



Montaser, A.	2020	[2018-2021]	BIM-3543	Value- BIM-Enabled/Value Decision Making Engineering	The use of value engineering (VE) in construction industry has grown significantly in view of its extensive benefits. This paper presents a software that integrates building information modeling (BIM) and VE in construction projects to support project stakeholders. The software is developed to automate the process of data extraction and manipulation from BIM and processing the extracted data to evaluate competing alternatives. A vital stage in applying VE is the evaluation of alternatives through different assessment criteria by project team members, which places subjectivity in perspective. To reduce subjectivity in the developed software, analytical hierarchy process (AHP) algorithm is used to support VE multi criteria decision making. The developed integration software was implemented in prototype software that is named values. It is a three-tier software, which utilizes an object-oriented BIM model. It has been applied to an actual case study to demonstrate and verify its use and capabilities. The project is phase 2 of a new liquid natural gas (LNG) support camp with 1,000 m2 land area. Nine evaluation criteria were selected to choose the optimum solution from three alternatives for a slab structure system.	This paper presents a software that integrates building information modeling (BIM) and VE in construction projects to support project stakeholders.	It has been applied to an actual case study to demonstrate and verify its use and capabilities. The project is phase 2 of a new liquid natural gas (LNG) support camp with 1,000 m2 land area. Nine evaluation criteria were selected to choose the optimum solution from three alternatives for a slab structure system.	Analysis	BIM
Montaser, A.	2021	[2018-2021]	BIM-3678	BIM+ Integrated Site Data Acquisition Model for Construction Projects	Tracking and control of construction projects depend mainly on the time required, accuracy, and frequency to capture and process onsite data of construction operations. Manual data acquisition methods may not be reliable or sufficient, as they are contingent upon motivation, judgment, and skills of the personnel in capturing and processing this data. To address those challenges, this paper presents automated data acquisition framework and its implementation in a software for integrated data acquisition in construction. The automated framework integrates building information modeling (BIM) and a set of automated site data acquisition technologies. It captures onsite data using several technologies. An onsite person equipped with a tablet PC that has the BIM of the project to provide visualization capabilities. As well, for data capturing, the tablet PC has a Bluetooth, Wi-Fi, GPS, RFID reader, barcode reader and a camera. The developed framework and its supporting algorithms are implemented in a prototype software named "BIM+". It is a two-tier software that uses an object-oriented BIM model. The paper reinforces this through applying the framework and its developed software to real project case study.	This paper presents automated data acquisition framework and its implementation in a software for integrated data acquisition in construction	The paper reinforces this through applying the framework and its developed software to real project case study.	Analysis	BIM
Montaser, A.	2021	[2018-2021]	BIM-3682	Control+ Integrated Data Analysis and Reporting for Construction Projects	Earned value analysis (EVA) is commonly used for reporting work progress and forecasting project status at completion. Critical to its reliable application is accurate and timely data for quantifying the earned progress. Traditional analysis and reporting methods place considerable load on project controls team due to the large amount of data that needs processing and the interdependency between the data. To address those challenges, this paper presents automated data analysis and reporting framework and its implementation software. The developed framework makes full use of building information modeling (BIM) to provide visualization capabilities and related activities information. It embraces human factors to augment the visualization information aspects and automated site data acquisition. The framework has a group of algorithms to allow data fusion of between BIM and a range of automated site data acquisition technologies. The developed framework and its algorithms are implemented in a prototype web-based software named "Control+" for processing, analyzing, and reporting the project status. These reports are generated in different granularity (i.e., project, activity, object, and resource levels) and time windows (i.e., daily, weekly, and monthly). The developed framework is applied to real project to illustrate its features.	This paper presents automated data analysis and reporting framework and its implementation software.	The developed framework and its algorithms are implemented in a prototype web-based software named "Control+" for processing, analyzing, and reporting the project status.	Analysis	BIM
Moore, C.	2018	[2018-2021]	PS-2924	Evaluating Current Construction Scheduling Tools	Contractors and owners invest a great deal of resources when choosing a scheduling software, making it important to choose the software that meets all their necessary criteria. With a focus on project controls needs, this paper shares the pros and cons of construction Critical Path Method (CPM) scheduling software for users, including owners and contractors alike. Some of the important factors considered here are licensing cost, mobile platform, the ability to interface with Building Information Modeling (BIM), the update process, handling of baselines, and the ability to import and export to other software. Software evaluated and compared was Oracle Primavera Professional Project Manager P6, Asta Power Project, Phoenix Project Manager, and Microsoft Project. All of these programs are capable of efficiently scheduling a construction project, but each have distinct capabilities that set them apart from the rest.	This paper shares the pros and cons of construction Critical Path Method (CPM) scheduling software for users, including owners and contractors alike.	All of these programs are capable of efficiently scheduling a construction project, but each have distinct capabilities that set them apart from the rest.	Management	BIM
Muniz-Correa, S. L.	2020	[2018-2021]	BIM-3355	Adaptation of ACEC Cost Classification System to Define BIM Uses in Infrastructure Bidding	Building information modeling adoption, as well as the use of new technologies are gaining relevance in Brazilian construction industry, mainly at construction jobsites, where its benefits have already been proven. Given the increasing trend for developing innovation practices through infrastructure projects lifecycle, this article aims to discuss and exemplify the adaptation of ACEC cost estimate classification system in order to guide building information modeling use during the bidding stages of a Brazilian general contractor. By adopting the methodologies, it was possible to structure and standardize bidding processes, providing better value engineering, and giving the client high-quality analysis given the use of technology.	This article aims to discuss and exemplify the adaptation of ACEC cost estimate classification system in order to guide building information modeling use during the bidding stages of a Brazilian general contractor.	By adopting the methodologies, it was possible to structure and standardize bidding processes, providing better value engineering, and giving the client high-quality analysis given the use of technology.	Analysis	BIM
Newman, J. B.	2019	[2018-2021]	TCMA-3130	Implementing UniModel in an Owner Environment	Leveraging the existing capabilities of BIM, and 2D representation, with the addition of metadata (3D + 2D + 1D) one will get a UniModel. What is a UniModel? It is a relatively new word that describes an adherence to a process that accounts for the majority (80-90%) of project construction costs. Considering that the concept of total cost management (TCM) involves determining the quantity of work, including costing and pricing, using a combination of a sophisticated library (or database) of cost items with detailed resources (labor, material, equipment, etc.). Factored and intelligent assemblies, standardized cost and WBS (work breakdown structure) coding structures, will allow cost professionals to more efficiently provide valuable cost data. Project control at the Central Puget Sound Regional Transit Authority (RTA), also Sound Transit (ST), which services Pierce, King and Snohomish Counties in Washington State, have successfully employed part of this process with their unit cost library (UCL) used for the ST3 program presented and approved by voters for \$53.8B, in year of expenditure dollars (NOE). There remain challenges that have yet to be overcome. However, a proof of concept (POC) has been established and the future of managing project cost looks bright.	Leveraging the existing capabilities of BIM, and 2D representation, with the addition of metadata (3D + 2D + 1D) one will get a UniModel.	**	Management	BIM
Pang, X.	2018	[2018-2021]	BIM-2854	Novel Single-side Suspension Footbridge, BIM, P3 and Cost Control Case Study	Wishing Star Lake Park is located beside the Shanghai Disney Resort and contains two distinctive footbridges constructed across the river. Both structures are concrete, oval and cable suspension with unique curved space beams, double decks and single-side suspension. Two bridges contain both creative aesthetic design features and also a cleverly-created load path. The unique bridge features required different techniques in component fabrication, structural analysis and construction technologies, compared with the conventional suspension bridges. There were unusual risks in progress, performance and safety during the construction, which had an effect on the project cost control. The unique design also created new challenges for cost control, which is in contrast to the typical suspension bridge design. This paper reports the novel features that encompasses the architecture and structural design, cable system and construction methods. The paper outlines the successful application of Building Information Modeling (BIM) technology. It also discusses the cost control process by use of subcontracting the novel project segments, project work flow arrangement, construction processing selecting and component selecting and component selecting, and fabrication. As a case study, this paper highlights the Integrated Project Delivery (IPD), including the team organization, underwriting methods. Based on the IPD input, the reasonable technologies, methods and products of construction are selected, which is the key to the cost control in this new project.	This paper reports the novel features that encompasses the architecture and structural design, cable system and construction methods. The paper outlines the successful application of Building Information Modeling (BIM) technology. It also discusses the cost control process by use of subcontracting the novel project segments, project work flow arrangement, construction processing selecting and component selecting, and fabrication.	this paper highlights the Integrated Project Delivery (IPD), including the team organization, underwriting methods.	Design	BIM
Shah, J. S.	2017	[2015-2017]	BIM-2558	Building Information Modeling for Infrastructure Projects- Emphasis on 4D, 5D and 6D	Building Information Modeling has been widely used in the building construction industry for nearly a decade now, but in the civil infrastructure industry, it has not been widespread due to many reasons the massive scale, complexity, geometry involved and the types of software available currently. This paper will discuss how the BIM technology is being used in civil infrastructure sector specifically taking a detailed look at the 4D Scheduling/Sequencing, 5D Cost Estimating and 6D Visualization. Introduction to different types of software available in market, the process to perform these functions, benefits of using BIM and limitations, difficulties and lessons learned. It is absolutely certain that the currently unfashioned BIM techniques for civil infrastructure will develop and overcome all the limitations. All the stakeholders of the infrastructure projects will have to realize that BIM adoption for their projects is more about cultural change than technological enablers to maximize profits.	This paper will discuss how the BIM technology is being used in civil infrastructure sector specifically taking a detailed look at the 4D Scheduling/Sequencing, 5D Cost Estimating and 6D Visualization.	introduction to different types of software available in market, the process to perform these functions, benefits of using BIM and limitations, difficulties and lessons learned.	Design	BIM
McCaun, T. L.	2016	[2015-2017]	BIM-2340	Use of BIM for Asset Management in North American Airports	Airports are facing shrinking budgets, limited resources and aging assets/infrastructure issues. Asset Management strategies are increasingly being implemented by airports to address these issues by enhancing the cost effectiveness and efficiency of managing assets over their lifecycles. Although building information modeling (BIM) is being used by some airport operators to facilitate the Asset Management process, there is very little available literature regarding the related challenges, opportunities and benefits. Therefore, a goal of this study was to gain an understanding about BIM use for Asset Management in North American airports. The effort included an online survey designed to gather information about current BIM implementation, users' experience level, BIM use across the lifecycle, and future plans for implementation. In addition to the survey, case study participants were interviewed. This paper reports study results that illuminate the use of BIM for airport asset management. Results from the study revealed that airport owners are realizing benefits by having a model representing existing conditions and assets, along with the information available for developing a single inventory repository for managing assets.	A goal of this study was to gain an understanding about BIM use for Asset Management in North American airports.	This paper reports study results that illuminate the use of BIM for airport asset management.	Management	BIM
Valderrama, F.	2021	[2018-2021]	BIM-3692	BIM and Cost Estimation: What Will Change and What Will Remain the Same	The explosion of BIM has given rise to new real possibilities for improving the economic management of construction. Changes appear in traditional processes and roles, but new agents also enter that place BIM as an objective in itself, instead of just another component of project management. The paper develops the impact of BIM on cost estimation, showing real examples the changes that are taking place. It also suggests how to take advantage of the new environment to improve processes and describes the knowledge and skills that will continue to be needed in construction management, no matter what happens with technology.	The paper develops the impact of BIM on cost estimation, showing real examples the changes that are taking place. It also suggests how to take advantage of the new environment to improve processes and describes the knowledge and skills that will continue to be needed in construction management, no matter what happens with technology.	**	Management	BIM

	2021	[2018-2021]	DEV-3687	Expected Competencies of Graduate Quantity Surveyors Working in New Zealand	In New Zealand, all seven polytechnics are undergoing a merging process into one institute – Te Pūnanga (New Zealand Institute of Skills and Technology) and currently, different polytechnics have their own curricula of quantity surveying/engineering. Thus there is an urgent need to standardize. The building construction industry evolved significantly in New Zealand in the past few years, especially to address new technologies, e.g., building information modeling (BIM), digital technology, and there are more international construction contractors participating in the domestic New Zealand market. To ensure that quantity surveying education is keeping pace with the market demand, the purpose of this study is to identify the gap between the competencies of graduate quantity surveyors and the expected competencies that the New Zealand construction industry is looking for. Eventually, the study provides information about the industry's current trend leading to review of quantity surveying education and updating of the corresponding curriculum.	The purpose of this study is to identify the gap between the competencies of graduate quantity surveyors and the expected competencies that the New Zealand construction industry is looking for.	the study provides information about the industry's current trend leading to review of quantity surveying education and updating of the corresponding curriculum.	Analysis	BIM
McCaen, T. L.	2009	[2018-2021]	BIM.01	The Quantification Process and Standards for BIM	Building Information Modeling (BIM) is an emerging phenomenon in which business processes combine with innovative information technology to optimize efficiency and minimize waste in the design, building, and operations of a facility. The elimination of non-value added redundant tasks, along with the addition of reliable information in the communication between stakeholders, facilitates these improvements. The identification of the information that a BIM must contain and the process of exchange between functional roles to facilitate the quantity take-off task is needed. The AACE International – BIM Committee, in association with the National BIM Standard Committee, has answered this need with a project titled, "Quantification (Take-off) Process and Standards for BIM." This article presents the AACE International task force objectives, the project design, methods for development, and recommended information exchange process. This article discusses the outcomes from the task force and the contribution of this project to the cost engineer's role in BIM.	This article presents the AACE International task force objectives, the project design, methods for development, and recommended information exchange process. This article discusses the outcomes from the task force and the contribution of this project to the cost engineer's role in BIM.	Design	BIM	
