

Implications of Construction Industry Trends on the Educational Requirements for Future Construction Professionals

Timothy C. Becker,[1] Edward J. Jaselskis [2] and Cory P. McDermott[3]
[1]Ph.D. Student, Department of Civil, Construction and Environmental Engineering, Iowa State University, 451 Town Engineering Building, Ames, IA, 50011, tcbecker@iastate.edu
[2]Professor, Department of Civil, Construction and Environmental Engineering, Iowa State University, 456 Town Engineering Building, Ames, IA, 50011, ejaselsk@iastate.edu
[3]Project Engineer, The Beck Group, 1807 Ross Avenue, Suite 500, Dallas, TX, 75201, USA, cory.mcdermott@gmail.com

Innovation creates opportunity for improvement within the construction industry. Yet for construction professionals to benefit from innovative technologies and emerging business environments, they must both recognize opportunities and possess the prerequisite education and training needed to capitalize them. In order for construction educators to properly prepare students with the associated competencies for the advanced work of construction of the future, they must forecast the future and develop curriculum aligned with the projected proficiency requirements. Although, a crystal ball is not available to foretell a clear and predictable view of the future, construction educators are able to study established and emerging trends and are encouraged to use this information to understand the implications of these trends to curriculum and learning activities. Framed within the context of the construction industry, this paper presents scientific methodology of future prediction and trends research and also describes trends identified and studied over multiple years by the Strategic Planning Committee of the Construction Industry Institute (CII). In response to the presented construction industry trends, specific recommendations are made for construction curriculums to satisfy the expected proficiency required of the builders of the future.

Key Words: Construction Industry Trends, Construction Education, Information Technology, Globalization, Leadership

Introduction

Jack Welch, General Electric chairman from 1981 to 2001, has suggested that "if the rate of change on the outside exceeds the rate of change on the inside, the end is near." Change within the construction industry is evidenced by advances of information technology and by the evolution of the global business environment. Construction professionals should feel a sense of alarm when reading this quote by Mr. Welch, as often times the rate of change within construction companies is much slower than the rate of change evidenced by of the rest of industry (Business Roundtable, 1982). In order to sustain the health of the U.S. construction industry, construction companies must minimally understand trends in the industry. However, greater accomplishment can be attained by leading the industry through recognition of change and by capitalization of the opportunities presented.

Literature Review: Scientific Methods for Predicting the Future

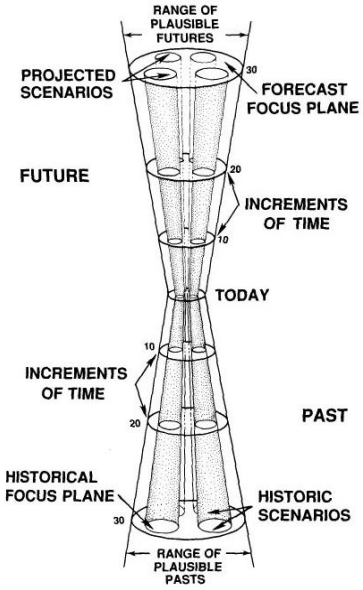
Throughout history society has attempted to foretell the future so it might benefit by planning for future events. This human nature can be observed in the simple example of basing one's coat selection upon the weather forecast. In contrast to questionable methods such as carnival fortune tellers, toy maker Mattel's Magic 8 ball, and newspaper published horoscopes; significant science-based methodology has been developed for studying the future and numerous rigorous approaches have been established for making reasonable and substantiated predictions. A summary description of "futuring" methods is provided by Edward Cornish in his book titled Futuring: The Exploration of the Future. Cornish presents an overview of 12 futuring methods (Cornish, 2004). This paper describes the following five methods for future prediction: scanning, scenario planning, trend analysis and extrapolation, expert interviews/polling, and brainstorming.

