating findings.
2. Mathematics
• Experts are needed in statistical modelling, signal processing, probability models, pattern recognition, predictive analytics and a variety of subspecialties
• The best teams develop AI, pattern-matching and machine-learning tools that generate the building blocks for predictive models.
• Great mathematicians are critical to any data science department, but they cannot operate in isolation.
3. Computer Science
• Having the right architecture for a data science function (i.e. specification for hardware and software interaction) is as important as having the right physical architecture for a physical work environment.

Data science exists at the intersection of these three foundational skills. Discounting or overweighting any of them will yield suboptimal results.
TYPES OF REASON IN DATA SCIENCE

For many years, the convention within the project controls community has been to solve problems by relying upon deductive or hypothesis-based reasoning. Data science supports and encourages a shift toward inductive or pattern-based reasoning. Figure 4 summarizes the differences between these two approaches.

Inductive reasoning and exploratory data analysis provide a means to form or refine hypotheses and discover new analytic paths. With this in mind, one may start to appreciate how this shift can provide the catalyst for exciting change.

Essentially, Data Science creates an environment where models of reality no longer need to be static and empirically based. Instead, models are constantly tested, updated and improved until better models are found.

![Figure 4 Inductive vs. Deductive Reasoning (6) (reproduced with permission)](image)

PRIMARY CHARACTERISTICS OF BIG DATA

Within recent years, much has been written about “big data.” Big data sets are simply vast amounts of data that are too big for humans to deal with without the help of specialized machines or tools.

This phenomenon is the by-product of increasing digitalization and this trend is set to continue at an exponential rate: “the world’s technological capacity to store information has increased with a compound annual growth rate of 31% during the three decades between 1986 and 2014 (from 2.6 exabytes to 4.6 zettabytes), while the world’s installed telecommunication capacity has grown with a compound annual growth rate of 35% during the same period, from 7.5 petabytes to 25 exabits)” [12].

To secure the greatest value from big data, an organization’s policy, process and procedure should account for and manage the following five characteristics: [3]

- **Volume** – The amount of produced, available or required data. Determined by potential value or insight (i.e., collecting data for the sake of it is not a good strategy). Typically measured on a petabyte scale (where one petabyte is equal to 1,000,000 gigabytes). Anticipate serious players exploring quantum computing as means to wrangle rapidly expanding data sets.
- **Variety** – The form in which data will (can or should) be processed. For example, structured, semi-structured or unstructured. Structured data is machine generated or formatted within spreadsheets. Unstructured data is less easily searched and may include audio or video/photographic feeds. Variety is often very useful for inductive reasoning and unearthing previously hidden insight.
- **Velocity** – Consideration should be given to the speed at which data is (can be or should be) created captured and streamed i.e., from big data to fast data or real-time streaming data. In this category, asset tagging (e.g., GPS, RFID or Bluetooth) within the construction field is a likely game changer.
- **Veracity** – The value of an analysis performed is only as good as the quality of the underlying data. Data cleansing and validation is often an area that requires a disproportionate amount of time to get right either due to error, missing data labels or missing values.
- **Variability** – A well-defined, robust data management process will go a long way to ensure the consistency of data during the project/program lifecycle.

KEY DATA SCIENCE ACTIVITIES

It’s generally held that the complex field of data science can be distilled into four key activities: [6]

1. **ACQUIRE**
   - Focus here is on obtaining the data required to address a defined problem or hypothesis.
   - Diversity is good and complexity is not to be shunned. Benefit is often found when going beyond structured databases, embracing unstructured and semi-structured data as viable sources.

2. **PREPARE**
   - Data Lakes (e.g., vast repositories of raw data) offer data scientists the best opportunity to prepare data for analysis and later analyze a disparate variety of data forms.
   - By eliminating time-consuming and expensive Extract, Transform, Load (ETL) processes, organizations benefit from removing silos and subsequent blind-spots.