Oswell, J.	2015	[2015-2017]	EST-2008	A Case for Unified Work Breakdown Structure (WBS)	This paper addresses the need for the development of a work breakdown structure (WBS) forewording its use. It discusses the background and basic, suitable formats, optimal use for the industry, and how to connect the start with the ultimate goal of integrating data in the engineering and project management practice. The discussion will cover available resources, application linking, and current utilization of these market tools, BIM environment, and the coding structure impact. Also addressed is the varying perspective of owners, contractors, and specialty consultants (cost, schedule, BIM specialists) in linking data and the single point of entry. It is the aim of the authors to show the industry groups toward unifying the efforts of all segments of the design into construction as a project life cycle, including maintenance. The goal is for a more common WBS platform to improve the understanding and meet the need for interlinking data, in a common coding structure for enhanced integration and better accuracy, increased industry efficiency, and an overall positive return to all participants.	This paper addresses the need for the development of a work breakdown structure (WBS) forewording its use. It discusses the background and basic, suitable formats, optimal use for the industry, and how to connect the start with the ultimate goal of integrating data in the engineering and project management practice. The discussion will cover available resources, application linking, and current utilization of these market tools, BIM environment, and the coding structure impact. Also addressed is the varying perspective of owners, contractors, and specialty consultants (cost, schedule, BIM specialists) in linking data and the single point of entry. It is the aim of the authors to show the industry groups toward unifying the efforts of all segments of the design into construction as a project life cycle, including maintenance. The goal is for a more common WBS platform to improve the understanding and meet the need for interlinking data, in a common coding structure for enhanced integration and better accuracy, increased industry efficiency, and an overall positive return to all participants.	The goal is for a more common WBS platform to improve the understanding and meet the need for interlinking data, in a common coding structure for enhanced integration and better accuracy, increased industry efficiency, and an overall positive return to all participants.	Management	BIM
Hannon, J. J.	2007	[2010-2014]	IT.03	Estimator's Functional Role Change with BIM	The emergence and growing use of Building Information Models (BIM) as a project delivery mechanism mandated by owners will change the traditional functional role of the estimator. Case studies of successful project delivery have proven the BIM methodology a truly cost beneficial and disruptive innovation which is here to stay. As a result, persons employed in the estimating functional role will require additional skills and knowledge in order to practice the discipline in this context. At the very least, there will be shifts in emphasis upon required skills and knowledge of those performing the estimating function as expressed in AACE International's recommended practice 131-88 Required Skills and Knowledge of Cost Engineering. This paper explores the forthcoming estimating functional role changes which interestingly should promote the AACE's Total Cost Management Framework and the job title of Cost Engineer.	This paper explores the forthcoming estimating functional role changes which interestingly should promote the AACE's Total Cost Management Framework and the job title of Cost Engineer.	Management	BIM	
Kraus, W. E.	2007	[2010-2014]	IT.01	Challenges in Estimating Costs Using Building Information Modeling	There has been a lot of press lately concerning building information modeling or "BIM." The purpose of this paper is to cut through the hype, define the term "BIM," discuss how organizations are benefiting from BIM today complete with an example or two, and to discuss the challenges in estimating costs using BIM.	The purpose of this paper is to cut through the hype, define the term "BIM," discuss how organizations are benefiting from BIM today complete with an example or two, and to discuss the challenges in estimating costs using BIM.	Management	BIM	
Coyne, K.	2008	[2010-2014]	BIM.03	Leveraging the Power of 4D Models for Analyzing and Presenting CPM Schedule Delay Analysis	This paper explores the use of 4D models, which provide a virtual construction simulation by linking a 3D model and project schedule, in support of CPM schedule delay analysis. Traditional delay analysis methodologies rely on bar charts or Gantt graphics for analyzing and conveying the results of complex schedule analyses. This paper supports the fact that the use of a 3D model and project schedule, in support of CPM schedule delay analysis, is a more effective and efficient method for analyzing during negotiations, alternative dispute resolution, or litigation. The author shares findings from case studies that used 4D models to visually analyze and present as-planned versus as-built CPM schedule delay analyses and time impact analyses. The paper also discusses the benefits and shortcomings of the use of 4D models, as well as additional topics for research.	This paper explores the use of 4D models, which provide a virtual construction simulation by linking a 3D model and project schedule, in support of CPM schedule delay analysis. Traditional delay analysis methodologies rely on bar charts or Gantt graphics for analyzing and conveying the results of complex schedule analyses. This paper supports the fact that the use of a 3D model and project schedule, in support of CPM schedule delay analysis, is a more effective and efficient method for analyzing during negotiations, alternative dispute resolution, or litigation. The author shares findings from case studies that used 4D models to visually analyze and present as-planned versus as-built CPM schedule delay analyses and time impact analyses. The paper also discusses the benefits and shortcomings of the use of 4D models, as well as additional topics for research.	The author shares findings from case studies that used 4D models to visually analyze and present as-planned versus as-built CPM schedule delay analyses and time impact analyses.	Analysis	BIM
McCaen, T. L.	2008	[2010-2014]	BIM.01	Scheduling, Estimating, and BIM: A Profitable Combination	It may be difficult to realize the true spirit of a building information modeling (BIM) system when a design team creates a model independent of the 4D (schedule) and 5D (estimating) "know-how" of industry professionals. Project scheduling and cost estimating are essential components in the pre-construction process and should be included in an enhanced BIM system to facilitate informed decisions with regards to time and costs and the impact of each on a project's bottom line. Adding 4D and 5D to a BIM project creates an environment that enhances profitability. This paper presents a case study in which the scheduling and cost functions added value in the model development. It concludes with a method for 4D and 5D integration to optimize the benefits of BIM for both the project team and project owner.	This paper presents a case study in which the scheduling and cost functions added value in the model development. It concludes with a method for 4D and 5D integration to optimize the benefits of BIM for both the project team and project owner.	Management	BIM	
Spittler, J. R.	2009	[2010-2014]	PM.05	Designing and Constructing Cost-Neutral Greener Facilities in the "Energy Climate" Era	In "Hot, Flat, and Crowded," Thomas Friedman makes a compelling argument for the convergence of global warming, global flattening, and global crowding going both to the "energy-climate" era. Given growing uncertainties surrounding future energy supplies and a built environment in the US that accounts for 39 percent of energy use, the author agrees with Friedman's premise and believe that every building should be a "greener" building. The solution includes overcoming the current paradigm that the cost of building "green" is 5 to 10 percent higher than conventional construction? using LEED Silver certification as a baseline, the authors offer five suggestions that can make designing and constructing a generic mid-rise commercial/residential building cost neutral. The solution includes establishing an "integrate everything" mindset, which leads to both starting and planning differently, employing emerging technologies such as building information modeling (BIM), and changing procurement methods, contracting strategies, and relationships amongst participants.	Using LEED Silver certification as a baseline, the authors offer five suggestions that can make designing and constructing a generic mid-rise commercial/residential building cost neutral.	The solution includes establishing an "integrate everything" mindset, which leads to both starting and planning differently, employing emerging technologies such as building information modeling (BIM), and changing procurement methods, contracting strategies, and relationships amongst participants.	Design	BIM
Hjazi, W.	2009	[2010-2014]	BIM.04	Constructability Assessment Using BIM/4D CAD Simulation Model	Implementation of constructability/buildability ideas in the construction industry has a potential return on investment concerning time and money. Literature shows that quantified assessment of constructible designs provides benefits to the owners, contractors, and designers. The potential use of new technology-based tools to assess constructability of a design has not been fully realized. A new methodology to evaluate the level of application of constructability principles in residential buildings was proposed. This methodology integrates the object-oriented Building Information Model (BIM) and the 4D CAD simulation model. Factors affecting constructability of building designs in Canada are identified from a questionnaire survey on constructability attributes. Multi-attribute decision analysis and Analytical Hierarchy Process (AHP) were used to assess the overall constructability value. The new methodology was validated using a case study of a condo project in downtown Montreal. The outcome showed that integrating BIM with 4D CAD simulation models has many benefits to designers in which evaluation of different designs can be done in a more accurate and faster way.	A new methodology to evaluate the level of application of constructability principles in residential buildings was proposed.	The new methodology was validated using a case study of a condo project in downtown Montreal. The outcome showed that integrating BIM with 4D CAD simulation models has many benefits to designers in which evaluation of different designs can be done in a more accurate and faster way.	Design	BIM
McCaen, T. L.	2009	[2010-2014]	BIM.01	The Quantification Process and Standards for BIM	Building Information Modeling (BIM) is an emerging phenomenon in which business processes combine with innovative information technology to optimize efficiency and minimize waste in the design, building, and operations of a facility. The elimination of non-value added redundant tasks, along with the addition of reliable information in the communication between stakeholders, facilitates these improvements. The identification of the information that a BIM must contain and the process of exchange between functional roles to facilitate the quantity take-off task is needed. The AACE International – BIM Committee, in association with the National BIM Standard Committee, has answered this need with a project titled, "Quantification (Take-off) Process and Standards for BIM." This article presents the AACE International task force objectives, the project design, methods for development, and recommended information exchange process. This article discusses the outcomes from the task force and the contribution of this project to the cost engineer's role in BIM.	This article presents the AACE International task force objectives, the project design, methods for development, and recommended information exchange process. This article discusses the outcomes from the task force and the contribution of this project to the cost engineer's role in BIM.	This article discusses the outcomes from the task force and the contribution of this project to the cost engineer's role in BIM.	Management	BIM
Prentice, J. P.	2010	[2010-2014]	PM.504	The Art of Construction Administration	Construction Administration (CA) is where the art of the imaginable in architecture and engineering is tested in a real world environment. When this happens, the CA process often determines whether a particular design feature or detail becomes a design inspiration or a stumbling block to project progress. The art and skill of CA must contribute to the ultimate success of the construction effort. CA is an administrative process, which can have a profound influence on construction outcomes. Every designer should learn to be an effective construction administrator, striving for a CA process that is as seamless and flawless as possible, in order to ensure that his or her design intent is realized in construction. CA has changed significantly over the last few decades. Legal rulings and precedents, ConsensusDocs, Building Information Management (BIM), the Independent Decision Maker (IDM), and integrated project delivery methods demand new CA skills and developments. Thoughtful CA integration during the early stages of design results in the most effective and successful projects.	Every designer should learn to be an effective construction administrator, striving for a CA process that is as seamless and flawless as possible, in order to ensure that his or her design intent is realized in construction.	Legal rulings and precedents, ConsensusDocs, Building Information Management (BIM), the Independent Decision Maker (IDM), and integrated project delivery methods demand new CA skills and developments. Thoughtful CA integration during the early stages of design results in the most effective and successful projects.	Design	BIM
Zalinger, W. R.	2010	[2010-2014]	BIM.03	BIM: Sharing Project Data Reduces Conflict	In 2005, Buric posed the rhetorical question, "Does sharing project data create claims?" and discussed survey results on how sharing information helps to avoid claims and improve projects. Buric is a consulting company founded in 1968, by Robert V. Buric. It serves the world's diverse construction industry. Since the time of Buric's 2005 preliminary industry survey regarding the sharing of project data amongst project stakeholders, Building Information Modeling (BIM), a then relatively new process, has taken an increasingly more prevalent foothold in the industry. BIM models produce a wealth of data. It is the successful implementation of effective project controls systems within a collaborative and committed team environment that transforms that data into information. So that the participating team parties effectively address the sharing of reward (and risk) in projects implementing integrated design solutions, transparency and candor must accompany this revolutionary development. The open communication and exchange of this data through a team BIM approach will generate more informed decisions by the project's stakeholders. As the industry embraces the existing capabilities and knowledge of BIM, it should also be embracing the transparency required for project success.	BIM models produce a wealth of data. It is the successful implementation of effective project controls systems within a collaborative and committed team environment that transforms that data into information.	The open communication and exchange of this data through a team BIM approach will generate more informed decisions by the project's stakeholders. As the industry embraces the existing capabilities and knowledge of BIM, it should also be embracing the transparency required for project success.	Analysis	BIM
Ali Mashra, S.	2010	[2010-2014]	BIM.02	Integrated Cost Budgeting and Estimating Model for Building Projects	The importance of a reliable cost estimate in the various phases of building projects is beyond dispute. However, in the traditional context, preparing a detailed cost estimate requires extensive work-hour. Consequently, it is not feasible to be performed repetitively. Considering this, cost estimates are performed during the design phases and the bidding process, leaving gaps where project cost can grow out of control. This paper presents an integrated cost budgeting and cost estimating model for building projects. By integrating multiple cost databases with Building Information Modeling (BIM) geometrical data, the proposed model streamlines the process of cost estimation. The generated estimate complies with AACE International class 1 / class 2 classifications. It is also capable of rendering cost estimates in multiple work breakdown structures, allowing it to be implemented at both the design and construction phases (e.g., UniformFormat™ is assembly-based for the design phases, and MasterFormat™ is trade-based for the bidding and construction phases).	This paper presents an integrated cost budgeting and cost estimating model for building projects.	The generated estimate complies with AACE International class 1 / class 2 classifications. It is also capable of rendering cost estimates in multiple work breakdown structures, allowing it to be implemented at both the design and construction phases (e.g., UniformFormat™ is assembly-based for the design phases, and MasterFormat™ is trade-based for the bidding and construction phases).	Management	BIM