1. Scanning

Trends can be systematically identified and monitored through routine scanning of published information. Scanning is defined by Cornish as an "ongoing effort to identify significant changes in the world beyond the organization or group doing the scanning. Typically, scanning is based upon systematic survey of current newspapers, magazines, Web sites, and other published media for indication of changes likely to have future importance." (Cornish, 2004, page 78). A continued review of selected literature over time provides the reader with substantial knowledge of the studied area and establishes for the reader a creditable basis upon which to anticipate future trend movement.

2. Scenario Planning

Charles W. Taylor created a graphical model to illustrate the notion of scenario-based future predicting which he named the Cone of Plausibility (Taylor, 1993, page 14). The cone visually depicts the evolution of historical events into four different, yet "plausible," scenarios of the future. The proportionately increasing size of the cone diameter represents an increased uncertainty of actual occurrence of the particular predicted scenario as the timeframe for evaluation advances into the future. "Scenarios developed within the cone are considered plausible if they adhere to a logical progress from a starting point to a selected planning focus plane (Taylor, 1993)." The Cone of Plausibility implies that there is inherent uncertainty not only in projections of the future, but also in the understanding of the present and the past.



The Cone of Plausibility: Past and Future (Taylor, 1993)

3. Trend Analysis and Extrapolation

A third methodology used in predicting the future is trend analysis and extrapolation. This approach to prediction relies upon the monitoring and analysis of specific changing conditions within an environment to determine any change in direction and/or rate of change. Based upon data collected over an extended period of time, a knowledgeable individual can then make justified mathematical extrapolations of these trends into the future. Barry B. Hughes states that "Extrapolation is trend projection." (Hughes, 2006, page 2). For example, trend analysis and extrapolation can be used to forecast population growth for a nation. A pattern of change in population (i.e. growing, declining or stable) can be charted based upon historical counts and the rate of change can be calculated to determine the speed at which this change is occurring (e.g. growing exponentially, declining slowly, etc.). A mathematical extrapolation of the data can be calculated. As with all prediction methods, the ability to accurately extrapolate the future decreases as extrapolation is proposed at timeframes increasingly further into the future.

4. Expert Interviews/Polling

Collecting data for prediction of the future through interviews or polling, particularly with experts in the specific subject area, provides a common technique of trend identification and forecasting. Nicholas Rescher states "the judgmental mode of prediction roots in the personal estimation of individuals – ideally people who have expert

knowledge of the issues involved" (Rescher, 1998, page 85). The process of predictive data collection through expert interviews involves both the collection of information and the analysis or aggregation of the information. The data collection procedure is typically individual in nature, including: one-on-one, in-person interviews; telephone-conducted interviews; or individually-responded, paper format survey questionnaires (paper-based questionnaires are being replaced by Internet-based, on-line survey instruments). In each of the interview methods, the expert contributes his or her view of the future or opinion on trends in an isolated setting, independent from any bias and removed from any influence that might result from differing or contrary responses that other experts may have offered. Once the information from individual experts has been collected, it then is aggregated to develop a multilateral response representing a collective view of the numerous surveyed experts.

A second method of combining individual predictions is the Delphi method. The Delphi polling method or forecasting technique was developed by RAND Corporation (Research and Development Corporation) in 1953 by Olaf Helmer and Norman Dalkey (Bolling, 1996, page 75). The Delphi method solicits an individualized submittal of responses, yet builds a consensus through successive rounds of sharing of the independent answers provided by other respondents. In the first round, respondents provide their initial survey responses. These responses are then shared with all respondents, but the respondents are not told who provided which responses. In the second round, respondents submit another response which may be influenced by the peer responses from the first round. This cyclical process can be repeated until responses indicate which questions have a consensus response among the experts and which questions have no consensus.

5. Brainstorming

In contrast to an individual polling approach, brainstorming methods generate predictions through interactive and collaborating groups of experts. In a group setting, one contributor's idea develops through debate, deliberation and discussion among the group members. Brainstorming or "trigger sessions" (as termed by Bolling) should be carefully directed to ensure that all participants are contributing to the collective forecasting of the group regardless of an individual's shyness or uneasiness in a group setting. Effective brainstorming sessions "break down the posse mentality and yet have ideas from different people trigger each other" (Bolling, 1996, page 72). Specific tools used in group brainstorming sessions include professional mediators; public sharing of individually-prepared flip-charts; and real-time, electronic voting equipment.

