Beyond Vertical Integration:  
The Re-engineering of the Design and Construction Industry

For decades, mergers and acquisitions have shaped the design and construction industry's business landscape. Through these mergers, companies have often achieved better economies of scale, branched out into new geographies and added new services and expertise. Although the industry consolidation has occurred – and continues to take place – at a relatively slow pace compared to other economic sectors, in recent years a growing number of large, multinational engineering and construction (E&C) companies have combined disciplines and expertise into full-service firms.¹

While design and construction functions are becoming increasingly complex and require ever-more specialization, the disciplines' segregated silos are crumbling, creating space for integrated, cross-disciplinary thinking; new risk management strategies; and comprehensive business structures. The recent surge in Public-Private Partnerships (P3s), the ongoing evolution of design and construction functions, the widespread adoption of high-resolution digital modeling, and technological trends like cloud computing and “big data” are just a few of the most visible examples of this transformation. What we have is the emergence of the polymath or “master builder,” reintegrated – within companies or between industry players.

In this paper, we look at some of the current trends that are driving the convergence of design and construction disciplines, including: 1) digital ubiquity, 2) a continuing squeeze for capital, and 3) a shift to systems thinking. Information is based on interviews carried out with company executives over the past three years as well as ongoing conversations with FMI senior consultants.

A New Kind of Renaissance

“Renaissance” literally means “rebirth” and refers specifically to the rebirth of learning that began in Italy in the 14th century and ended in Northern Europe in the mid-17th century. It was an age of new discoveries that was geographical (i.e., the exploration of the New World) and intellectual in scope and that resulted in tremendous changes for Western civilization.

It was during this time that the concept of the “Renaissance Man” was born: a man with many talents or areas of knowledge (http://oxforddictionaries.com). Such individuals included Da Vinci and Michelangelo, for example. Their roles covered strategic advisor, builder, planner, designer, engineer, artist, inventor and physician – each of whom is considered a distinct profession today. These multi-talented individuals were also commonly known as polymaths or Master Builders.

Several centuries later, during “The Age of Synergy” (1867-1914),\(^2\) rapid industrial development blended with new technologies to advance engineering and construction techniques. As a result, both disciplines became far more complex, forcing professionals to specialize in specific areas within their chosen disciplines. Consequently, the Master Builder’s environment splintered into many branches of specialization.

Fast-forward to the 1970s and 1980s – an era when “vertical integration” began to surface across numerous industries, particularly in the industrial and manufacturing sectors. Defined as the merging of two businesses that are at different stages of production, vertical integration helped companies gain tighter controls over processes and position themselves closer to their end users. In the oil and gas industry, for example, many companies that were primarily engaged in exploration and the extraction of crude petroleum decided to acquire downstream refineries and distribution networks. Companies such as Shell and BP controlled every step involved – from bringing a drop of oil from its North Sea or Alaskan origins right to a vehicle’s fuel tank.

Fluor Corporation, one of today’s largest EPCM contractors, is another example of a company that participated in the early stages of vertical integration. The firm began building a reputation for applying innovative methods and performing precise engineering and construction work within the emerging petroleum industry at the time.

The seeds of vertical integration that were planted several decades ago by companies such as Fluor, KBR and Bechtel, to name a few, are now affecting smaller companies in the engineering and construction space. Ron Oakley, chief operating officer at the M+W Group, adds, “The ‘Fluors’ of this world have been doing design-build-finance for decades and have moved up the food chain, so to speak, doing multi-hundred-million to several billion-dollar jobs. Today, you’re seeing smaller companies, such as Haskell, AECOM, Lane, M+W (U.S.), Kiewit and others, that are building their capacity to fill the design-build void in the $50 million to $250 million range.”

During the last decade in particular, the evolution of design and construction functions has taken a leap forward with the transition from electronic drafting to high-resolution digital modeling (also known as Building Information Modeling or BIM). Ubiquitous digital connectivity, cloud computing and “big data” are some of the evolving drivers that are responsible for the current melding of engineering, architecture, fabrication, construction and other related disciplines, undoing 100 years of expansive industry fragmentation.