McCaun, T. L.	2010	[2010-2014]	BIM.01	Underdeveloped and Underused: Cost Estimating in BIM	Building Information Modeling (BIM) is gaining momentum in the A/E/C industry as an increased number of facility owners now require BIM for the design and construction of projects. As a result, more A/E/C companies are adopting and implementing BIM to compete for projects. However few projects have gone beyond the graphics, clash detection, and sequencing, to include the information critical for the cost estimator. Cost estimating is the underutilized and underdeveloped dimension in BIM. Clarification of the cost estimator's role and responsibilities is essential. This paper discusses the impact BIM is having on the cost estimator and reports the current state of practice as indicated in industry trends. This paper presents the roles, responsibilities, technical skills, and information exchange requirements necessary for cost estimating in BIM. Each of the above items is addressed as a cause in the underutilization of BIM for cost estimating. Consequently the underdeveloped quantification and estimation tools are a result of the level of utilization by cost estimators.	This paper presents the role, responsibilities, technical skills, and information exchange requirements necessary for cost estimating in BIM.	Each of the above items is addressed as a cause in the underutilization of BIM for cost estimating. Consequently the underdeveloped quantification and estimation tools are a result of the level of utilization by cost estimators.	Management	BIM
Chokals, P. N.	2011	[2010-2014]	PM.472	4D/5D BIM, IOC, IPD - Why the AEC Industry Must Change	Within the facility management industry, major productivity gains within the Architectural, Engineering, and Construction (AEC) sector can be realized through the implementation of robust business processes as well as systems integration and industry knowledge domains both facilitated by information technology. The emerging complementary processes and technologies of 4D/5D Building Information Modeling (BIM), Integrated Project Delivery (IPD), and Job Order Contracting (JOC) provide an actionable framework for professional collaboration, and increased productivity from capital planning through construction and downstream operations and maintenance. The success of these processes and technology tools is totally dependent upon transformational changes regarding the ways in which AEC professionals deliver their services. The purpose of this paper is to delineate various transformational modalities for planning and operations to allow for faster adoption in the construction industry.	The purpose of this paper is to delineate various transformational modalities for planning and operations to allow for faster adoption in the construction industry.	The emerging complementary processes and technologies of 4D/5D Building Information Modeling (BIM), Integrated Project Delivery (IPD), and Job Order Contracting (JOC) provide an actionable framework for professional collaboration, and increased productivity from capital planning through construction and downstream operations and maintenance. The success of these processes and technology tools is totally dependent upon transformational changes regarding the ways in which AEC professionals deliver their services.	Management	BIM
Shah, J. S.	2011	[2010-2014]	BIM.760	The Fifth Dimension of BIM--Cost Estimating	Building Information Modeling has come a long way. Many owners require it in design and construction of projects. Therefore, many A/E/C firms are adopting and implementing BIM. Definitely BIM is here to stay, and it is the future of the construction industry. Many of us are aware of the 3D and 4D capabilities of BIM. This paper presentation moves beyond the graphics, clash detection or construction sequencing. We will discuss about the fifth dimension of BIM (i.e., cost estimating). This paper presents the capabilities of 5D BIM, and shows how it is useful to project owners, architects, designers, general contractors and sub contractors. Currently 5D BIM-based cost estimating is underused. This is because it is not mandatory in the construction documents required by owners. They do not have the detailed information as to how related to the project. This will change as soon as the owner realizes the amount of time and money saved by using the 5D BIM-based cost estimating process. 5D BIM is not a fad, but is the future of the construction industry.	This paper presentation moves beyond the graphics, clash detection or construction sequencing. We will discuss about the fifth dimension of BIM (i.e., cost estimating).	This paper presents the capabilities of 5D BIM, and shows how it is useful to project owners, architects, designers, general contractors and sub contractors. Currently 5D BIM-based cost estimating is underused.	Management	BIM
Larson, P. D.	2011	[2010-2014]	BIM.751	Building Information Modeling (BIM)--Designing a Comprehensive and Interpretive Database	This paper is intended to give a clear understanding to the challenges and benefits related to designing a comprehensive and interpretive database for BIM projects. This process can be particularly challenging, since "BIM" can be different things to different people. For this paper, BIM is defined as an object oriented quantitative model that is fully coded to the LOE, represented by the model, and those codes can then be used downstream to provide enough information to create a resource based cost estimated time and materials, based on actual or assumed specifications. This will provide enough information to facilitate the creation of a reasonable construction schedule, based on resources, and then that schedule can be resource leveled and resource constrained, to provide a more representative Critical Path Method (CPM) schedule vs. traditional fixed duration schedules. So, by understanding what the flaws are, and by creating a cost database not only with detailed line items but a hierarchical assembly structure, then the cost estimator can take more advantage of the software tools designed for cost estimating.	This paper is intended to give a clear understanding to the challenges and benefits related to designing a comprehensive and interpretive database for BIM projects.	So, by understanding what the flaws are and by creating a cost database not only with detailed line items but a hierarchical assembly structure, then the cost estimator can take more advantage of the software tools designed for cost estimating.	Analysis	BIM
McCaun, T. L.	2011	[2010-2014]	BIM.751	BIM, Sustainable Construction and Integrated Approaches to Project Delivery	Sustainable Construction and Building Information Modeling (BIM) are independent trends that share a common goal--reduce waste. Driving both trends are recent reports about the alarming rate of raw material depletion, wasteful building practices, inefficient processes, and redundant work. A holistic approach that considers the site, building performance, and occupied space simultaneously is recommended for the design and building of projects requiring sustainable construction and BIM. Holistic approach integrates the team, project delivery method, and technology. Results from an industry survey on project delivery methods for sustainable projects revealed that integrated approaches to project delivery are consistently more effective at meeting, and often exceeding, the owner's sustainability requirements. Participants in follow up interviews to the survey attributed their successful achieving the sustainable requirements to an integrated approach for project delivery. BIM provides project teams with the means to integrate input from all stakeholders for evaluation and informed decision making. The results in this study reflect the current state of practices that impact traditional roles in project delivery.	A holistic approach that considers the site, building performance, and occupancy type simultaneously is recommended for the design and building of projects requiring sustainable construction and BIM.	The results in this study reflect the current state of practices that impact traditional roles in project delivery.	Management	BIM
Meadari, P.	2011	[2010-2014]	BIM.555	BIM and Quantity Estimates during the Construction Process	Today, the Building Information Modeling process plays an important role when preparing quantity estimates during the construction process of a project. Implementation of existing active BIM solutions partially automate an automatic quantity estimate for the schedule of activities of the entire project. These generated estimates need to be tailored by the subcontractor to execute the daily construction activities. This process is tedious and not user friendly. This paper discusses the development of an user friendly interface, to generate quantity estimates for the schedule of activities that facilitate the project schedule implementation from the subcontractor's perspective. The process adopted in this study includes four steps: The development process includes: creating a three dimensional (3D) model, creating a planned project schedule, defining unique parameters, (such as: "from date" and "to date," "direction," "floor level," "element type," and "identification number"), and finally extracting the required data for the preparation of a quantity estimate, as per the job site requirements.	This paper discusses the development of an user friendly interface, to generate quantity estimates for the schedule of activities that facilitate the project schedule implementation from the subcontractor's perspective.	The development process includes: creating a three dimensional (3D) model, creating a planned project schedule, defining unique parameters, (such as: "from date" and "to date," "direction," "floor level," "element type," and "identification number"), and finally extracting the required data for the preparation of a quantity estimate, as per the job site requirements.	Analysis	BIM
McCaun, T. L.	2011	[2010-2014]	BIM.555	Cost Savings Achieved Through Changing Processes for Cost Estimating in Building Information Modeling	Inadequate planning often leads to costly errors on construction projects. Many construction inefficiencies can be avoided through better planning. Building Information Modeling (BIM) is a method that can alert designers and contractors to potential errors and omissions, through manual and automated checks, using 3D visualization and computer analysis techniques during. If errors and omissions are identified early, troubleshooting, alternative development, and solution selection are substantially less expensive and easier to implement. The purpose of this paper is to expand the discussion about estimating in BIM across the project lifecycle by linking the value of BIM for cost savings to the estimating goal of reducing costs. The paper begins with a comparison of the traditional estimating process, and estimating in BIM, to establish an understanding of changes in the process necessary in BIM. Next is a brief discussion about potential project cost savings, followed by excerpts from three previously published case studies about costs and estimating using BIM. The three case studies include evidence about the benefits from all phases--design, construction, operations, and maintenance.	The purpose of this paper is to expand the discussion about estimating in BIM across the project lifecycle by linking the value of BIM for cost savings to the estimating goal of reducing costs.	Next is a brief discussion about potential project cost savings, followed by excerpts from three previously published case studies about costs and estimating using BIM.	Design	BIM
Gunnemont, M.	2012	[2010-2014]	BIM.995	4D Scheduling Using Delmia® and Microsoft Project® on Hydroelectric Construction Projects	A major Canadian utility company has recently added the dimension of time (4D) to its scheduling on four new facilities and rehabilitation hydroelectric projects using Delmia®. As planned project schedule evolution is viewed on a Gantt chart, while progress shown on the project's 3D mockups. Each mock-up piece is matched to distinct schedule activities and according to project complexity and user type, a summary or detailed level is selected for simulation. With this new technology, new schedulers, estimators, engineers and managers are able to improve internal standards by building quick thinking schedules, reviewing project scenarios, providing insight on constructability, methods and optimizations, preventing safety hazards, choosing better materials and predicting costs to a more accurate fashion. 4D scheduling facilitates earlier knowledge about interfaces, existing conditions, access and material handling, reduce requests for information, accelerate change process and enables easier communications between stakeholders from pre-feasibility till end of construction phase.	A major Canadian utility company has recently added the dimension of time (4D) to its scheduling on four new facilities and rehabilitation hydroelectric projects using Delmia®.		Management	BIM
Montasser, A.	2012	[2010-2014]	BIM.918	RFID and BIM for Automated Progress Reporting	This paper presents a near-real-time automated method for data acquisition and progress reporting of construction operations indoor. The developed method utilizes the joint use of low cost passive Radio Frequency Identification (RFID) tags, RFID reader, tablet PC, project schedule and Building Information Modeling (BIM). RFID is used for indoor zone identification where GPS cannot technically be used. By integrating project schedule and BIM, a 4D model is generated to simulate a planned construction sequence. Visualization of zone activities, in near-real-time, via the planned 4D model is achieved through assigning a zone to the user from the received nearest RFID tag signals. Meanwhile, automated data acquisition from each zone will generate numerous data in formats such as images, notes and video clips, which is then compared to the planned 4D model to generate an automated progress report. This will enhance traditional progress reporting procedures and makes it more objective and less time consuming. The developed method is applied to a construction project in Montreal area to demonstrate its use.	This paper presents a near-real-time automated method for data acquisition and progress reporting of construction operations indoor.	The developed method is applied to a construction project in Montreal area to demonstrate its use.	Analysis	BIM
Chatzisyriou, A.	2012	[2010-2014]	BIM.846	Application of BIM and GIS in Class 1-5 Cost Estimates	Building Information Modeling (BIM) and Geographic Information Systems (GIS), based on open standards, transform the way the civil engineering industry works and will work in the future. This paper presents four examples to demonstrate how BIM and GIS can be applied to all classes of estimates. The first example includes a building in conjunction with GIS, to model and optimize a real estate development project to produce a Class 5 estimate. The second example demonstrates how architectural BIM sketches can be combined with smart assemblies that use conceptual cost data to produce a Class 4 estimate. The third example uses a basic design BIM model combined with commercial assemblies to produce a Class 3 estimate. The fourth example uses a detailed Information Foundation Class (IFC) model for a quantity takeoff, and combined with commercial databases, generates a Class 2 estimate. The same BIM model is used as a basis for creating and managing quotes from suppliers and subcontractors and developing detailed Class 1 estimates. The resource and cost loaded detailed BIM model is examined through value engineering and analysis as an alternate method for presenting proposals.	This paper presents four examples to demonstrate how BIM and GIS can be applied to all classes of estimates.	The resource and cost loaded detailed BIM model is examined through value engineering and analysis as an alternate method for presenting proposals.	Design	BIM
Rasmi, E. I.	2012	[2010-2014]	BIM.837	Building Information Modeling -The Cost Estimator's Role	Building Information Modeling is a term representing a new process or approach that is being widely implemented in the architecture, engineering and construction (AEC) industry. If new works in this industry and has not yet heard the term, it is reasonable to expect it will not be the case much longer. The adoption of this approach to designing and managing projects is catching on at a phenomenal pace in the US and in Europe. The firms that have been early adopters of BIM are reaping the benefits and enjoying a competitive advantage as they work to secure and perform new projects in a much more efficient manner, from the conceptual design stage through project completion, and the operation and maintenance of the building. BIM continues to overcome the initial hesitancy among architects, designers, engineers, contractors and owners, proving itself to be a powerful data management system and time saver. BIM is in its early stages of development and the tools that support BIM are being improved each year. The AEC industry will continue to reap the rewards as the tools and processes of BIM are fine-tuned.	The firms that have been early adopters of BIM are reaping its benefits and enjoying a competitive advantage as they work to secure and perform new projects in a much more efficient manner, from the conceptual design stage through project completion, and the operation and maintenance of the building.		Design	BIM