CII Trends Research Methodology

The Construction Industry Institute (CII), specifically its Strategic Planning Committee (SPC), annually conducts trends research to identify issues and trends with the potential for affecting CII and its membership companies. CII's membership is primarily comprised of multi-national/global owner companies and large engineering and construction (E&C) firms. The methodology of the trends research employed by CII is founded upon the scientific methodologies of future prediction and trend evaluation presented in the literature review section of this paper. Further, the CII trends data collection and research activity may be categorized into four approaches: environmental scanning, survey questionnaires, interviews and group workshops.

The first approach includes environmental scanning of numerous publications regarding both construction industry specific trends and other general business and economy-related trends. The literature review completed for 2010 included, but was not limited to, the following published sources: World Economic Forum (WEF), International Council for Research and Innovation in Building and Construction (CIB), FMI Corporation, *Construction Executive*, *Engineering News Record* and a report of the National Research Council of the National Academies.

The second approach, a hard paper survey questionnaire, was implemented in 2008 to broadly query the CII membership regarding its insights regarding emerging trends in the construction industry (McDermott, 2009). In total 64 surveys were submitted for analysis, including 35 from contractor companies and 29 from owner companies. The third approach involves one-one-one interviews with subject area experts. During the CII trends investigation of 2008 and 2009, 4 on-on-one interviews were conducted with individuals from CII member companies and 5 were conducted with individuals from outside organizations.

The fourth approach is collection of trends data obtained through numerous workshops in which academic moderators posed certain suggestions of industry trends based upon published trends literature and then directed structured and topical discussions to solicit personal insights and validation from the participating industry experts. The research workshops were conducted through two methods. The first method included traditional face-to-face group meetings

through which extensive discussion was conducted and minutes were captured. The second method, described as "webinars," included teleconferencing and web-site based presentations to allow individuals to participate from distributed, remote locations. By accessing a web-site, all participants could view and follow along with a Microsoft PowerPoint presentation. In addition to verbal sharing of qualitative information, the webinar format also allowed for submittal and analysis of quantitative data via an on-line polling functionality.

Trends Reporting

Since 2005 a comprehensive list of construction industry trends have been researched, compiled and reported by CII. Table 1 (included at the end of this paper) provides a summary of the key trends identified during the 2010 CII trends research. The scope of this paper is limited to description of the following categorical trends: green building, alternative/renewable energy, information technology, globalization, integrated project delivery/lean construction, public private partnerships, infrastructure re-building, and retirement boom. A brief summary of each trend by category follows with certain examples of construction industry implications of the trend.

Green Building

Sustainability of the natural environment is a global concern. Consumers have prominently indicated support for conservation initiatives through purchasing decisions. Construction companies and designers have followed this market demand through the design and delivery of green buildings; specifically including projects certified by LEED, an internationally recognized green building certification system sponsored by the United States Green Building Council (USGBC). Certification by USGBC requires that the design and construction of the proposed project attain specific environmental building standards in the categories of site selection, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.

An increasing trend in the number of construction projects which include the reuse and renovation of existing buildings rather than demolition of existing improvements and new ground-up construction has been reported in the CII research and is consistent with the green building movement. Additionally, contractors report a growing demand for projects which modernize information technology and other building systems within historic and other existing buildings. These trends further demonstrate society's concern for the environment and its respect for older buildings, particularly those with unique architectural character or historical significance.

Alternative/Renewable Energy

Literature review, surveys and subject area interviews have identified a trend of increasing alternative energy production projects, including solar farms, wind turbine facilities, and nuclear-based electrical generation facilities. The demand for these facilities originates both in the concern for depletion of coal and petroleum natural resources found in the U.S. and in the desire for cleaner energy production. The U.S. government has strongly fueled the trend of increased renewable energy production projects. FMI reports that "renewal of the production tax credit (as part of the stimulus bill) will ensure wind, solar, geothermal and other renewable energy sources remain financially viable through at least through 2012." (FMI, 2010).