3. **ANALYZE**
   - Both an art and science, analytics are applied iteratively to create value from data. Specialized and scalable computational resources enable real-time risk review by evaluating situational, operational and behavioral data. Maturity will determine the extent to which analytic goals are achieved. Learning analytics are typically employed. More sophisticated organizations may perform predictive analytics.
   - Techniques for learning analytics include:
     - **Regression** – estimating the strength of relationships between variables and which are important in predicting future events
     - **Clustering** – segments data into naturally similar groups
     - **Classification** – identifies data elements by group membership
     - **Recommendation** – based on historic behavior, predicts the rating for a new entity
   - Techniques for predictive analytics include:
     - **Simulation** – imitates the operation of a real-world process or system and is useful for predicting behavior under new conditions
     - **Optimization** – focuses on selecting the best element from available alternatives to maximize utility

4. **ACT**
   - The ability to make use of the analysis is critical. After investing significant resources to discover meaningful insight, a common pitfall for any data science program is for leadership teams not to follow-through and take appropriate action, so findings must clearly answer real business questions.
   - Every effort must be made for the decision-maker to meaningfully recognize and interpret patterns, trends and exceptions.
   - Logic supporting findings must be clear, compelling, traceable, free from bias and, in a word, credible.
Among these four key activities, eighty percent of the level of effort may be easily expended on activities two and three (i.e., prepare and analyze). More often, during preparation, resolving data quality issues can be the largest time burden, especially for relatively immature or novel data science initiatives. When manipulating data to meet needs, transforming analytics such as aggregation, enrichment and processing techniques can be employed.

**THE ROAD TOWARD AUGMENTED PROJECT DELIVERY**

In recent years there has been much hype concerning the significant strides that have taken place in the field of AI. While the authors recognize that autonomous systems will likely revolutionize the construction sector within the next decade, there is value in considering the broader context of AI.

Taking a brief look at the history of the AI concept will help us make a distinction between robotic systems such as RPA (i.e., robotic process automation) and traditional sci-fi images of robots walking alongside humans. While both are entirely feasible, such a distinction will help the reader consider which aspects of these technological advancements are likely to first drive the greatest change within the profession.

**A BRIEF HISTORY OF AI**

The concept of intelligent robots and artificial beings can be traced back through antiquity. More recently, in the 1950s, at the dawn of the computer age, the idea captured popular imagination and, in 1956, the term “Artificial Intelligence” was first coined.

The AI concept is one of building machines that are capable of thinking like humans. The concept is a crucial linchpin of digital transformation. Fundamentally, AI simulates deductive thought and an ability to learn. These aspirational goals were constrained over several decades owing to the high cost and limited processing power of computers.

In 1997, computing power had reached a point where brute force or, more simply, the number of possible calculations, was sufficient to challenge and beat a world champion chess player. Kasparov’s loss to IBM’s Deep Blue machine was a watershed moment since it was the first time that a computer, after several years of training, had performed better than a human under scientific conditions (although Kasparov contends that conditions were not truly controlled).

From 2010, Machine Learning (ML) began to represent the current state-of-the-art in the wider field of AI. Arthur Samuel first defined ML in 1959 as, “a field of study that gives computers the ability to learn without being explicitly programmed” [21]. ML systems work by observing, classifying and learning from mistakes. Used in conjunction with ML, the term Machine Intelligence (or MI) has gained in popularity.

To provide some perspective concerning the current pace of change, it might be worth noting that on December 6, 2017, Google’s DeepMind AI algorithm developed “superhuman” capability by absorbing the entire history of chess in less than four hours [18]. Employing this insight via an application called AlphaZero, it was able to beat anyone or anything. Currently, the DeepMind team are using their algorithm to solve big health problems, but how long will it be before such algorithms could be routinely employed by project teams or decision review boards?

And today, Natural Language Processing (NLP) solutions such as Apple’s Siri or Amazon’s Alexa are tangible examples of AI solutions that many are familiar with, providing clear benefit to society. How long will it be before virtual agents become common place in an engineering and construction environment?

**THE SELF-DRIVING ENTERPRISE**

Self-driving cars provide an interesting metaphor for analyzing the capability of AI today. Tech companies and, most prevalently, digital marketers are incorporating MI strategies (consider for example Netflix and Amazon “recommendations”). How long before all enterprises may seek to employ automation as their primary competitive advantage? [8, 24].

If computing and processing power are no longer constraints to MI adoption in the E&C sector, it is plausible that the only barriers concern the availability of data.

While the importance of data curation and the potential for tagging assets has already been addressed, there is value in highlighting that another way to generate new data streams would be via the deployment of mature MI technology such as Robotic Process Automation (RPA) [7]. RPA is inexpensive and easy to implement. It is also suited to high-volume, rules-based/deterministic, rote work that typifies accounting or traditional project controls activity such as estimating, scheduling, and reporting.