McCaun, T. L.	2012	[2010-2014]	BIM.1107	Cost Estimating in Building Information Modeling: Process Development Report	n2008, AACE International members initiated in advancing the state of estimating in building information modeling (BIM) began collaborating with members from the American Society of Professional Estimators (ASPE), and members from the Royal Institution of Chartered Surveyors (RICS), to define the information exchange requirements for cost estimating in BIM. The information exchange requirements are the basis for an information delivery manual (IDM) required from the designers to the estimator. This is a unique and important effort for estimators to take an active role in developing a future national standard. Without defined requirements for information exchange, estimators run the risk of receiving a BIM that is populated with inaccurate or incomplete project information. The ultimate goal of the collaborative effort, reported in this paper, is to produce a ballot item for submission to the National BIM Standard (NBIMS). This paper reports on the process development to date and the future plan for the collaborative effort.	The ultimate goal of the collaborative effort, reported in this paper, is to produce a ballot item for submission to the National BIM Standard (NBIMS).	This paper reports on the process development to date and the future plan for the collaborative effort.	Design	BIM

Saez, G. F.	2012	[2010-2014]	BIM.1161	Total Cost for Multi-Unit Residential Building using BIM Modeling, Life Cycle Cost and Energy Analysis (EA)	Buildings are significant contributors to consumption of resources. The concept of a Green Building has received an increased attention primarily as a result of Leadership in Energy and Environmental Design (LEED) certification. However, the economic benefits of many of these buildings are not realized until several years after their construction and operation. This paper presents an approach using Building Information Modeling (BIM) tools combined with a framework for the life cycle cost assessment to determine the long term benefits of sustainability features of multi-unit residential buildings. This paper examines in detail the factors that should be considered to efficiently model the building envelope in conducting Energy Analysis (EA) for the various system components and materials. The impact of key design decisions are assessed in terms of performance and total cost. A case study is presented using information gathered for a LEED Gold certified dormitory building of a higher education institution located in the US.	This paper presents an approach using Building Information Modeling (BIM) tools combined with a framework for life cycle cost assessment to determine the long term benefits of sustainability features of multi-unit residential buildings. This paper examines in detail the factors that should be considered to efficiently model the building envelope in conducting Energy Analysis (EA) for the various system components and materials.	This paper examines in detail the factors that should be considered to efficiently model the building envelope in conducting Energy Analysis (EA) for the various system components and materials.	Analysis	BIM
Chokshi, P. N.	2013	[2010-2014]	PM.1219	Project Delivery Methods of the Future, Cloud Computing, and BIM	The authors suggest that cultural, technological and supply chain barriers endemic to the AECOD (Architecture, Engineering, Construction, Owner, Operations) sector create inefficiency and waste. As a result, facility managers continue to struggle with cost effective life cycle management of the built environment. The only truly effective way of delivering great buildings that delight end users, on time and to budget, is to achieve excellence at both a business and project level through collaboration. [1] Various market drivers are weakening these barriers, including 1) worldwide changes in the economic and environmental landscapes, 2) the advent of disruptive technologies specifically BIM and Cloud Computing, and 3) the associated application and integration of transparent and collaborative project delivery methods. [2] Studies suggest that construction industry productivity/efficiency issues have their root in the fragmentation of design, engineering, and construction, a process this was needed in the Renaissance. [3] Specialization of AECOD professions, disparate educational paths for design professionals vs. construction professionals, and adversarial business models contribute to cultural divide, have resulted in unintended divergent interests which does not serve the owners interests.	The only truly effective way of delivering great buildings that delight end users, on time and to budget, is to achieve excellence at both a business and project level through collaboration. [1] Various market drivers are weakening these barriers, including 1) worldwide changes in the economic and environmental landscapes, 2) the advent of disruptive technologies specifically BIM and Cloud Computing, and 3) the associated application and integration of transparent and collaborative project delivery methods. [2]		Design	BIM
MacBrien, S.	2013	[2010-2014]	BIM.1415	BIM Based Cost Management for Large Scale Construction Projects	It is not uncommon in large scale construction projects to experience cost overruns of up to 100% of the original cost estimates. The need for appropriate project planning and efficient progress tracking becomes even more important when cost is the major concern for these projects being successful from an operational standpoint. This study presents a BIM based model for cost management. In this model, project information is deconstructed and reorganized at granularity of component level, and each component is associated with relevant cost information, such as variable man hours, actual man hours, material cost, etc. By tracking the status of each component, it is easy to produce accurate cost estimate and monitor/control project costs. A web-based construction management system is developed based on this model, and has been implemented for major oil sands projects in Alberta, Canada.	This study presents a BIM based model for cost management. In this model, project information is deconstructed and reorganized at granularity of component level, and each component is associated with relevant cost information, such as variable man hours, actual man hours, material cost, etc. By tracking the status of each component, it is easy to produce accurate cost estimate and monitor/control project costs.	A web-based construction management system is developed based on this model, and has been implemented for major oil sands projects in Alberta, Canada.	Management	BIM
McCaig, T. L.	2013	[2010-2014]	BIM.1348	Validating a Quantity Takeoff Generated by a Building Information Model	Validating the quantity takeoff (QTO) is an important step in any cost estimating process however it may be even more important when the QTO was generated automatically from a building information model (BIM). Generating a QTO as an export from a BIM is as simple as "pushing the button" or selecting the feature from a menu. Validating the QTO for accuracy and completeness is proving to be more of a challenge. In the traditional process the cost estimator is responsible for each of the activities in the process from QTO generation through validation. Validating a QTO exported from a BIM is much different because the cost estimator receives the QTO as a dataset generated from a design model. In this paper the author reviews some of the current practices used by professional cost estimators in the construction industry. In addition to reviewing current practices, the author discusses best practices and makes some recommendations for validating a quantity takeoff generated by a BIM.	In this paper the author reviews some of the current practices used by professional cost estimators in the construction industry. In addition to reviewing current practices, the author discusses best practices and makes some recommendations for validating a quantity takeoff generated by a BIM.	The author discusses best practices and makes some recommendations for validating a quantity takeoff generated by a BIM.	Design	BIM
Redmond, A. M.	2013	[2010-2014]	BIM.1265	Designing a Cloud BIM Business Process Model Case Study	The theory of organizational/capital requires both business managers and computer programming to collaborate in developing applications such as the business managers outlining their work tasks through a business process flow diagram and computer programmers developing software to suit. The focus of this paper is to demonstrate a construction business process model Cloud BIM that enabled software developers to implement business procedures identified by managers into an executable code. The chosen business processes were based on design 3D, planning 4D, costing 5D, and the cycle management 6D because individually they supported the simplicity of the feasibility study phase in order to validate the productivity bottlenecks in writing such codes. The identified semantic engines of Web services coupled with the results of the operational tasks created the case study context of testing the capable benefits of transferring information through sublayers of BIM XML and plug-in exchanges. The results demonstrated the interoperable capabilities of Web services APIs for exchanging partial sets of BIM data with real-time constraints at the feasibility design stage.	The focus of this paper is to demonstrate a construction business process model Cloud BIM that enabled software developers to implement business procedures identified by managers into an executable code.	The results demonstrated the interoperable capabilities of Web services APIs for exchanging partial sets of BIM data with real-time constraints at the feasibility design stage.	Design	BIM
Holmann, L. K.	2014	[2010-2014]	RISK.1584	Risk Analysis at the Edge of Chaos	Empirical studies show that the distribution of actual/estimated cost data has a very long, bimodal tail on the high side. Actual and values are often triple the values we are estimating. Traditional risk analysis is failing to predict the tail. The author hypothesizes that the bimodal tail reflects the cost outcome of project chaos. Borrowing from chaos and complex systems theory, the author developed a practical method to warn management when a project's risks threaten to push project behavior over the edge into chaos and cost disaster. Complex systems theory is a maturing project management topic (e.g., in Lean Construction, etc.), however, it has not found much practical application in risk quantification. This paper reviews chaos and complex systems theory and how they relate to project cost uncertainty, and presents a method that brings the understanding of chaos and complexity into a practical risk quantification toolset.	This paper reviews chaos and complex systems theory and how they relate to project cost uncertainty, and presents a method that brings the understanding of chaos and complexity into a practical risk quantification toolset.	presents a method that brings the understanding of chaos and complexity into a practical risk quantification toolset.	Management	BIM
Redmond, A. M.	2014	[2010-2014]	BIM.1291	Environmental Performance of Buildings: Linking Practical BIM/ICT to Practical Policymaking	The United States faces large and complex energy challenges due to our changing demographic economy, changing population dynamics, uncertain technology funding, immature Public-Private Partnerships for infrastructure, and aging public and private infrastructure. Previous energy projection models anticipate that U.S. energy demand will increase by more than one third by 2030, with electricity demand alone rising by more than 40 percent. The main purpose of this paper is to assess an information system architecture for maintaining building related performance criteria through an urban BIM-FM model extending the nation's energy efficiency guidance prototypes with BIM-FM guidance and standards. The following research methods and techniques will be discussed: i) pre-qualification of existing and new construction information communication technology (ICT) advancements with emphases directly related towards BIM, ii) identify BIM/ICT energy related investigations (as user cases), and iii) assemble, store (data modeling), and disseminate Object-Header linked building and construction-related technical data. In conclusion, this paper will assist policymakers in making decisions which impact the entire building community and where possible, a united building community can influence an appropriate action.	The main purpose of this paper is to assess an information system architecture for maintaining building related performance criteria through an urban BIM-FM model extending the nation's energy efficiency guidance prototypes with BIM-FM guidance and standards.		Analysis	BIM
Prentice, J. P.	2010	[2010-2014]	CDK.11	The Spearin Doctrine Revisited	The Spearin Doctrine is fundamental to any assignment of responsibility or risk to the owner in a construction contract. New developments have arisen since an article about The Spearin Doctrine was first published in the 2004 AACE International Transactions. Recent legal precedents have refined owner risks in contract delay clauses. An AACE 2007 introduced the Independent Decision Maker (IDM) in an effort to settle disputes as they arise. Building Information Modeling (BIM) is redefining design and construction responsibility in the hope of reducing risk, design costs, and time. Imagine a process plan with no orthographic drawings. Some states have enacted statutes enabling public agencies to use the design-build delivery method, changing the relationship between owner, designer, and contractor. And not least among these, the battle of the forms continues with new documents from Associated Owners & Developers, Constructors, AIA, AEC, and Engineers Joint Council.	The Spearin Doctrine is fundamental to any assignment of responsibility or risk to the owner in a construction contract. New developments have arisen since an article about The Spearin Doctrine was first published in the 2004 AACE International Transactions.		Design	BIM
Bau, A.	2015	[2015-2017]	PS.2001	Leveraging BIM for Project Planning, Scheduling and Controls	Building Information Modeling (BIM), where a structure is digitally represented by a three dimensional (3D) model is increasingly used during design and construction of building projects. The emphasis has been on "Click Free Design" and "Zero Change Order" coordination in the construction phase. This paper will show how to extend the use of BIM beyond the low hanging fruits and leverage the information to enhance planning, scheduling and project controls during the construction and commissioning phases of a project. The location and room data in the BIM model are exported and combined with Architectural and Mechanical, Electrical and Plumbing (MEP) schedules to provide visual planning and communication aids and spreadsheets for quantitative tracking of progress. The data is organized and used to plan and sequence construction work zones, confirm schedule durations, identify just in time delivery options, define and manage commissioning zones and report progress. This paper provides an overview of how the data is gathered from various sources, processed and attached to the model and scheduled to provide the project control functionalities discussed above.	This paper will show how to extend the uses of BIM beyond the low hanging fruits and leverage the information to enhance planning, scheduling and project controls during the construction and commissioning phases of a project. The location and room data in the BIM model are exported and combined with Architectural and Mechanical, Electrical and Plumbing (MEP) schedules to provide visual planning and communication aids and spreadsheets for quantitative tracking of progress.		Design	BIM
Freider, K.	2015	[2015-2015]	BIM.1926	Strategies for BIM Adoption	Facilities are becoming increasingly complex. Building Information Modeling (BIM), a digital representation of a facility, offers the potential to simplify the facility development process by improving accuracy, shortening project schedules, reducing risk, improving communication and increasing collaboration. BIM has the potential to radically transform the Architecture, Engineering, and Construction (AEC) industry. Firms that fail to plan and adopt BIM over the next few years will not be competitive in the marketplace. The adoption process for BIM, like other technological advancements, needs to be wellplanned. This plan should include assessing internal processes, aligning new processes, and developing an advancement plan. BIM can dramatically improve how cost estimating, scheduling and other project analytical and control functions perform. Failure to adopt is not an option.	The adoption process for BIM, like other technological advancements, needs to be wellplanned. This plan should include assessing internal processes, aligning new processes, and developing an advancement plan. BIM can dramatically improve how cost estimating, scheduling and other project analytical and control functions perform. Failure to adopt is not an option.		Analysis	BIM