Information Technology

Advances in information technology have provided revolutionary tools for the design and construction of projects and have created research and development in the area of virtual design and construction (VDC). For example, CII trends research indicates a growing number of contractors utilizing Building Information Modeling (BIM). With BIM, project team members, including designers, construction managers and specialty contractors, coordinate the design and installation of building systems using computer models. The reliability of these models reduces physical conflicts during execution of the construction work and allows for increased use of pre-fabricated and off-site manufactured building components.

A second advance in information technology relates to the integration of design and fabrication software. Efforts are focused on the capability of information to move easily across traditional company or contractual boundaries. For example, design software now allows for sheet metal ductwork design information to be seamlessly transferred from the

initial engineer of record to the shop machine which fabricates the sheet metal assemblies. Such integration increases speed, reduces costs and eliminates typical errors caused by manual replication of data. Further, specialty fabrications of very complicated shapes designed for building facades, stairs, and other unique architectural features, which were previously impossible using manual operation, are now able to be manufactured using computer-controlled machines. Other trends within information technology include the application of radio frequency information devices and global positioning systems (GPS) for the location tracking of material, equipment and labor and laser scanning to collect large scale, as-built conditions.

Globalization

Globalization of business has affected all industries to some degree or another. The implications of globalization to the domestic construction industry have become deeper and broader over the past decade. One example of globalization is the use of globally-distributed design and project management teams. It is common for project teams to consist of members located around the world, each contributing a special component to the collective process. Such work is made possible by modern video conferencing and electronic data transfer technologies.

Globalization is also changing competition for construction companies. At one point considered only a market of local competition, construction now must be viewed in terms of the larger environment of global competition. Global competition is local when foreign-based construction firms enter local markets. FMI reports that "more than 100 international firms operating in the U.S. E & C market with more coming" (FMI, 2010). Overseas markets, which at one time were especially lucrative for U.S.-based engineering-procurement-construction (EPC) firms, are becoming crowded with new foreign competition that now possesses the financial and technical ability to compete for and win project historically out of their reach. Additionally, many examples can be cited in which smaller U.S.-based firms are being acquired by larger multi-national and global construction organizations, as such firms buy entry into established local markets and jockey for position as international "mega-firms."

Another element of the globalization trend is the emergence of powerful and competitive economies of developing countries, especially including the "BRIC" countries of Brazil, Russia, India and China. The sheer size of population in these countries creates a stronger demand for consumer products than currently present in the generally plateaued economies of Western Europe and North America. As a result, much of the largest new construction projects are located in these foreign countries. The African continent is commonly mentioned as the next market for industrialization and modernization, thus an opportunity for future large-scale construction work.

Integrated Project Delivery/Lean Construction

Another trend identified in the CII research relates to the growth of integrated project delivery (IDP) and lean construction. These closely related, innovative contracting and project management approaches build upon the relationship fostering of partnering and the team-based, design collaboration integral to design-build project delivery. Yet, in IDP and lean construction projects, manufacturing-based approaches to efficient production (e.g. collaborative risk sharing, pull-based project scheduling, inventory minimization, value stream mapping and waste reduction) are added to traditional project management metrics (e.g. cost, schedule, quality and safety). Firms executing projects with a lean construction operating system are completing projects faster and at a lower cost. IDP tri-party contract agreements among the owner, architect and contractor have been introduced by the American Institute of Architects and the ConsensusDOCS coalition.

Public-Private Partnerships

Growth continues in the application of public-private partnerships (PPP) as the financial and contractual instrument to execute large infrastructure projects both in the U.S. and around the globe. PPPs are offered as a financing solution for governmental entities with strapped cash resources and/or limited borrowing abilities to leverage private capital and private financing mechanisms to fund public infrastructure projects.