RPA, asset tracking and supervised learning systems are likely to have a radical impact within the construction sector within the coming decade. However, it is unlikely that AI will become contextually aware for a long time yet. On the AI timeline, cognitive computing is today confined to a period where it remains a theory. With that in mind, autonomous systems within a project environment will require a co-pilot, or domain expertise, to validate findings and make the final decision to proceed. In the near-term, we should anticipate elements of augmented project delivery to become more and more widespread.

**TCMA AND OPPORTUNITIES FOR EMPLOYING MI THROUGHOUT THE INVESTMENT FUNNEL**

Within the development lifecycle, there are two clear opportunities for seizing upon the potential for machine intelligence to conduct Total Cost Management Analytics (TCMA).
Counterintuitively, the first instance may arise later in the capital project delivery lifecycle (i.e., Augmented Project Delivery) and then later, as an organization acquires, curates, and better manages the requisite data flows, opportunities may arise for Augmented Feasibility Analysis. See Figure 5 for an example. Also, worth stressing is the importance of an effective and rigorous project close-out process (i.e., consistently formatted and quantitative), at each stage gate and not only at project completion. See for example, the Knowledge Management feedback loop in Figures 6 and 7.

AUGMENTED PROJECT DELIVERY

Figure 6 provides a simple illustration of the value model underpinning the rationale for Augmented Project Delivery. Ultimately, the goal is to minimize uncertainty and deliver increasingly predictable project outcomes [2], ensuring the efficient allocation of capital, and consequently, a risk-based competitive advantage for the owner and partners.

In order to develop an augmented estimate at completion or final forecast, the primary or dependent variables, highlighted in blue, bring together key themes described earlier in this paper (i.e., data curation, data management/data quality and advanced data analytics). To reiterate, a multiplicative benefit can be anticipated if conventional project control inputs are combined with exploratory measurements by, for example, tagging assets in the field to more effectively track and control productivity.

It is also worth emphasizing that a couple of these underlying, driving forces are not yet universally defined. Bearing in mind the current rate of urbanization within developing countries, in addition to the pressing need for infrastructure renewal within developed countries and the billions of tax dollars at stake, the authors would advocate the need for further research and collaboration in two areas: Project delivery data quality and standardized project performance metrics. Is ISO 8000 Part 8 adequate for ensuring project data quality or is there a need for an AACE RP to account for emerging specialized needs? Is it possible to devise universal project performance metrics or is it not possible to normalize for scope, scale and escalation?

AUGMENTED FEASIBILITY ANALYSIS

In order to use data science to support the project selection process, the primary or dependent variables (highlighted in blue) are as aforementioned in this article. Additionally, a multiplicative benefit can be anticipated if conventional project control inputs are combined with exploratory measurements by, for example, including data points that address: typical contract terms, proposed team experience, proposed contractor’s safety incident rate, weather records, competitive intelligence and recent opposition activity within a target market.

Similar to augmented project delivery, the authors would advocate further research and collaboration in two areas: data quality and, in this case, standard delivery benchmarks. Again, is ISO 8000 Part 8 adequate for ensuring project data quality or is there a need for an AACE RP to account for emerging specialized needs? Does the International Construction Measurement Standard (ICMS) and/or ISO 15663 adequately provide a universal basis for decision-makers to evaluate project feasibility or do does an organization, such as AACE International, need to provide guidance here? A case could also be made for a consortium of independent groups such as AACE, CII, and RICS, to receive and maintain anonymized, high-level benchmarks.

Figure 7 provides a simple illustration of the value model underpinning the rationale for augmented feasibility analysis. Ultimately, the goal is for organizations to learn which risks they can successfully manage and, consequently, choose to proceed with projects which they have the most confidence in offering rewarded risk [1].
As before, organizations will benefit from the efficient allocation of capital and, ideally, a risk-based competitive advantage.

**MINIMALLY VIABLE METRICS**
As described before, the topic of standardized metrics and benchmarks is ripe for further research and industry-wide collaboration. The following examples are adapted from relevant publications [14, 15, 19] and shared as a starting point, to help stimulate further discussion concerning the need for common or standardized viable quantitative performance measures.

All performance metrics typically generated and refreshed each reporting period (e.g., weekly or monthly, whichever may be soonest).