Bounds	1986	[2010-2014]	N-5	Expert systems potential as a cost engineering tool	The value of good project historical data and metrics for use in project planning (estimating, planning and scheduling, risk analysis, etc.) has always been recognized by cost engineers. The AACE® virtual library includes examples of successful implementations. However, the challenges of developing and maintaining a database (sustained demands on resources and budgets and extended time to achieve objectives) have resulted in relatively few companies successfully implementing them. However, increasing interest in artificial intelligence (AI), analytics, business intelligence tools and the availability of commercial software has raised interest. This interest resulted in the development of Recommended Practice (RP) 1148-20 "Project Historical Database Development". The RP is a guideline for requirements assessment, specification, development, implementation, and maintenance of a project historical database system. A database maturity model is also included. The intended audience is owner, contractor and agency organizations having access to project historical and/or actual data. The main focus is on databases for estimating, planning and scheduling, and risk management uses (e.g., estimate validation, conceptual estimating and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework.	The intended audience is owner, contractor and agency organizations having access to project historical and/or actual data. The main focus is on databases for estimating, planning and scheduling, and risk management uses (e.g., estimate validation, conceptual estimating and scheduling, parametric risk modeling, etc.).	The intended audience is owner, contractor and agency organizations having access to project historical and/or actual data. However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework.	Analysis	AI

Factor	1986	[2010-2014]	A-2	Is there artificial intelligence in project management?	The goal of this research is to understand more clearly the lifecycle costs of supplier selection using methods of artificial intelligence (AI) with a total cost of ownership (TCO) model to reduce uncertainty and make better decisions. As it is a technology for operations management and its usage is still in infancy. Few have successfully integrated AI methods into their operations and across their supply chains but are currently starting to emerge. The research driven by the question of how to reduce uncertainty to provide better information for selecting the right supplier. A case study is conducted at a German automobile manufacturer based on three informed data sets. These include: 1. New algorithm models are evaluated as baselines for quality of cost prediction based on supplier selection nomination. 2. Engineering and production changes are analyzed since they often lead to price increases. 3. Cost breakdowns are considered, as they are applicable during several lifecycle phases. For the last 50 years, AACI international and the project management community have made significant contributions to increase the maturity in the practice of project management and control. This continuous commitment applies to remain resident in the era of data science. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the applicability indicated to other settings such as construction, aerospace, defense, and public procurement where considerable related research is conducted. The work confirms previous research that in particular regression trees and Bayesian optimization can reduce the uncertainty inherent in supplier selection more than previously utilized methods.	The goal of this research is to understand more clearly the lifecycle costs of supplier selection using methods of artificial intelligence (AI) with a total cost of ownership (TCO) model to reduce uncertainty and make better decisions. The research driven by the question of how to reduce uncertainty to provide better information for selecting the right supplier.	This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the applicability indicated to other settings such as construction, aerospace, defense, and public procurement where considerable related research is conducted. The work confirms previous research that in particular regression trees and Bayesian optimization can reduce the uncertainty inherent in supplier selection more than previously utilized methods.	Management	AI
Nhuon	1987	[2010-2014]	Cost engineering	Applying artificial intelligence to project cost estimating	The project management industry is continuously facing challenges with rather low project success rates, which therefore demands a new intelligent approach to how projects are being managed and delivered. Artificial intelligence (AI) represents a welcomed opportunity for the project management practice to improve its service quality, to address its existing shortcomings with project delivery and increase the efficiency of projects. Accordingly, AI in project management is expected to enter and revolutionize the project management industry over the next months and years. This new reality however raises also dramatic change for an organization regarding its decision-making and project culture since this will mean a fundamental change in the beliefs and behaviors of project professionals. The paper aims to investigate the key elements of an AI-powered project management approach and how it will impact project management practitioners and their norms and values in terms of decision-making in projects. Based on the findings, a recommended approach will be drafted to transition to an analyzed cultural setting that fits in a wider data-driven organizational culture, to improve the predictability of project outcomes.	The paper aims to investigate the key elements of an AI-powered project management approach and how it will impact project management practitioners and their norms and values in terms of decision-making in projects.	Based on the findings, a recommended approach will be drafted to transition to an analyzed cultural setting that fits in a wider data-driven organizational culture, to improve the predictability of project outcomes.	Management	AI
Wulf	1987	[2010-2014]	G-4	Knowledge based systems in cost engineering	The fourth industrial revolution has led to widespread digitalization across the delivery chain of construction and project industries. The digitalization of project processes and other technological enhancements such as digital project delivery, building information modeling, and digital twins have created vast amounts of promising data. At the same time, data science, artificial intelligence, and machine learning are becoming ever more streamlined and available for a variety of tasks, raising debates and discussions about what is project analytics and how analytics processes and functions can create competitive advantage. Systematic approach to this issue requires a holistic view into three aspects of it: first, inherent complexities of projects as complex and interdependent systems; second, nature of project delivery processes, management, and controls; and third, knowledge of high-performance analytics, algorithms, tools, and trends in technological innovation. This paper provides an overview of the authors' experiences and perspectives on project complexities, and success factors in dealing with such complexities. A framework is then proposed for successful project analytics functions.	This paper provides an overview of the authors' experiences and perspectives on project complexities, and success factors in dealing with such complexities. A framework is then proposed for successful project analytics functions.		Analysis	AI
Shale	1987	[2010-2014]	B-7	Six steps to successful expert systems	This paper will explore technical and legal issues expected to be encountered in testimony of engineering, scheduling and cost expert opinions relying on the use of automated systems and artificial intelligence (AI). Specific topics include: • The current state of the law and practice • The degree of reliance on the output from automated systems and artificial intelligence • The extent to which the expert must be familiar with the inner workings of the software • What data need to be provided to discovery • Does proprietary software need to be provided for the opposing expert? • Can the paper will conclude with a set of key considerations for experts, lawyers and policy makers regarding this fast-developing area of practice.	This paper will explore technical and legal issues expected to be encountered in testimony of engineering, scheduling and cost expert opinions relying on the use of automated systems and artificial intelligence (AI).	The paper will conclude with a set of key considerations for experts, lawyers and policy makers regarding this fast-developing area of practice.	Management	AI
Mouaifi	1988	[2010-2014]	B-9	Expert systems building tools: a selection criteria	Project stakeholders go through painstaking exercise to identify required material and to expedite them for timely delivery to the site in avoiding project delays, thus creating complicated warehousing and logistics challenges of having the right material at the right time and location. This paper presents an analytical model to manage the megaproject warehousing issues. Drones equipped with streaming video capability can help survey sites, identify optimal locations for warehouses, and monitor the status for suspicious activity – allowing the project team to easily monitor locations and quantities of assets and materials at a glance to ensure they will be there when needed. When the request for a particular material arrives, an optimal path is digitally mapped for the drone to travel and map ground previously. The paper will discuss an optimization model for warehouse management through the use of drones and artificial intelligence (AI). An analytical model of warehouse management with huge potential cost and schedule savings will be presented.	This paper presents an analytical model to manage the megaproject warehousing issues. The paper will discuss an optimization model for warehouse management through the use of drones and artificial intelligence (AI).	An analytical model of warehouse management with huge potential cost and schedule savings will be presented.	Management	AI
Westney	1991	[2010-2014]	G-6	Resource scheduling. Is AI the answer?	Thorough, reliable information is a necessary component for making sound decisions. While many sources of data are available in the construction industry they can be difficult to access or may be inaccurate. Lately, companies have undertaken initiatives to compile past results, making the information available and usable for better predictions. Also, recently developed technological systems and tools are improving the quantity, quality, and timeliness of information available to the construction industry. Although past data sources and new tools are providing a wealth of information, a critical issue remains: ensuring the data is trustworthy. Creating a trusted historical database requires consistent, methodical data collection techniques, analysis, monitoring, verification, and documentation. While improving data quality is necessary for improving predictions, it can also better position companies to take advantage of upcoming machine learning and artificial intelligence (AI) capabilities. Developing proper strategies to ensure useful quality data can help improve tracking, decisions, and predictions related to future works.	While improving data quality is necessary for improving predictions, it can also better position companies to take advantage of upcoming machine learning and artificial intelligence (AI) capabilities.	Developing proper strategies to ensure useful quality data can help improve tracking, decisions, and predictions related to future works.	Analysis	AI
Arens	1991	[2010-2014]	F-2	Using AI to estimate development equipment costs	Researchers and industry practitioners agree that changes are an integral part of construction projects and that overlooked cumulative impact of changes should not be overlooked because it can be detrimental to project success. Cumulative impact of changes on construction labor productivity is difficult to identify and measure. Although Measured Mile Analysis (MMA) is well known and widely accepted method for quantifying the cumulative impact of changes on labor productivity, it is not easily applicable to many cases. This paper presents a novel Artificial Intelligence (AI) approach to quantifying loss of productivity due to changes during project development. Two datasets were collected from earlier studies using real construction projects, namely, the developed models of Leonard (1988) and Assum (2000). The model developed in this paper, along with two widely used regression models, "Leastard method", are tested against actual cases to demonstrate the developed model's capabilities. While the developed model is expected to be beneficial for construction practitioners in evaluating the cumulative impact of changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes.	This paper presents a novel Artificial Intelligence (AI) approach to quantifying loss of productivity due to changes during project development.	While the developed model is expected to be beneficial for construction practitioners in evaluating the cumulative impact of changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes.	Analysis	AI
Micks	1993	[2010-2014]	F-5	Neural Networks and identification and estimation of risk	The innovation collaboration forum is a moderated panel discussion that looks at the challenges cities and owner agencies (innovation enablers) are navigating then the companies that are there to provide solutions (innovation providers). City and owner agency executives discuss challenges they are having and how they are enabling innovation. Key challenges involving smart city initiatives, infrastructure, enabling transit, emerging technology, and data integration are discussed. Innovation providers will discuss how the right technology platforms can enrich the design, planning and delivery of critical assets with pragmatic approaches to BIM and digital delivery as well as the forward frontier of wearables, augmented reality, artificial intelligence and connected infrastructure.	Key challenges involving smart city initiatives, infrastructure, enabling transit, emerging technology, and data integration are discussed. Innovation providers will discuss how the right technology platforms can enrich the design, planning and delivery of critical assets with pragmatic approaches to BIM and digital delivery as well as the forward frontier of wearables, augmented reality, artificial intelligence and connected infrastructure.	City and owner agency executives discuss challenges they are having and how they are enabling innovation.	Design	AI
Micuae	1997	[2010-2014]	F-01	Scope definition is a company affair	Artificial intelligence has deeply intrigued humans, and inspired biologists, philosophers and mathematicians. The term artificial intelligence caught a new meaning when the first attempt to formalize appeared. Those attempts have increased and their ranges have been broadened as a result of new technological development of the modern tools of rapid calculations and data processing. The first mathematical description of a neuron was developed by McCulloch and Pitts in 1943. The ideas of the artificial neural networks (e.g., the algorithmic reverse propagation of error) were improved and propagated in the 1970s and 1980s by Werbos (1974), Rumelhart (1986), Hinton (1986), Parker (1985) and Rumelhart (1986) (2). Neural networks can be successfully used to describe a structural problem. Those types of problems are both of risk of projects and risk management, which consists of lots of complex tasks and issues.	neural networks		Management	AI
Al-Jabab	1998	[2010-2014]	Cost engineering	An Evolutionary Approach to the Budgeting of Construction Projects	Major construction firms often face a difficult decision about the optimum combination of projects to select from a range of available projects. This decision usually requires the evaluation of all feasible combinations of projects and the choice of the combination that has the highest net present value associated with it. Defining all of the possible combinations of projects becomes increasingly cumbersome as the number of projects increases and as the number of years on the planning horizon increases. In this article, an artificial intelligence research strategy called the genetic algorithm, which is based on evolution theory, is proposed to determine the optimum set of projects, considering the interdependencies of projects, their characteristics, resources, environmental constraints, and the managerial policies faced by physical construction firms.	In this article, an artificial intelligence research strategy called the genetic algorithm, which is based on evolution theory, is proposed to determine the optimum set of projects, considering the interdependencies of projects, their characteristics, resources, environmental constraints, and the managerial policies faced by physical construction firms.		Management	AI
Bode	1998	[2010-2014]	Cost engineering	Neural Networks for Cost Estimation	There is a growing movement in the construction industry away from procurement through traditional low-bid methods toward performance based or best-value procurement. Until now, the one-step and two-step methods have been the major types of best value procurement. The major difficulty with both systems is finding an unbiased way to evaluate the value of performance. This article explores the procurement of construction services by the State of Hawaii, using an artificial intelligence performance information procurement system (PIPS) to identify best value. A best value environment is one in which contractors optimize both price and performance.	This article explores the procurement of construction services by the State of Hawaii, using an artificial intelligence performance information procurement system (PIPS) to identify best value.		Analysis	AI