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\(^2\) Vaclav Smil called the period 1867–1914 “The Age of Synergy” during which most of the great innovations were developed. Unlike the First Industrial Revolution, the inventions and innovations were science-based.
Connecting Digital Data and People

The embryonic phase of BIM is already revolutionizing project delivery. Virtual design and construction now allows project teams to build a structure twice – once virtually and once physically. Design activities have been horizontally integrated across disciplines while construction activities are integrated vertically through distinct supply chain stages. The demonstrated results include cost and time savings plus enhanced project quality and improved project safety.

Anthony Fieldman, president of RAFT Architects, states, “Today’s digital era demands an integrated approach to create and manage parametric processes (economics, planning, design and engineering) that directly feed and, in fact, physically control outputs (fabrication and construction). In other words, cross-disciplinary thinking is an emerging prerequisite to success.”

The business structures that support this type of interdisciplinary thinking and virtual collaboration are very different than yesterday’s siloed approaches. Thomas Z. Scarangello, chairman and CEO of leading international engineering firm Thornton Tomasetti, explains, “The tools of collaboration, such as BIM, 4D and 5D data utilization, cloud project hosting/delivery, etc., have made the ‘virtual project team’ a reality. We have reinvented the master builder’s brain in a virtual environment, and it is completely turning around the siloed project team environment that delivery tools like CAD fostered for more than 25 years. This kind of ‘insourcing’ allows us to take full advantage of the diverse talents of our global workforce, not just for marketplace and cost diversity, but so every project can benefit from a creative and technical worldview as well as a 24/7 workforce.”

Technology has and continues to play a critical role in this trend toward virtual knowledge sharing and cross-disciplinary thinking. Though the construction industry still lags other industries in technology adoption (e.g., the manufacturing industry invests four times more in digital tools compared to the construction industry), things are progressing. A recent McGraw-Hill survey found that BIM adoption rates by architects and contractors are currently above 70% in the U.S. (compared to 28% in 2007).

Combined with other communication tools and cloud technologies, BIM establishes a common platform where people and businesses can instantaneously communicate and share data, tools and information on a global scale. Most importantly, this digital ubiquity redefines relationships among industry stakeholders and gives everyone the opportunity to share wide-ranging knowledge and cross-disciplinary thinking.
Progressive design and construction companies of all sizes are adjusting and adapting to this new era of interconnectedness and “fusion of knowledge.” More large engineering organizations are now in the at-risk construction business, as more companies seek to create true “E&C” business models. These larger E&C companies capitalize on new technologies and tools to drive both construction and field-engineering activities and to optimize O&M services on a global scale. In the infrastructure space, specifically, many of today’s large E&C companies are expanding their portfolios along the infrastructure value chain and are adding new expertise in project management and financing, program management, systems integration, and lifetime operation and maintenance of facilities.

Many of today’s engineering companies that do not take on construction risk are now managing the construction process for a fee. Conversely, we see numerous construction companies expanding their services and taking on “design manager” roles to develop cost-effective and innovative solutions – either with in-house or external resources. David Miles, senior vice president of Kiewit’s Infrastructure Group, adds, “We’re not replacing the function that external designers provide, but our in-house designers help us take on a bit more control of the design to make sure we come up with the best technical solutions.”

Small niche companies are also branching out and combining new disciplines. Fieldman says, “Several of my former architect colleagues (most of which are under 30 years of age) have started their own companies. These enterprising folks are diving earnestly into real estate development, building fabrication, construction, operations and software creation. They aren’t necessarily changing their careers so much as they are expanding them.”

**Hard Times Drive Innovation**

In addition to recent technological advancements, the Great Recession has also been a key trigger for changes in the restructuring of companies, professions and the integration of design and construction functions. According to Dr. Clayton M. Christensen, a Harvard Business School professor who focuses on innovation, “The breakthrough innovations come when the tension is greatest and the resources are most limited. That’s when people are actually a lot more open to rethinking the fundamental way they do business.”