All delivery benchmarks generated after project completion. In these examples, it can be appreciated that the accuracy and availability of accurate performance data by hour is essential.

**TCMA RECOMMENDED PRACTICE**
Today, as the use of Building Information Modeling (BIM) becomes more prevalent, it is feasible that such design solutions morph into tools that all contracted parties are required to use as a platform for collaboration throughout the project lifecycle. After that, project professionals may anticipate the increasing use of “digital twins” (or virtual facsimiles of work being undertaken), as a means to radically improve the ability to mock-up and analyze what-if scenarios. During such time, conventional numerical ratios may be replaced by commonly defined “objects” or assemblies of inherently related components. Until that time, there is an opportunity for project controls professionals to collaborate and agree upon common protocols for sharing analytical variables.

Modern technology offers an opportunity for project teams to swiftly corroborate estimates or forecasts with an “outside view” [11]. To help realize this possibility, the authors advocate the development of a recommended practice, guiding AACE International members on the skills and knowledge required to perform Total Cost Management Analytics (TCMA) and deliver effective, actionable insight that will reduce capital project uncertainty.

**CONCLUSION**
The construction sector is entering a rapid and exciting period of change. Ubiquitous computing, increased processing power, embedded sensors and rapidly expanding data streams will all likely conspire to radically change the role of the project controls professional within the next decade.

The possibilities can be exciting for some but they also risk being a threat for others who are unprepared for change. It is imperative that professionals embrace this period of fundamental disruption with their eyes wide open. The profession has a fantastic opportunity to create, not respond to, their collective future. As many traditional project functions are automated, project controls professionals...
they can support the transition require an effort, by all members of the roles all have a part to play in driving change intelligence. Teams, supported by AI, will is within everyone’s best interest that the industries in recent decades will soon the first step in this journey may simply help secure a sound premise for data-driven decision-making. And before that is possible, the first step in this journey may simply require an effort, by all members of the professional community, to better classify, categorize or curate data required to support decision-making at key stage gates.

In the near to mid-term, a risk-based competitive advantage will be secured by organizations able to harness machine intelligence. Teams, supported by AI, will be best placed to unearth the most effective business strategies and execute work in an optimal way.

The productivity gains enjoyed in other industries in recent decades will soon materialize in the construction sector. It is within everyone’s best interest that the profession is ready to embrace this change sooner than later.

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The Sixth Brazil Section Annual Meeting was in Rio de Janeiro, on Dec. 6-7, 2018. The Brazil Section was founded in 2012. The annual meeting was an effort to promote the strengthening of the section in Brazil by offering a high-quality technical program. What better venue than Rio de Janeiro in the summer month of December. Cost management professionals meet annually to discuss issues related to cost engineering, best practices, and to present real cases and share experiences in the numerous projects already completed or ongoing in Brazil and worldwide. The topics discussed in the two-day technical event addressed technical and managerial issues related to the entire project lifecycle, such as: lessons learned from real projects, productivity and schedule analyses.

Brazil Section 2018 Annual Meeting: From the left, Rafael Monteiro (reelected as Educational Director), Henrique Furtado (former Administrative Director), Dennis Bocuzzi (Institutional Relations Director for 2019), Aldo Mattos (Counselor), Claudia Melo (Event Director for 2019), Luiz Gronau (reelected as Vice President), Henrique Takemoto (reelected as President), Joao Vitor Wiese (Treasurer for 2019), Adriana Sarra (Secretary for 2019), Luis Otavio Rosa (Event Director) and Pedro Paulo Magnabosco (Administrative Director for 2019).
The technical program at the 2018 Brazil Section annual Meeting was formed by four international presentations, ten national presentations and four panels to discuss actual and fundamentals matters for the cost engineering.

Above: The technical program at the 2018 Brazil Section annual Meeting was formed by four international presentations, ten national presentations and four panels to discuss actual and fundamentals matters for the cost engineering.

Above: On the second day of the 2018 Brazil Section annual Meeting, some awards were given. Shown above former Brazil Section President Filipe Alves (2016-2017) presents one of the awards.

Left: Brazil Section Annual Meeting: At the Dec. 6-7, 2018 Brazil Section Annual Meeting, there were over 160 professionals, representing practitioners of Total Cost Management from various industries and geographic locations in Latin America.

scheduling, budgeting, cost control, risk and contract management, claims and litigation approaches, innovation and technology up to macroeconomic discussions regarding Brazil’s current infrastructure situation and its challenges and trends.