Smith	1999	[2010-2014]	IT/MS	IT and Quantity Surveying—the Australian Perspective	This paper examines the application of information technology by the quantity surveying profession in particular, and its effect on the way we communicate. Supercomputers, the Internet, e-mail, electronic data interchange, 3D graphics with immersive virtual reality, artificial intelligence, teleconferencing, videoconferencing, teleconferencing, and Australia. T	This paper examines the application of information technology by the quantity surveying profession in particular, and its effect on the way we communicate. Supercomputers, the Internet, e-mail, electronic data interchange, 3D graphics with immersive virtual reality, artificial intelligence, teleconferencing, videoconferencing, teleconferencing, and Australia. T	Analysis	A
El-Choum	1999	[2010-2014]	IT/OT	An Integrated Construction Activity Cost System	An effective planning mechanism in the construction industry is needed to help construction planners achieve their goals. The construction process is heterogeneous in nature and is of paramount concern to transit agencies. The identification of construction tasks, materials, equipment, and crew/operators requires skilled and knowledgeable managers to execute complex networking processes, especially when dealing with underground station rehabilitation projects. To set up a good model to identify tasks in subway station rehabilitation projects, past data and current data, as well as an artificial intelligence system that emulates the expert thinking process, must be readily available. Such a system must be robust to allow flexibility to amend and revise the model, standards, and methods necessary to improve quality, safety, schedule control, cost control, and other related administrative and support activities. Also, corrective actions must be taken to eliminate inefficiencies and prevent their recurrence. Firms expected to be beneficial for construction practitioners in evaluating the cumulative impact of changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes on labor productivity. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the applicability indicated by other settings such as construction, aerospace, defense, and public procurement where considerable related research is conducted. The work confirms previous research that in particular regression trees and Bayesian optimization can reduce the uncertainty inherent in supplier selection more than previously utilized methods. An integrated program schedule, identifying and mitigating performance risks in conjunction with the BIM model, and reporting to the program management team. This lessons-learned approach from a variety of successful industry programs enables efficient development and use of an integrated program schedule to meet the owner's needs and goals. Several researchers in construction have also used the powerful random search capabilities of GA to optimize site layout planning [7, 8, 10]. While these GA models have different formulations, they all reported the benefits of the GA technique in solving large-scale problems, for which traditional mathematical optimization is likely to fail. While these AI tools can provide solutions to practical site problems, most models may not be easily implementable by practitioners due to their sophisticated formulation. In an attempt to simplify the facility layout problem and present it in a form that is easily implementable by practitioners, a site layout model has been developed on a spreadsheet program. To investigate various layout optimization, two spreadsheet add-in programs based on the principles of GA have been applied on the developed model and their results compared. Two case studies are used to illustrate the applicability of the model for solving layout	this problem relies on developing a knowledge-based system.	Management	A
Ehshegi	1999	[2010-2014]	IT/OS	Genetic Optimization of Site Layout Planning	The appropriate layout of temporary facilities has a large effect on construction time and cost, especially for large projects. The process involves identifying, sizing, and placing temporary facilities, ranging from lay-down areas to warehouse, education shops, and residence facilities, within the boundaries of construction site. Various factors affect the selection of necessary temporary facilities that support construction activities, including project size and nature, in addition to site location and space. Site layout planning has been dealt with extensively in the literature, with the objective of minimizing the total travel distance within the site. Most developed algorithms can be classified as one of two broad categories: layout improvement, and layout construction. Layout improvement algorithms begin with an initial layout and continuously exchange the locations of facilities, until a layout of minimum cost is obtained. Using the same objective, layout construction algorithms construct a layout to ensure useful quality data can help improve tracking, decisions, and predictions related to future works. A driver organizational culture, to improve the predictability of project outcomes, and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework required for project success. ram scheduling, with multiple prime contractors, and have developed a workable and efficient method of handling the program, following the AACE TCM Framework and recommended practices. This paper will provide detailed guidelines for setting up the project controls process, developing the program schedule, analyzing the integrated program schedule, identifying and mitigating performance risks in conjunction with the BIM model, and reporting to the program management team. This lessons-learned approach from a variety of successful industry programs enables efficient development and use of an integrated program schedule to meet the owner's needs and goals.	In an attempt to simplify the facility layout problem and present it in a form that is easily implementable by practitioners, a site layout model has been developed on a spreadsheet program	Design	A
Kashwagi	2001	[2010-2014]	State of Hawaii Selects "Best Value" for Artificial Intelligence	There is a growing movement in the construction industry away from procurement through traditional low-bid methods toward performance based or best value procurements. Until now, the one-step and two-step methods have been the two major types of best value procurement. The major difficulty with both systems is finding an unbiased way to evaluate the value of performance. This article explores the procurement of construction services by the State of Hawaii, using an artificial intelligence performance information procurement system (PIPS) to identify best value. A best value environment is one in which contractors optimize both price and performance.	This article explores the procurement of construction services by the State of Hawaii, using an artificial intelligence performance information procurement system (PIPS) to identify best value.	Analysis	A	
Park	2003	[2010-2014]	EST-24	A Budget Estimating Method of Environmental Cost for Housing Projects	The principle of sustainable development has become the predominant subject within the construction industry over the last decade. This leads the industry to accommodate the importance of the environment. Nevertheless, the costs related to the environment during the construction process have often been omitted or diverted to other purposes due to including the costs into common work costs in Korea, the related laws and regulations were revised to reduce the impact of the positive environmental management of contractors and the proper use of the environment cost (EC). In accordance to the revised laws and regulations, the owner has to account for the EC as a separate cost item in the construction budget. However, the definite standard and method for estimating the EC have not been established yet in the Korean industry. For the last 5 years, the contract volume of multihousing construction projects in Korea has formed approximately 25% of the total building construction volume [1]. In general, the multi-housing projects to ensure useful quality data can help improve tracking, decisions, and predictions related to future works. A driver organizational culture, to improve the predictability of project outcomes, and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework required for project success. ram scheduling, with multiple prime contractors, and have developed a workable and efficient method of handling the program, following the AACE TCM Framework and recommended practices. This paper will provide detailed guidelines for setting up the project controls process, developing the program schedule, analyzing the integrated program schedule, identifying and mitigating performance risks in conjunction with the BIM model, and reporting to the program management team. This lessons-learned approach	This paper reviews the various methods that can be used in estimating the EC and investigates the factors affecting the EC items and then calculates the environmental unit cost by the statistical method	Management	A
Storupka	2004	[2010-2014]	RISK-15	Neural Networks in the Risk Management of a Project	Artificial intelligence has always intrigued humans, and inspired biologists, philosophers and mathematicians. The term "artificial intelligence" got a new meaning when the first attempt to formalize appeared. These attempts have increased and their ranges have been broadened as a result of new technology and development of the modern tools of rapid calculations and data processing. The first mathematical description of a neuron was developed oped by McCulloch and Pitts in 1943. The ideas of the artificial neural networks (e.g., the algorithm of reverse propagation of error) were improved and propagated in the 1970s and 1980s by Werbos (1974), Rumelhart (1986), Hinton (1986), Patar (1985) and Rumelhart (1986) [2]. Neural networks can be successfully used to describe a stru- turalized problem. These types of problems are both risk of project and risk management, which consists of lots of complex tasks and issues. This article outlines the concept of using artificial neural networks in the phase of the organizational and technological planning of engineering projects, particularly the building works.	This article outlines the concept of using artificial neural networks in the phase of the organizational and technological planning of engineering projects, particularly the building work	Management	A
Gokaraghi	2018	[2018-2021]	CDR-2072	Productivity Loss Quantification Using a Novel Artificial Intelligence Approach	Researchers and industry practitioners agree that changes are an integral part of construction projects and that overlooked cumulative impact of changes can be detrimental to project success. Cumulative impact of changes on construction labor productivity is difficult to identify and measure. Although Measured Mile Analysis (MMA) is a well-known and widely accepted method for quantifying the cumulative impact of changes on labor productivity, it is not easily applicable to many cases. This paper presents a novel Artificial Intelligence (AI) approach to quantify loss of productivity due to changes during project development. Two datasets were collected from earlier studies using real construction projects, namely, the developed models of Leonard (1988) and Assem (2005). The model developed in this paper, along with two widely used regression models – "Lognormal and Ibbot" – are tested against actual cases to demonstrate the developed model's capabilities. While the developed model is expected to be beneficial for future works to ensure useful quality data can help improve tracking, decisions, and predictions related to future works. A driver organizational culture, to improve the predictability of project outcomes, and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework required for project success. ram scheduling, with multiple prime contractors, and have developed a workable and efficient method of handling the program, following the AACE TCM Framework and recommended practices. This paper will provide detailed guidelines for setting up the project controls process, developing the program schedule, analyzing the integrated program schedule, identifying and mitigating performance risks in conjunction with the BIM model, and reporting to the program management team. This lessons-learned approach	This paper presents a novel Artificial Intelligence (AI) approach to quantify loss of productivity due to changes during project development.	Analysis	A
French	2020	[2018-2021]	TCMA-3375	Enhancing Data Reliability in a World of Increasing Information	Thorough, reliable information is a necessary component for making sound decisions. While many sources of data are available in the construction industry, they can be difficult to obtain or may be inaccurate. Lately, companies have undertaken initiatives to compile past results, making the information available and usable for better predictions. Also, recently developed technological systems and tools are improving the quantity, quality, and timeliness of information available to the construction industry. Although past data sources and new tools are providing a wealth of information, a critical issue remains: ensuring the data is trustworthy. Creating a trusted historical database requires consistent, methodical data collection techniques, analysis, monitoring, verification, and normalization. While improving data quality is necessary for improving predictions, it can also better position companies to take advantage of upcoming machine learning and artificial intelligence (AI) capabilities. Developing proper organizational and technological planning of engineering projects, particularly the building works changes on labor	Developing appropriate strategies to ensure useful, quality data that can help improve monitoring, decisions and predictions related to future	Analysis	A
Al-Rusood	2020	[2018-2021]	IT-3394	Use of Drones and Emerging Technology in Megaproject Supply Chain	Project stakeholders go through painstaking exercise to identify required material and to expedite them for timely delivery to the site in avoiding project delays, thus creating complicated warehousing and logistics challenges of having the right material at the right time and location. This paper presents an analytical model to manage the megaproject warehousing issues. Drones equipped with streaming video capability can help survey a site, identify optimal locations for warehouses, and monitor the jobsite for suspicious activity – allowing the project team to easily monitor locations and quantities of assets and materials as a glance to ensure they will be there when needed. When the request for a particular material arrives, an optimal path is digitally mapped for the drone to travel based on mapping done previously. The paper will discuss an optimization model for warehouse management through the use of drones and artificial intelligence (AI). An analytical model of warehousing management with huge potentialities to ensure useful quality data can help map	This paper presents an analytical model to manage the megaproject warehousing issues.	Management	A
Baker	2020	[2018-2021]	CDR-3516	"Six Told Me So" – Expert Witness Testimony at the Dawning of the Age of Artificial Intelligence	This paper will explore technical and legal issues expected to be encountered in testimony of engineering, scheduling and cost expert opinions relying on the use of automated systems and artificial intelligence (AI). Specific topics include: • The current state of the law and practice • The degree of reliance on the output from automated systems and artificial intelligence • The extent to which the expert must be familiar with the inner workings of the software • What data need to be provided in discovery • Does proprietary software need to be provided for the opposing experts' use? The paper will conclude with a set of key considerations for experts, lawyers and policy makers regarding this fast-developing area of practice.	This paper will explore technical and legal issues expected to be encountered in testimony of engineering, scheduling and cost expert opinions relying on the use of automated systems and artificial intelligence (AI). Specific topics include: • The current state of the law and practice • The degree of reliance on the output from automated systems and artificial intelligence • The extent to which the expert must be familiar with the inner workings of the software • What data need to be provided in discovery • Does proprietary software need to be provided for the opposing experts' use? The paper will conclude with a set of key considerations for experts, lawyers and policy makers regarding this fast-developing area of practice.	Management	A

Zangeneh	2021	[2018-2021]	TCMA-3733	Analytics of What? Implications of Industrial Megaprojects: Complexity in Data-Driven Forecasting	The fourth industrial revolution has led to widespread digitalization across the delivery chain of construction and project industries. The digitalization of project processes and other technological enhancements such as digital project delivery, building information modeling, and digital twins have created vast amounts of promising data. At the same time, data science, artificial intelligence, and machine learning are becoming more prominent and available for a variety of tasks, raising debates and discussions about what is project analytics and how analytics processes and functions can create a competitive advantage. Systematic approach to this issue requires a holistic view into three aspects of it: first, inherent complexities of projects as complex and interdependent systems; second, nature of project delivery processes, management, and controls; and third, knowledge of high-performance analytical algorithms, tools, and trends in technological innovation. This paper provides an overview of the subject to ensure useful quality data can help improve tracking, decisions, and predictions related to future works to drive organizational culture, to improve the predictability of project.	This paper provides an overview of the author's experience and perspectives on project complexities, and success factors in dealing with such complexities.	proposed for successful project analytics	Management	AI