Infrastructure Re-building

The American Society of Civil Engineers (ASCE) and many others have expressed the tremendous need of re-building the U.S. infrastructure, including roads, bridges, and airports. Policy makers are faced with the delicate trade-off of spending to provide critical infrastructure improvements with reducing public deficits to a publically-acceptable range.

Retirement Boom

In North America, owner companies, engineering and construction firms, and the U.S. government all have reported through the CII trends research a phenomenon of delayed retirements of their senior work-force due to depressed stock prices and devaluation of employee retirement plans (reported by industry experts during CII Webinar conducted on 3/25/2010). However, with anticipation of an economic recovery combined with the natural aging of the workforce, an impactful "retirement boom" is expected among the most experienced employees in the coming 3 to 5 years.

In addition to the occurrence of an unusually large retirement of many construction professionals, the construction industry employment base is also experiencing a trend of younger people avoiding construction employment, specifically "field jobs" within the building trades (reported by industry experts during CII Webinar conducted on 3/30/2010). Although construction unemployment remains high in 2011, the longer term trend for construction employment demonstrates a challenge of replacing the aging construction work-force given that young people, in general, are attracted to newer technology/modern industries rather than traditional labor-based field construction work.

Recommendations for Construction Education

The construction industry continues to work its way through the effects of the "Great Recession." It is unknown when or if construction activity will return to its pre-recession levels or if it will level off at some new "normal" level. Yet, optimism remains for opportunities within the construction industry. The CII trends research indicates that growth is expected in alternative energy, infrastructure projects and renovation work. Projects in these building sectors are anticipated within established markets (i.e. U.S. and Western Europe) and perhaps more significantly as "mega-sized" projects in emerging markets of rapidly developing, foreign countries. A challenge for construction educators is how to best provide construction students with the necessary competencies to succeed in the future impacted by the trends elaborated upon in this paper. The following sections set forth recommendations for advancement of construction education in three selected areas: globalization, communication/leadership and technology adoption.

Globalization

Many construction professionals will be called upon to integrate project team members who are geographically distributed around the world. These members may be engineering-related disciplines, owner representatives or suppliers of material. In many cases, the success of the construction project will be dependent upon the ability of the group of individuals to work together in an environment of trust and open communication. Construction professionals will contribute a critical role as the aggregator of team work and consolidator of distributed efforts into a final completed project. Successfully doing so will require an understanding of how cultural differences impact the actions and manners exhibited by people of diverse cultures. A critical soft skill of construction professionals will be the ability to generate the highest results from people from many different countries, perspectives and personalities.

A second element of globalization relates to economic rather than human aspects. For example, globalization impacts where projects are placed and where firms station employees. The "mega-projects" are commonly located in foreign countries with emerging economies. Out-sourcing of engineering and other technical support functions have been relocated to overseas facilities able to offer lower wages and best value.

These are just a few representative concerns that construction professionals will be challenged to address as globalization continues to expand. In order to properly prepare students for this work, construction education programs are encouraged to discuss construction in foreign markets, including unique project types, innovative means and methods, and differing business etiquette. As a class assignment, students should be asked to investigate

construction firms from other countries and gather a preliminary understanding of the breadth and depth of capability of these firms. Further, students can gain valuable insights regarding alternate design methods and construction innovations employed in other countries through case study-type learning methods.

In addition to lecturing, construction programs should allow for real, hands-on practice with global communication and interpersonal interactions. The Project Based Learning (PBL) Lab established by Dr. Renate Fruchter at Stanford University is a pilot model for how construction educators might teach and allow students to practice team collaboration in a "geographically distributed," global framework. Through the PBL lab organization, students of architectural, engineering, construction and other related disciplines collaborate with industry professionals and diverse academics from international companies and foreign universities to complete semester long class projects. The pioneering success of the PBL Lab has been acknowledged by the United States Distance Learning Association (USDLA) which presented its 2010 International Distance Learning Award to the PBL Lab.