The Annual Meeting was at the Rio Othon Palace Hotel in Rio de Janeiro, Brazil. It was well received by all attendees which included individuals from several areas of Brazil, as well as professionals from the United States and Colombia. There were over 160 professionals, representing practitioners of Total Cost Management from various industries and geographic locations in Latin America.

The technical program included four international presentations, ten national presentations and four panels to discuss actual and fundamentals matters for the cost engineering. Furthermore, several sponsoring vendors shared their services, automation and tools with the attendees during the presentation breaks, such as: Deloitte, Alvarez & Marsal, Duff & Phelps, Oracle, Palisade and Hexagon-Ecosys.

The program included in the first day presentations on: “The History of AACE International and Brazil Section” by the Brazil Section President, Henrique Takemoto; “Execution of Linear Projects: Techniques and Methodologies” by past AACE International President, Nelson Bonilla; “P3 Projects – What, Why & How is Risk Allocated?” by past AACE International President, Jim Zack; an interesting “Case Study – Comparison between AACE Classes of Estimate and IPA Gates” by Melissa Mathews; “Risk Analysis in Project Controls” by Simon Braithwaite; “Challenges and Lessons Learned in Program Management – A Real Case” by the Brazil Section President, Henrique Takemoto; “Vetor AG – A Success Case of Technology Acceleration in Construction” by Clarisse Gomes; “Project Control with Agile Approaches” by Flavio Costa; “BIM – Real Application” by the two speakers Rosangela Castanheira and Joao Gaspar; “Why Use Probabilistic Gantt Charts to Analyze Schedule Risks” by Rafael Harte; and, to end the first day, a closing panel chaired by Luiz Fernando Reis and panelists Daniel Caldeira and Bruno Lima was formed to discuss “The Problem of Paralyzed Works”, an extremely relevant topic within Brazil.

The second day was also very interesting, where the 2018 Brazil Section Officers were honored, the elected 2019 Brazil Section Officers were presented, and some awards were given to: former Brazil Section President Aldo Mattos (2012-2013 and 2015-2016), former Brazil Section President Filipe Alves (2016-2017) and to Alexinaldo Silva, professional who participated in five Brazil Section Annual Meetings.

The program included in the second day presentations on: “Integrating TCM and Advanced Work Packaging” by David Elio; “The Benefits and Challenges in the Pre-Award Phase” by Rafael Monteiro; “Structure of Guarantees in Infrastructure Projects” by Andre Dabus; “Transforming Engineering and Construction Project Management through Oracle Technology” by Bruno Mega; “Schedule Validation” by former Brazil Section President, Aldo Mattos; and “How to Validate the Cost and Return of Innovations in Capital Projects” by the professor Alessandro Amarante. The event had also three panels, the first chaired by the former Brazil Section President Filipe Alves and the panelists Leonardo Toledo, Christiane Polazzi and Fernando Landau to discuss about “Contract Modalities - Common Misconceptions in Contracting and Administration”; the second chaired by Fernando Marcondes.
HAWAII SECTION

On Friday, Feb. 8, fourteen Hawaii Section members and guests participated in a visit to the Kalaeloa site of GPRM Prestress. Les Kempers, PE, gave attendees an informative presentation on the use of Prestressed Concrete in Hawaii. It was very interesting to see how much of an impact prestressed concrete has had on the architectural landscape around Hawaii.

The Hawaii Section was one of several sections that the Southern California Section shared a webinar with on Dec. 14, 2018. In addition to the Hawaii Section, the other sections sharing in this event were Region 6 Sections, including: Alaska, San Francisco, Idaho Snake River, Cascade (OR), Seattle, South Central California, Las Vegas, Rattlesnake Mountain (WA), Spokane. The presentation was titled, “Turning Around Problem Projects,” by Joseph A. Lukas, PE CCP, Vice President, PMCentersUSA. The goal of the webinar was to help prepare viewers to more effectively deal with a problem project.

Lukas talked about how we will all eventually be faced with events that result in a troubled or ‘problem’ project – one that is in jeopardy of not meeting the project objectives. He talked about the types of problems that could occur and provided suggestions on how to identify the early symptoms of problem projects. Different types of problem solving strategies were noted, including advantages and disadvantages of each. A five-step systematic problem resolution technique was presented in detail, with a creative approach to problem solving. Rider Levett Bucknall organized group viewing for section members and friends at their new office location. Ten people from scheduling, project management and cost estimating backgrounds were in attendance.