Glowacz	2021	[2018-2021]	TCMA-3674	The Impact of AI-Driven Project Management On an Organization's Decision-Making Culture	The project management industry is continuously facing challenges with rather low project success rates, which therefore demands a new intelligent approach to how projects are being managed and delivered. Artificial intelligence (AI) represents a welcomed opportunity for the project management practice to improve its service quality, to address its existing shortcomings with project deliverables, and increase the efficiency of projects. Accordingly, AI in project management is expected to enter and revolutionize the project management industry over the next months and years. This new reality, however, means also dramatic change for an organization regarding its decision-making and project culture since this will mean a fundamental change in the beliefs and behaviors of project professionals. The paper aims to investigate the key elements of an AI-powered project management approach and how it will impact project management practitioners and their norms and values in terms of decision-making in projects. Based on organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing	The paper aims to investigate the key elements of artificial intelligence (AI) with a total cost of ownership (TCO) model to reduce uncertainty and make better decisions. As is a key element of the AI-powered project management approach and how it will impact project management practitioners and their norms and values in terms of decision-making in projects	Based on the findings, a recommended approach will be drafted to transition to an adjusted cultural setting that fits in a wider data-driven organizational culture, to improve the predictability of project outcomes.	Management	AI
Spreitzerberth	2021	[2018-2021]	TCMA-3603	Supplier Selection with AI-Based TCO Models: Cost Prediction Case Study in an Automotive OEM	The goal of this research is to understand more clearly the lifecycle costs of supplier selection using methods of artificial intelligence (AI) with a total cost of ownership (TCO) model to reduce uncertainty and make better decisions. As is a key element of the AI-powered project management approach and how it will impact project management practitioners and their norms and values in terms of decision-making in projects. Based on organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing	The goal of this research is to understand more clearly the lifecycle costs of supplier selection using methods of artificial intelligence (AI) with a total cost of ownership (TCO) model to reduce uncertainty and make better decisions.	This study suggests practical ways to break down uncertainty into a measurable quantity.	Management	AI
Holmann	2021	[2018-2021]	TCM-3756	Recommended Practice for Project Historical Database Development	The value of good project historical data and metrics for use in project planning (estimating, planning and scheduling, risk analysis, etc.) has always been recognized by cost engineers. The AACE's virtual library includes examples of successful implementation. However, the challenges of developing and maintaining a database (located demands on resources and budgets and extended time to achieve objectives) have resulted in relatively few companies successfully implementing them. However, increasing interest in artificial intelligence (AI), analytics, business intelligence tools and the use of commercial software has raised interest. This interest resulted in the development of Recommended Practice (RP) 1148-20 "Project Historical Database Development". The RP is a guideline for requirements assessment, specification, development, implementation, and maintenance of a project historical database system. A database maturity model is also included. The intended audience is owner, contractor and agency organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the capability index score.	The main focus is on databases for estimating, planning and scheduling, risk analysis, etc. as cost and schedule performance indicators, into measures of efficiency, productivity, and scope variance.	databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis and other processes in the TCM Framework.	Analysis	AI
Whitledge	2008	[2010-2014]	EST-04	A Practical Application of Monte Carlo Simulation in Forecasting	This paper describes a practical application of the Brownian walk Monte Carlo simulation in forecasting. By setting up a simple spreadsheet and time-dependent historical data, this simple Monte Carlo routine is useful in forecasting productivity, mobilization rates, labor trends, etc. This is especially useful when historical data can not be modeled using standard data regression techniques. The paper discusses basic forecasting for single commodities, and it outlines a more robust methodology to create a composite forecast by combining several single commodities. While Monte Carlo simulation is very popular to calculate the "P50 value" for contingency planning, the true power of Monte Carlo simulation is in data extrapolation, or forecasting beyond the known data points, and understanding the range of outcomes expected. The paper addresses some basic elements of Monte Carlo simulation, approach for its application via a Brownian walk approach in understanding ages to ensure useful quality data can help improve tracking, decisions, and predictions related to future works to drive organizational culture, to improve the predictability of project.	This paper describes a practical application of the Brownian walk Monte Carlo simulation in forecasting.	The approach can help companies develop unique near term market insights and trends in order to compete in marketplace on analytics	Analysis	Analytics
Wurf	2012	[2010-2014]	RSK-905	Scope Analytics: A Quantitative Approach to Scope Management for Environmental Remediation Projects	Perhaps the most significant source of cost and schedule risk within an environmental remediation project is uncertainty around scope. More specifically, variance in cost and schedule are typically driven by variance in the quantity of impacted material driving a project, not by the efficiency or productivity of field tasks. The intelligence used to characterize a cost in a remedial manner, to the full extent of contamination is frequently uncertain prior to implementation of the remedial solution. In order to plan, control, and learn from remediation projects, an analytical approach to scope variance is needed. This paper discusses quantitative methods for decomposing traditional variance measures, such as cost and schedule performance indices, into measures of efficiency, productivity, and scope variance. It then shows how these historical performance metrics are benchmarked to improve project planning through estimating and risk measurement. The paper will illustrate a hypothetical application in remediation and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the capability index score.	This paper discusses quantitative methods for decomposing traditional variance measures, such as cost and schedule performance indices, into measures of efficiency, productivity, and scope variance.	The paper will illustrate a hypothetical application in remedial excavation, but the fundamental theories apply to any scope of work in which the quantity of impacted media is a factor in understanding cost, schedule, and the associated risk.	Management	Analytics
Budgett	2012	[2010-2014]	OWN-1055	Implementing Primavera P6 Release 8.1.1 Leading Change in a Large Owner Organization	In 2011, my company decided to implement the Oracle Primavera suite of Project and Portfolio Management (PPM) tools. As the owner of the project, the scope was the upgrade of our existing Primavera P6 Client and Web to Release 8.1.1 and the implementation and integration of Primavera Analytics, Primavera Inspire interface with SAP, Oracle Business Process Management (BPM), and Oracle Data Publisher for reporting. It has been a long journey from its standard PPM tool to now may be one of the largest implementations of this scale at the major Oracle tools. There is much contemplation and apprehension in the construction profession about the "Oracle-lization" of the Primavera we all know and love, and what this means to the future of the P6 Client and even P6. This paper will discuss the business case for upgrading to the most current version, leading change from the grass roots in a large owner organization, innovative uses for some of the modules in the tool, and realizing the results of the change on overall project and program performance.	This paper will discuss the business case for upgrading to the most current version, leading change from the grass-roots in a large owner organization, innovative uses for some of the modules in the tool, and realizing the results of the change on overall project and program performance.		Management	Analytics
Budgett	2014	[2010-2014]	OWN-1670	Integrated Project Reporting Using Dashboards: Harnessing the Power of Primavera P6	"Integrated Reporting" can be accomplished by using reporting and dashboard tools that support accessing multiple data sources directly or through a data warehouse. The data sources can include Primavera P6 for planning and scheduling, financial tool such as SAP, and/or internal home-grown databases. The data warehouse is the "central" database containing data with flexible structure used in producing reports that incorporate the data directly from their suitable source and databases. The report/dashboard solution is supported by programming to align the data based on common elements to provide Enterprise level information, supported by individual system audit reports. A further objective is to move beyond sheet spreadsheet data by incorporating various sources into a single source of consolidated information. The data warehouse can also be used to store snapshots of data in order to perform trending and analytics. This paper will discuss the business case for developing integrated reporting dashboards, an organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the capability index score.	This paper will discuss the business case for developing integrated reporting dashboards; an example case-study of an existing dashboard developed and used by a Utility company; and alternative approaches, such as off-the-shelf intelligence offerings.	A further objective is to move beyond sheet spreadsheet data by incorporating various sources into a single source of consolidated information. The data warehouse can also be used to store snapshots of data in order to perform trending and analytics.	Analysis	Analytics
Lucy	2017	[2015-2017]	OWN-2565	Data-Driven Management for Digital Capital Projects	Construction projects and budgets are under scrutiny—requiring an increase in transparency, accountability, and accessibility to information. Combined with an influx of data from emerging technologies, the challenge for executives is to transform this information into insights, promoting data-driven decisions as they balance increased demands with limited resources. The typical implementation of project management solutions within capital programs often leads to redundant tracking from multiple systems and decreased data quality from disconnected systems. The various data sources often deliver fragmented, prioritizing, understanding, and reporting project performance. Analytical and data visualization solutions tailored to the construction industry can help summarize performance, provide deeper insights, and highlight previously unknown risks critical in managing complex construction portfolios. Maintaining access to construction analytics based on readily available data sets provides owners with rapid and reliable snapshots to ensure useful quality data can help improve tracking, decisions, and predictions related to future works to drive organizational culture, to improve the predictability of project.	Maintaining access to construction analytics based on readily available data sets provides owners with rapid and reliable snapshots of project performance along with predictive indicators.	This allows business owners to more effectively monitor their projects and more easily identify risks.	Management	Analytics
Arrow	2018	[2018-2021]	RSK-2926	Project Controls & Data Analytics in the Era of Industry 4.0	Economists predict that the Fourth Industrial Revolution (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, 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 I&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 paper will explore algorithms for data science capability improvement. How project controls professionals can develop and lead an effective digital strategy through steps for effective data science opportunities for employing machine learning, organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the capability index score.	This paper will explore algorithms for data science capability improvement. How project controls professionals can develop and lead an effective digital strategy through steps for effective data science opportunities for employing machine learning, organizational and technological planning of engineering projects, particularly the building works changes on labor productivity, it should not be considered a replacement for professional judgment in assessing the cumulative impact of changes. This study suggests practical ways to break down uncertainty into a measurable quantity. References are drawn from the Total Cost Management Framework and the capability index score.	New technologies promise to make the theory of risk intelligent strategies a possibility for both companies large and small.	Analysis	Analytics



Leika	2018	[2018-2021]	PM-2886	Improving Portfolio Management through Integrated Master Schedules and Dashboard Analytics	On time and on budget: these are targets not easily achieved—and often missed. The specific project management practices that drive success are challenging to identify, let alone adjust as the project proceeds. As the builders to project management, project schedules and related reporting struggle to provide actionable, insightful information and often the result of integrating project dependencies and shared resources across programs and business units is a complex, integrated master schedule (IMS) caribean down slopes between project stakeholders, consolidate disparate information, and track progress holistically. Data-driven dashboard reporting tools can then integrate related project data such as cost and risk, analyze progress against program benchmarks, and visualize progress. By first developing a comprehensive, integrated, and confirmed master schedule, then utilizing dashboard reporting and schedule analytics, organizations can reduce the likelihood of human error in the reporting process. This concept aims to ensure useful quality data can help improve tracking, decisions, and predictions related to future work-to-driven organia	By first developing a comprehensive, integrated and confirmed master schedule, then utilizing dashboard reporting and schedule analytics, organizations can reduce the likelihood of human error in the reporting process.	This in creases confidence across the leadership levels of the portfolio and enabling objective, data-driven decisions to improve project delivery	Management	Analytics
Bomba	2019	[2018-2021]	EST-2881	Benchmarking and predictive Analytics to Improve Estimates, Forecasts, and Performance Measurement	By applying predictive analytics to an organization's historical data, project cost estimate risk assessment can be more accurate, improving forecasts and execution on a multi-year investment plan. The challenge with using historical data is that it is often dispersed throughout various financial and project management software systems, requiring significant data analysis efforts to be able to use it. This paper describes the steps involved in developing a robust cost benchmarking tool that centralizes historical project data into a user-friendly platform and predictive cost of a construction project with a high degree of confidence using only a few input variables. This paper will detail the four development steps: data gathering, data classification, data analysis, implementation, and refinement. Using the results from the tool, organizations can negotiate project cost reductions and focus risk management processes to inform contingency decisions. Across a portfolio, the changes can result in significant savings and operational and technological planning of engineering project	This paper will detail the four development steps: data gathering, data classification, data analysis, implementation, and refinement. Using the results from the tool, organizations can negotiate project cost reductions and focus risk management processes to inform contingency decisions.	Across a portfolio, the changes can result in significant savings and form the basis for setting achievable performance targets.	Analysis	Analytics