Communication & Leadership

The degree to which a construction professional is able to effectively communicate information, integrate ideas and lead teams of individuals is a critical factor to both an individual's professional success and the success of the project in which he or she is involved. Knowing this criteria, universities must focus on academic exercises and extracurricular activities that develop and practice communication and leadership skills. Proficiency of communication must include all forms, including professional writing, verbal presentation, appropriate social-networking and effective electronic messaging. Construction professionals must develop an understanding and appreciation for what format of communication is best suited for the situation and the audience at hand.

The university setting provides excellent opportunities for students to develop and practice communication and leadership abilities. One such initiative, the Construction Engineering Cornerstone Learning Community, has been conducted at Iowa State University since 2004. In addition to an exposure to a broad range of construction-related topics, this program specifically fosters teamwork abilities through execution of student selected and organized service projects. These projects require that students coordinate and schedule activities, organize communication networks for the distribution of directions and deadlines related to work tasks, and practice leadership skills necessary to motivate and reward fellow student team members.

Construction programs have traditionally offered student branches of national industry organizations, such as student chapters of the Associated General Contractors (AGC) of America. Student-run clubs provide an exceptional training ground for communication and leadership development, competencies so critical for successful management of multi-disciplinary, collaborative and geographically-distributed project teams. Rather than limiting clubs to a certain degree program, these clubs should encourage membership and participation that crosses educational disciplines or "silos," thus exposing students to a broader range of perspectives. For example, architects should be encouraged to join and participate in Design-Build Institute of America student chapters and finance majors should be recruited to bring new perspectives to AGC student chapters. Similarly, multi-disciplinary class assignments should be used to bridge departmental barriers. For example, in a construction materials and methods class at Iowa State University, construction engineering and architecture students are brought together in multi-disciplinary teams to produce a simple design project. Such an assignment encourages dialogue and establishes mutually beneficial relationships among contractors and designers, just as necessary in the industry work environment.

Technology Adoption

Information technology is no longer a specialized trade delegated to the "IT department." All construction professionals, in order to succeed in the future, must consider themselves part of the IT department. The daily work of construction professionals is immersed by technology. Construction professionals must have a comfort and appreciation for applying technology to construction management work. For example, Building Information Modeling (BIM) has become a common tool for coordination of building systems and organization of construction site laydown and storage areas. Sophisticated, integrated software systems are used to exchange and manage project

information. Construction schools should provide opportunities for students to both gain exposure and some practice to the various information technology tools available to industry.

Virginia Polytechnic Institute and State University has identified the need to include information technology education in its Building Construction program and has responded by offering Building Construction 2114 — IT in Design & Construction. The Virginia Tech catalog describes this class as a "lecture and lab-based computer applications course." The objective of this class is to familiarize students with the many applications of information technology available for use by design and construction professional with a focus on BIM. Students are introduced to Autodesk Revit and the VICO Software Suite software. Laboratory time is used to experiment and practice with the software and to deliver a finished project in the form of a Vico-based 4D model, a combination of a typical 3D model with material and labor assignments also made to the model parameters. As senior-level capstone classes, Virginia Tech offers Construction Practices I and II (BC 4433 and BC 4434). These classes require that students use visualization software including Autodesk Revit and Autodesk Navisworks to create 4D simulations for the sequencing of construction work for a specific assigned project. The Building Construction Department at Virginia Tech also provides Integrated Lab Courses (BC 2064, BC 3064, and BC 4064.) Through the completion of this series of courses, sophomores are responsible for the structural system of the building, juniors are responsible for the mechanical system, and seniors/graduate students act as the general contractor. This course incorporates BIM application and the sophomores and juniors are responsible for making a general model in Revit of their assigned system. Seniors complete the work with responsibility for all systems and compilation of a detailed model of the building.