Fourteen Hawaii Section members and guests participated in a visit to the Kalaeloa site of GPRM Prestress. Les Kempers, PE, gave attendees an informative presentation on the use of prestressed concrete in Hawaii. Shown above from left to right are: Les Kempers, Adam Kempers, Maelyn Uyehara, Nelson Lian, Kainoa Tom, Chris Baze, Juhee Thorn, Brooks Ford, Brandon Leong, Rachel Mamiya, Cole Yamakawa, Kama Gaspar, Kristy Kastner, Will Wong, Christopher Kanae, Sidney Huo, Vinson Hiraoeka, and Joseph Uno.
MONTREAL SECTION

On Jan 30, the Montreal Section welcomed the top three participants in a graduate thesis presentation competition previously held at Concordia University to present highlights of their works followed by a panel discussion. The showcase was entitled, “Thought Leadership and Research for the Engineering and Construction Industry: An Industry and Academia Dialogue.”

- Sobhan Kouhestani, Master of Science student, presented on BIM for data mining and improved project management. Advanced data mining on the foundation of BIM (as an ERM system) is used for discovery, monitoring and optimizing work processes, by identifying and resolving bottlenecks, re-work, changes, and miscommunication among project team members.
- Alireza Mohammadi, PhD candidate, discussed automated materials management that generates delivery schedules and visualize daily progress. This research develops a comprehensive decision-making framework for urban railway systems (such as metro and regional trains), to analyze investment scenarios and select the ones that support strategic decisions to maintain the highest level of safety, comfort, reliability, and sustainability.
- Farzaneh Golkhoo, PhD candidate, introduced comprehensive decision-making framework for effective investment decisions. This research proposes an automated materials management system which not only generates an optimized material delivery schedule in the planning phase; but also extends to the construction phase.

The industry panel consisted of Karim N. Sellami - Planning Functional Team Lead at Hydro-Québec, Robert Broca - Senior Project Manager, Consultant and Robert Nadeau - Vice-Président, Directeur Général at Collectif Santé Montréal who were impressed with the quality of the presentations and the participants’ overall enthusiasm and knowledge on the topics at hand. The participants were able to receive constructive feedback from panelists and audience alike on improving industry best practices through academia.

Top: Farzaneh Golkhoo is shown giving a presentation on the automated construction material management system to attendees of the Montreal Section at the January Section meeting. Above: Shown above Montreal Section President Hagire Emrani addressed attendees while panelists are seated at right, including Karim N. Sellami – Hydro Quebec, Robert Broca – Consultant and Robert Nadeau - Collectif Santé Montréal. Below: Attendees at the January Montreal Section meeting listen to the technical presentation by Farzaneh Golkhoo who spoke about the automated construction material management system.
PAKISTAN SECTION
The Pakistan Section recently hosted an event in the country’s largest city and its commercial and financial hub – Karachi. The event was attended by several professionals from the industry. The event was primarily geared toward the introduction of AACE International to the attendees, and to engage them with the section. The Section President Mujtaba Shaikh gave a detailed presentation on the organization. The presentation covered the objectives, programs, and certifications of AACE and the benefits the association brings to its members. The efforts of AACE in promoting the fields of cost engineering, scheduling, and project controls around the globe were also discussed and appreciated. Attendees also discussed the current practices in cost engineering and beyond, industry market and job trends, and opportunities in growing fields. Section member Farrukh Siddiqui then gave a presentation on how to grow the local section and increase its events at the association level. All attendees showed great enthusiasm and committed support and involvement to the Section.

QATAR SECTION
In partnership with the Quantum Global Solutions, the Qatar Section recently launched its first live-stream training event. The training session was hosted by Rob Valenta, Quantum Creative Director, who discussed ‘Forensic Graphics – Visually Interpreting the Issues’ to an audience of around 90 people from around the world. “Our first Qatar Section live stream training event in Qatar was a great success. We understand that not everyone can attend our events in person and digital application training is increasing. Given the positive feedback from our first event we look forward to continuing to host more live-stream events in the future,” said Lucia Vernon, President of the Qatar Section. Speaking after the event Rob said, “Quantum has a long-standing relationship with the Qatar Section and we were delighted to launch our first live-stream training session with their local, and global members. Personally, I was very happy to find that we received an equal number of questions from our remote audience as we did from the audience present. I look forward to the next event.”
SUBMITTING SECTION NEWS