Crisis	2018	[2018-2021]	DEV-2787	PE Leadership, Training and Adoption Methods for Large Capital Programs	As infrastructure has necessitated a substantial increase in the size and intensity of owner capital programs in recent years. At the same time, projects are getting larger, more integrated, and more complex. Generally, project controls and governance have improved recent years with the introduction of new technologies and processes, but the project complexity is outpacing improvements. Layer onto this the volatile project failure and hesitations, and it becomes clear that something different is needed. These factors have led to a larger number of people needing to be trained and developed into project schedulers. A craft that used to be honed over many years of experience in the field now has to be developed over the course of several months. The Primavera P6 day standard training is not sufficient to make a proficient scheduler. Proficiency in tools such as P6 is critical for the adoption effective schedule management practices for organizations. Training should be strategic, targeted, and planned in such a way to ensure useful quality data can help improve tracking, decisions, and predictions related to future work-to-driven organizational culture, to improve the predictability of project outcomes, estimating and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework required for project success: risk scheduling, with multiple prime contractors, and have developed a workable and efficient method of handling the program, following the AACE TCM Framework recommended practices. This paper will provide detailed guidelines for setting up the project controls process, developing the program schedule, analyzing the integrated program schedule, identifying and mitigating performance risks in conju	This paper will present some key leadership lessons learned and strategies gleaned from training and mentoring hundreds of schedulers and project managers that were new to the Primavera P6 systems, as well as how to overcome the balance between having young people jumping in and using it without knowing the mechanics of scheduling.	Data analytics and metrics can be used to simplify the process of categorizing people into actionable groups.	Analysis	Analytics
Callahan	2019	[2018-2021]	TCMA-3285	Optimizing Construction Projects through Effective Information Governance and Data Analytics	The construction industry is generating data and information at an exponential rate. Due to the rapid increase of available construction data, information governance has become one of the most pressing industry priorities. This paper provides an introduction to information governance, outlining the potential benefits for stakeholders throughout the project lifecycle. In addition, this paper presents a maturity model that defines a four-level information governance framework to describe the level of information governance at each phase of the construction lifecycle. Finally, this paper describes how construction projects can leverage information governance and advanced analytics to make informed project decisions, locate information quickly, mitigate risk, and prepare for potential claims and litigation.	This paper presents a maturity model that defines a four-level information governance framework to describe the level of information governance at each phase of the construction lifecycle.	This paper describes how construction projects can leverage information governance and advanced analytics to make informed project decisions, locate information quickly, mitigate risk, and prepare for potential claims and litigation.	Analysis	Analytics
Naguri	2019	[2018-2021]	TCMA-3278	Developing and Implementing Visual Dashboards Using P6 Data	This presentation will focus on how to create enticing and attractive business intelligent dashboards to share with colleagues and clients using data from the most used scheduling tool. The author, working for an ENR Top 50 Program Management firm ranked #4 in June 2018, have experience in large program scheduling, with multiple Contractors, and have developed a workable and efficient method of handling the program scheduling reporting using two dynamic and interactive intelligent analytics tools, Microsoft Power BI and Google Data Studio. The sharing of multiple effective and successful implemented dashboards will tempt the reader to use this new technology in their everyday work and improve client satisfaction when it comes to dynamic visual reporting of project scheduling.	This presentation will focus on how to create enticing and attractive business intelligent dashboards to share with colleagues and clients using data from the most used scheduling tool.	The sharing of multiple effective and successful implemented dashboards will tempt the reader to use this new technology in their everyday work and improve client satisfaction when it comes to dynamic visual reporting of project scheduling.	Management	Analytics
Ayers	2019	[2018-2021]	TCMA-3054	Data Analytics to Drive Reporting and Insights for Timely Decisions and Improved Business Performance	Many large organizations have centralized reporting teams and data analysts who develop a variety of reports for project management and portfolio stakeholders. In large organizations, the sheer volume of data and the complexity of the work and processes, strong data management and analysis skills. The challenges for these teams include having to use data that is often contained in various disparate systems as opposed to one source, making analysis complicated and time-consuming. Both reporting and data analysis play key roles in influencing driving decisions and actions that lead to greater value for organizations; however, what often results is significant effort to manually curate the data to update recurring reports and less time for analyzing the data to drive key insights for timely decisions and improved business performance. In addition, large organizations cannot pivot as quickly to adopt industry-leading software or data solutions, resulting in a mixture of incompatible systems with different data formats and components. By developing a standardized reporting framework and a robust system architecture with a historical database from a data-driven perspective, an organization can be equipped with an end-to-end reporting structure and process that allows for transparent data analytics, helping project and portfolio stakeholders and leadership reach decisions more quickly and manage their business more effectively. This paper will focus on four key areas to consider when developing a standardized reporting framework for large organizations: data automation and management, assessing effectiveness and consistency of key performance indicators, tailored reporting that caters to the various levels of the target audience, and current systems and tools, including the integration of business intelligence and data visualization solutions. It will include the requirements to implement the framework, the development process, and the benefits that it offers.	This paper will focus on four key areas to consider when developing a standardized reporting framework for large organizations	data automation and management, assessing effectiveness and consistency of key performance indicators, tailored reporting that caters to the various levels of the target audience, and current systems and tools, including the integration of business intelligence and data visualization solutions.	Analysis	Analytics
Dufmarco	2019	[2018-2021]	EST-3201	Predictive Analytics Can Improve Cost Estimating for Smart City Projects	Smart city projects will dramatically improve urban living, if they succeed. Many cities and traditional infrastructure construction contractors are being challenged to understand, estimate, budget, propose and execute complex technology development and deployment projects. Failure to understand the internet of things (IoT) and other technologies, combined with typical contractor over-optimism, results in under estimates that may lead to disaster. Urban living will only improve if these projects start out with solid baseline cost and schedule estimates. New research shows that credible estimates can be achieved by leveraging benchmarks and lessons learned from defense and security command, control, communications, computers, intelligence, surveillance and reconnaissance projects (C4ISR). New smart city statistical predictive cost and schedule models, along with proven C4ISR predictive models, are a critical resource for city governments and contractors undertaking these challenging projects. This paper will explore to ensure useful quality data can help improve tracking, decisions, and predictions related to future work	This paper will describe these models and illustrate the value of accurate estimating through a smart city project case study.		Analysis	Analytics
Holmann	2019	[2018-2021]	EST-3184	Estimate Validation and Bias Assessment: Ratio-to-Drive Method	Cost estimate validation is often mentioned in AACE® International literature but not described in depth. This paper describes the practice of cost estimate validation including a method called ratio-to-drive. Validation starts with the business establishing an objective in terms of a cost strategy that is captured in the basis of estimate document. The cost strategy defines the estimating approach in respect to derived base estimate bias (and every estimate is biased). Achievement of the cost strategy is the quality being assured by validation. Then, relative, normalized metrics (cost estimating relationships in ratio form) are developed from a comparison set of projects drawn from an historical database (or obtained from some other reliable source). Database systems often do double-duty as validation tools; a precursor to the future of analytics and machine learning. The ratio-to-drive method applies the metrics in a logical, stepped sequence of comparisons that seeks to pinpoint the cause of variation. Because base estimate bias is a systemic risk, and validation measures bias, validation is also a first step in quantitative risk analysis, while a long-established practice, estimate validation is not defined in AACE® cost engineering terminology (RP 105-00) and is only superficially covered in other estimating RPs. As such, this paper is intended as a basis for an RP that will be aligned with others that include validation or benchmarking. The primary affected RPs (with abbreviated titles) are: 318-03 (estimate review), 348-05 (basis of estimate), 358-09 (estimate planning), draft 35-01 (estimate requirements) and draft 428-08 (parametric risk analysis).			Analysis	Analytics
England	2019	[2018-2021]	BIM-3072	The Construction Process - Moving Beyond BIM to Build with Confidence	Today's construction stakeholders don't care how fancy a building information model (BIM) is, they care about having buildings done on time with minimal overruns or mistakes. Traditionally, BIM has been used as a design tool to glow architecture, engineering, and construction (AEC) professionals insight into the design and construction of buildings and infrastructure. But, there's more to consider beyond just BIM. A constructive process integrates the complete building lifecycle to manage construction activities, team collaboration and improve overall productivity. By combining design, estimation, project management and engineering made into a collaboration platform, data from different sources can be combined and used to make more informed decisions before build and beyond. This integrated process helps all stakeholders to have complete visibility with the project so that they can coordinate before they get onsite. This data-centric process also enables construction stakeholders with analytics and insights to ensure useful quality data can help improve tracking, decisions, and predictions related to future work-to-driven organizational culture	This integrated process helps all stakeholders to have complete visibility with the project so that they can coordinate before they get onsite.	This data-centric process also provides construction stakeholders with analytics and business intelligence that can be used to not just build with confidence but also optimize their entire business process, procedures and operations.	Management	Analytics
Jan	2020	[2018-2021]	TCMA-3437	Design Principles for Creating a Visually Appealing Dashboard	Organizations have many professionals working on various data analytics initiatives. While the work of data professionals may vary from time to time, designing a dashboard is a common task for most of these individuals. A dashboard is a good way to provide insights ranging from a top-level summary analysis to detailed-level tracking. Often, however, data professionals struggle to fit a plethora of information in a dashboard because of the different requirements that come from various parts of an organization. This paper defines the 5 Ws and 1 H for designing an appealing dashboard and can guide data professionals in accommodating the needs of multiple people at various levels within the organization.	This paper defines the 5 Ws and 1 H for designing an appealing dashboard and can guide data professionals in accommodating the needs of multiple people at various levels within the organization.		Analysis	Analytics
Nelson	2020	[2018-2021]	PS-3493	Improve Planning and Decision-Making Using Advanced Schedule and Reporting Management	Construction firms usually focus on building the project. Recording events, tracking constraints, and monitoring progress often take a back seat. Therefore, opportunities to use available data, even when unstructured, is lost. Firms lose their ability to gather and study information, thus reducing their effectiveness in project planning, decision-making, and predictive analysis. The value of schedule management must be improved before project planning and decision making can be enhanced. Many firms keep multiple schedules that are not on-track, and so the potential of detailed planning and a well-constructed master schedule is missed. Improving the collection and integration of meaningful data while updating a single master schedule allows firms to anticipate and provide insight into costly project issues and assist with planning current and future projects. Data can then be converted in easy-to-analyze reports to improve project execution. By using data from real-life projects, this paper demonstrates how tags to ensure useful quality data can help improve tracking, decisions, and predictions related to future work-to-driven organizational culture, to improve the predictability of project outcomes, estimating and scheduling, parametric risk modeling, etc.). However, databases may also support resource planning,	This paper demonstrates how these reports and analysis have been proven to assist in multiple ways, including change-order requests, weekly reporting on progress, identifying key project issues, analyzing internal issues etc.	Identifying progress impact trends, and designing predictive analytics to identify future trends.	Analysis	Analytics

Zangeneh	2021	[2018-2021]	TCMA-3733	Analytics of What? Implications of Industrial Megaprojects: Complexity in Data-Driven Forecasting	The fourth industrial revolution has led to widespread digitalization across the delivery chain of construction and project industries. The digitalization of project processes and other technological enhancements such as digital project delivery, building information modeling, and digital twins have created vast amounts of promising data. At the same time, data science, artificial intelligence, and machine learning are becoming ever more streamlined and available for a variety of tasks, raising debates and discussions about what is project analytics and how analytics processes and functions can create a competitive advantage. Systematic approach to this issue requires a holistic view into three aspects of it: first, inherent complexities of projects as complex and interdependent systems; second, nature of project delivery processes, management, and controls; and third, knowledge of high-performance analytical algorithms, tools, and trends in technological innovation. This paper provides an overview of the as because have estimate bias is a systemic risk, and validation measures bias, validation is also a first step in quantitative risk analysis. While a long-established practice, estimate val	This paper provides an overview of the authors' experiences and perspectives on project complexities, and success factors in dealing with complexities.	proposed for successful project analytics functions.	Management	Analytics
Hollmann	2021	[2018-2021]	TCM-3756	Recommended Practice for Project Historical Database Development	The value of good project historical data and metrics for use in project planning (estimating, planning and scheduling, risk analysis, etc.) has always been recognized by cost engineers. The AACE® virtual library includes examples of successful implementations. However, the challenges of developing and maintaining a database (sustained demands on resources and budgets and extended time to achieve objectives) have resulted in relatively few companies successfully implementing them. However, increasing interest in artificial intelligence (AI), analytics, business intelligence tools and the availability of commercial software has raised interest. This interest resulted in the development of Recommended Practice (RP) 1149.20 "Project Historical Database Development". The RP is a guideline for requirements assessment, specification, development, implementation, and maintenance of a project historical database system. A database maturity model is also included. The intended audience is owner, contractor and agency agrees to ensure useful quality data can help improve tracking, decision, and predictions related to future works to drive organizational culture, to improve the predictability of project outcomes, estimating and scheduling, parametric risk modeling, etc.) However, databases may also support resource planning, project system benchmarking and performance improvement, forensic analysis, and other processes in the TCM Framework required for			Analysis	Analytics
							Total	100	