An innovative use of information technology, dubbed *virtual project tours*, is being conducted by researchers within the Construction Engineering group at Iowa State University. A virtual project tour allows for students to view and hear real-time construction activity being completed at remote project locations without leaving the classroom. Using cellular Internet service, a hand-held computer and standard digital video camera; an on-location tour guide transmits video and audio information back to large screen monitors and overhead speakers installed in the classroom. The learning problems that result from being in the back of a large tour group are eliminated as all students hear and see the same information. Further, this approach to delivery of field information exposes students to innovative information technology tools available for remote project monitoring and management ("*tele*-project management"). Table 2 included at the end of this paper, provides a list of the specific equipment used by Iowa State University to perform virtual project tours and approximate cost budgets for the equipment.

Another related information technology approach has been developed and tested at the University of Calgary. This educational tool, termed *virtual supervision*, consists of a network of fixed, web-enabled cameras which are used to view and record real-time construction operations. The cameras include remote-controlled functionality, such as directional movement and zooming, so that specific construction operations can be viewed at a close range, which might not be possible with a traditional physical premise due to safety concerns, mobility disabilities or other project-related constraints.

Closing

Construction is an ever evolving industry with many trends impacting the methods with which buildings are built and strategies upon which construction companies are managed. Construction professionals are charged with understanding these industry trends and converting emerging challenges into capitalized opportunities. Construction education programs have a related responsibility of forecasting the necessary competencies for successful future construction professionals and refining academic curriculums to best prepare students for the construction work of the future.

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Table 1— 2010 CII Trends Summary

Trend Category	**Sustaining & Growing Trends (previously reported)**	**Emerging Trends (greatest impact over 3 to 5 years)**
Workforce and Human Capability	• Outsourcing of higher level services to low cost, best-value countries • Increased mentoring for younger employees and implementation of knowledge management systems to capture know how • "Low water level" staffing • High unemployment in E & C industry • Challenge to attract 20-somethings to E & C industry	• Retirement Boom is anticipated when investments improve

Project Delivery	• 24/7, globally-distributed, virtual work teams • Integrated project delivery/tri-party agreements • Design-build • Lean construction • Private-Public-Partnerships (PPP) • Life-cycle cost based decisions • Program and portfolio management	• Bonding more difficult to obtain due to stricter surety requirements • PPPs requiring letters of credit which are more restrictive and limit a firm's capacity to chase more work. • Greater risk being pushed from owners to contractors
Corporate Strategy	• Foreign Purchase of US E & C firms	• New competition by foreign E & C firms entering U.S. markets
Technology and Innovation	• Virtual Design & Construction, Building Information Modeling • Modularization and prefabrication • Automated data collection (e.g., RFID, laser scanning, and GPS) • Integrated PM software • Integrated building control systems	
Markets and Demand Drivers	• Green Building • Renewable Energy • Consumer demand in emerging markets of developing countries • Government spending • Growth in renovation/retrofit projects (Europe & N. America)	• China has crossed over the threshold from emerging to emerged; • African continent is an emerging market
Social and Political Influences	• Environmental Conservation • Government Regulations and their effect on the industry (e.g., energy, tax, immigrant, and health care policies)	• Concern of growing national government deficit anticipated to reduce future government spending on construction

Table 2— Listing of Virtual Project Tour Equipment & Approximate Costs

Cellular-Based Approach

Video-conferencing software used in the cellular-based communication service is Adobe Connect. The equipment listed below is used to broadcast audio and video information from the remote construction site to the internet-based Adobe Connect meeting room (a dedicated web-site address - http://connect.extension.iastate.edu/virtualConE). This web-site is accessed from the field location using common cellular internet service. Remote participants access the meeting room via any internet connection. Most classrooms at Iowa State University have a computer with Internet access as well as the ability to project the image from the computer screen onto a larger screen. Access to this classroom technology has been available at no cost.