We invite all sections to submit news and updates to be included in the International Bulletin section of each Source issue. Please submit any and all text as a part of the e-mail or as a Microsoft Word file attachment. Please submit any photos as individual attachments in JPG formats. Do not embed photos in Microsoft Word files. For photos to be used, we require either large original files or print size photos at 300 dpi (dots per inch). For photos to be published, they must be in focus, of print quality, and of sufficient resolution. Please include the names and titles of each person shown in any photos. Please list names from left to right or refer to those shown as being above left or right. For group photos please list names from left to right, beginning with the front row and working to the back. All submissions should be e-mailed to editor@aacei.org. Please use the official name of the Section as approved by the AACE Board when the Section’s charter was approved. Within 2 to 3 business days of submitting a “Section News” item, you should receive a return confirmation e-mail that your submission was received at AACE headquarters.

MISSING SUBMISSIONS

Generally, all submissions received in the above scheduled times will be published in the listed issue. Items are not held because of space restrictions. There is no waiting list and no preference is given to one Section over another. Questions about incomplete submissions or failure to follow these submission guidelines could delay publication. Text will be published without submitted photos if the photo does not meet the listed quality requirements. AACE reserves the right to edit all submissions and/or to refuse to publish any submissions determined by the Managing Editor or the Art Director to not meet the standards of the journal. Any appeals of these decisions will have a final decision determined by the Executive Director.

If a submission is not included in the designated issue, please e-mail or call the Managing Editor to ensure that it has not been lost or misplaced. Call or e-mail if you do not receive a confirmation e-mail within 3 business days of submission.

Source has a submission deadline of two months in advance of the issue date.

Submission Dates                  Publication Date
By Dec. 31                      February
By Feb. 28                       April
By April 30                      June
By June 30                       August
By Aug. 31                       October
By Oct. 31                      December

DOES YOUR SECTION HAVE NEWS TO SHARE? See below for complete instructions for how to submit news and photos from your Section’s happenings to be included in the AACE® International Bulletin.

SOUTHERN CALIFORNIA SECTION

The Southern California Section had its January 2019 dinner meeting at Los Angeles Metro headquarters in downtown Los Angeles. The event was on Jan. 30, with record attendance! Rick Clarke, Chief Program Management Officer spoke about, “Managing LA Metro’s Mammoth Capital Program Mega Projects On-Time Within Budget.” Rick discussed the massive $160B transportation program and managing $17B currently in construction. Attendees learned about the mega transit, highway and regional rail projects underway. He discussed the challenges delivering the massive capital program and risks associated with the growing program and potential labor shortages. He highlighted efforts to achieve continuous improvement with new delivery strategies, technology innovation and application of best practices. He discussed new best practices being implemented regarding budget development, consultant staffing contracts, project readiness procedures, enhanced risk management and lessons learned sharing. The Section thanks all those that came out to hear Rick’s great presentation. It was truly a fantastic event.

The section has also continued to offer a free webinar during each month. The January webinar brought in approximately 40 attendees with people tuning in from California, Columbia, Hawaii and Seattle. January’s topic was, “Liars and Schedules”, by Nelson Bonilla, CCP FAACE. This webinar covered roles and responsibilities of the project team to ensure the success of the planning/scheduling effort and ensuring that stakeholders are actively engaged in the schedule development and review. If you would like information regarding the next webinar visit the SoCal sections website http://www.aace-scs.com.
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New, Fun, and Interactive Team Building Activity at the 2019 Conference & Expo

BY JENNIE AMOS

We are always looking for ways to make the Conference & Expo more fun while increasing networking opportunities. The Chain Reaction optional team building and networking event is just the answer!

Chain Reaction will be held on Sunday morning, June 16. This unique event is scheduled so that you can have a networking continental breakfast, collaborate and compete in the morning, grab a to-go lunch, and still get to the first technical session on time. (Both meals are included in the price.)

If your company sends 5 or more people, we are happy to offer a group discount of $50 off the registration price.

Registrants earn continuing education units (CEUs) to help toward required recertification credits for certifications that they may already hold.

As always, members receive the best rate. If you register for a seminar and the Conference & Expo, joining AACE will not only save you money on the registration, but you’ll get all of the benefits of membership.

Go to AACE’s website for the most up-to-date information on all of the continuing education seminars. Go here to find out more about the 2019 Conference & Expo including information on the host hotel, the Sheraton New Orleans. I look forward to seeing you this June in New Orleans!

CLICK HERE to check out a video from TeamBonding showing a taste of the Chain Reaction activity.

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Upcoming Events

APRIL

2 CONSTRUCTION NETWORK VIP BREAKFAST
LA Metro Regional Rail
City Club, 555 S. Flower, 51st Floor, Los Angeles, CA

4 CMAA BREAKFAST OF CHAMPIONS
LA River Restoration
The LA Hotel Downtown
333 S. Figueroa St., Los Angeles, CA

4 CONSTRUCTION NETWORK VIP BREAKFAST
U.S. General Service Administration
City Club, 555 S. Flower, 51st Floor, Los Angeles, CA

9 CMAA DINNER
The Future of Transportation
The LA Hotel Downtown
333 S. Figueroa St., Los Angeles, CA

16 CONSTRUCTION NETWORK VIP BREAKFAST
LA Convention Center Capital Program/Area Expansion Update
City Club, 555 S. Flower, 51st Floor, Los Angeles, CA

18 CMAA BREAKFAST OF CHAMPIONS
University Trends and Realities in 2019
The LA Hotel Downtown
333 S. Figueroa St., Los Angeles, CA

18 16TH ANNUAL SEAIO MIDWEST BRIDGE SYMPOSIUM
Maggiano’s Little Italy, 111 W. Grand Ave., Chicago, IL

24 CMAA SEMINAR
Best Practices and Scheduling Approaches for Mitigating Delays
Long Beach Marriott
4700 Airport Plaza Dr., Long Beach, CA

24-25 9TH ANNUAL SHOPPING MALLS SUMMIT
Malls Converging With Online Retail
Harbour Grand Kowloon, Hong Kong

29 UAS/DRONE SEMINAR
Impact on Construction Community
Long Beach Marriott
4700 Airport Plaza Dr., Long Beach, CA

MAY

2 SEAIO COURSE
Communications for the Built World
150 North Riverside, Chicago, IL

7 CMAA CODE COMMITTEE
Empowerment of minority, small and women owned businesses
Long Beach Marriott
4700 Airport Plaza Dr., Long Beach, CA

15 CMAA SOCIAL’S 27TH ANNUAL AWARDS GALA
Building Our Future
Hyatt Regency Long Beach
200 S. Pine Ave., Long Beach, CA 90802

20-25 THE 10TH INTERNATIONAL STRUCTURAL ENGINEERING AND CONSTRUCTION CONFERENCE (ISEC-10)
University of Illinois at Chicago

21-23 SPAR 3D EXPO & CONFERENCE/AEC NEXT TECHNOLOGY EXPO + CONFERENCE
Anaheim Convention Center, Anaheim, CA
Co-located with the AEC NEXT Technology Expo + Conference

21 CMAA MINDFUL LEADERSHIP AND ITS IMPACT ON THE BOTTOM LINE
Long Beach Marriott
4700 Airport Plaza Dr., Long Beach, CA

23 CMAA BREAKFAST OF CHAMPIONS
Healthcare Construction Industry Update
The LA Hotel Downtown
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Click event titles for more details.
SKILLS AND KNOWLEDGE OF COST ENGINEERING, 6TH EDITION
Dr. Makarand Hastak, PE CCP, Editor, 2015
This publication provides information on a wide range of cost engineering subjects and will prove to be a valuable resource to any individual seeking professional growth or pursuing an AACE International certification. This publication offers six sections comprising 34 chapters of content on topics such as cost estimating, project planning, value engineering, and strategic management, to name a few.

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Dr. Makarand Hastak, PE CCP, Editor, 2016
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Peter W. Griesmyer, Editor, 2008
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H. Lance Stephenson, CCP FAACE, Editor, 2015
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FIRST PRESENTED AT THE 2018 CONFERENCE AND EXPO AS CSC.2826
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FIRST PRESENTED AT THE 2018 CONFERENCE AND EXPO AS EST.2881
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Engineering Ingenuity: Garden Design in Desert Climates
FIRST PRESENTED AT THE 2018 CONFERENCE AND EXPO AS OTH.2736
BY DR. CAREN YGLESIAS

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