Table 2a – Equipment for Cellular Approach

Description of Item of Equipment	Approximate Cost
Sony Vaio Handheld Microprocessor/Computer, Model VGN-UX490N (1)	$3,000
Sony Handycam Digital Video Camera Recorder, Model No. DCR-HC62	$250
Standard cellular phone (phone commonly given at little or no cost with long-term service agreement)	up to $100
Hands-free Head Set for use with Cellular Phone	$30
Verizon Mi-Fi or Sprint Overdrive hot spot device (this device is commonly given at no cost with long-term service agreement)	no charge
Small messenger back with shoulder strap to carry Vaio during tour	$30

CyberPower Model CPS175SU Automobile Power Converter, Multiple Outlets	$80
TOTAL	**+/-$3,500**

Satellite-Based Approach

Similar to the cellular-based approach, video-conferencing software used in the satellite-based approach is also Adobe Connect. The equipment listed below is used to broadcast audio and video information from the remote construction site to the internet-based Adobe Connect meeting room. Remote participants access the meeting room via any internet connection. The web-site is accessed from the field location using satellite-based internet service offered by NewCom International (http://newcominternational.com/).

Table 2b - Equipment for Satellite Approach

Description of Item of Equipment	Approximate Cost
Satellite Equipment	
1.2 meter diameter Ku band antenna and mount (Patriot model) (purchased from NewCom International)	$750
LNB Ku-band & 4W Ku-band BUC (purchased from NewCom International)	$825
iDirect 3100 modem (NewCom International)	$1,100
50 feet of coax cable, 20 feet of orange cross over cable & 20 feet of blue Ethernet cable	$60
GPS unit for modem and cable	$450
Wi-Fi Equipment	
Cisco Aironet 1300 Series Wireless Bridge	$900
Portable Computer, Software & Equipment	
Dell Latitude E6410 ATG	$2,500
100 Gigabit Free Agent Portable External Drive	$120
Diamond MSP100B 4 Watts 2.0 Mini Rockers Mobile Speakers Black	$30
Logitech Webcam	$150
Camtasia Studio Software	$225
Power Generator & Conditioner	
Honda EU2000iA Generator	$1,150
Tripp-Lite LC1800 Power Conditioner (Grainger)	$310
50' 12/3 SJTV Yellow Extension Power Cable	$40
Satellite Phone	
Iridium 9555 Standard Package with 500 minute global prepaid SIM card (SatPhone Store)	$2,000
Compass/Inclinometer	
Suunto Tandem-360PC/360R Compass and Clinometer	$185
Portable GPS Unit & Tripod	
Garmin 010-00777-00 Foretrex 401 Portable GPS System	$200
Tripod for mounting GPS unit (for iDirect 3100 series router)	$20
Mobile Camera Equipment	
Sony Vaio Handheld Microprocessor/Computer, Model VGN-UX490N (1)	$3,000
Sony Handycam Digital Video Camera Recorder, Model No. DCR-HC62	$250
Flip Ultra HD Camcorder, 120 minutes (Black)	$150
Luggage /Pelican Cases for Protection of Equipment	
SUB 0 30 in. Roller Case by International Traveller Model 1188-30 Black (quantity of 3 recommended)	$450 ($150 each)
Pelican Cases with Solid Polyurethane Layers (various models: APP-1450SF, APP-1450A, APP-1470SF, APP-1470F-BK, APP-1430F-BK, APP-1400F-BK, APP-1450) (quantity of +/-10)	$1,200
Northface Base Camp XL Yellow (quantity of 3 recommended)	$450 ($150 each)
Case for Antenna Base	
Case Gun DLX Tactical (812614--877)	$60
Communication Shelter	
Shelter Cielo (Item No. C35211)	$80
Miscellaneous	
PVC pipe for Satellite dish/coax connectors	$50
Batteries/charger, Tools and extra hardware, Scotch electrical tape, Wood shims for leveling antenna base & wood slats for antenna base, Coax cable connectors for storing cable, Small Case for iPod and sack for shims	$250

I-pod Touch	$300
TOTAL	**+/-$17,500**

Note(s):

(1) Contact with Sony customer service representatives on January 25, 2010 resulted in the determination that Sony no longer manufactures this device. A typical laptop, although heavier and larger than desired for a pedestrian tour application, has also been used in lieu of the Sony Vaio Model VGN-UX490N by researchers at Iowa State University.