A good example of this fundamental shift in thinking can be found in the many Public-Private Partnerships (P3s) that are forming worldwide. Such alliances are proving themselves as viable means of repairing and upgrading infrastructure, particularly in a strained economy where public resources are limited and private capital needs strong, risk-adjusted investment opportunities. Robert Prieto, senior vice president at Fluor Corporation, explains, “I think we’re going to see much more of a return to the master builder concept where owners will be looking for somebody who can provide a good idea or solution to a problem. You see that competition of ideas most sharply in P3s, and it’s a trend toward defining outcomes rather than trying to control inputs, which is what a lot of public agency contracting tries to do.”

P3s also stoke innovation – a concept that is not always easy to harness or invoke. Dusty Holcombe, deputy director of the Commonwealth of Virginia’s Office of Transportation Public-Private Partnerships, says, “I think contractors just need to keep an open mind and not

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just focus on what was done in the past. This whole P3 concept is innovative, so they need to think of innovative ways to get these different things done and not dwell on what was a market precedent seven years ago.”

P3 projects tend to be very complex, demanding and often require many years to design and complete. Owners naturally want to work with firms that can perform the entire project and manage the resources needed to take on the various challenges presented. Miles adds, “Today we see many of the larger firms developing P3 expertise because they see it’s going to be a major area where funding will come from in the future, at least in the transportation market.”

Superimposing this movement toward increasingly complex, large projects are owners’ persistent demands for more collaboration among project team members and the request for increased transparency and efficiency. This push is leading to new team formations, joint-venture partnerships and varying “Integrated Project Delivery” (IPD) arrangements. Each iteration offers greater collaboration and integration between stakeholders in a departure from the linear hard-bid contract, traditionally driven by the owner spec.

Today’s emergent “cross-company” integration of design and construction is further breaking down adversarial silo thinking and transforming traditional industry business models to accommodate customers’ specific needs. Most importantly, though, all stakeholders are working toward a common goal or purpose in this type of collaborative, integrated setup. Brian Stiertz, senior vice president and director of the Transportation Design-Build Group at CH2M Hill, adds, “We learned that having everyone at the table when decisions were being made was critical. If it’s design-build or some other form of integrated project delivery, we all have a stake in it.”

The Great Metamorphosis: The Changing Business Face of Our Industry

Although some people would argue that buildings are still being constructed the way they always were, we have to face the fact that things are changing rapidly. Consider the example of Chinese construction company Broad Group, which decided to assemble a 30-story hotel in just 15 days. To expedite the process, sections of the building were prefabricated in factories and shipped to the site before construction (http://www.youtube.com/watch?v=Hdpf-MQM9vY).

Alternatively, Dutch architect Janjaap Ruijssenaars of Universe Architecture in Amsterdam wants to print a Mobius-strip-shaped building with about 12,000 square feet of floor space, using a massive D-Shape printer (Figure 3). The equipment can print up to almost a 20-foot by 20-foot model and uses a computer to add layers a quarter to half an inch thick. The objective is to use this technology to print houses on the moon someday.

Figure 3. A model of a house that will be created using the world’s largest 3D printer

Rendering courtesy of Universe Architecture
These are just two – if not extreme – examples of the melding of design, construction and fabrication functions. Nevertheless, they underscore the fundamental tectonic shift that is taking place in our industry today, which is geared toward “systems thinking” and streamlining. The three key areas impacted by this new approach to designing, building and managing the built environment are:

**Systems Design and Simulation.** The traditional function of design and engineering is moving in the direction of systems design and simulation. Buildings, infrastructure and other components of the built environment are already being modeled and simulated using vast computational power of the “cloud,” which allows participants to analyze various performance issues and building characteristics. Each component of a building, for example, may be simulated as part of an integrated system to optimize things like energy performance, cost, systems controls or any other aspect needed. This simulation-based approach provides a deeper understanding of design alternatives and trade-offs than traditional design methodologies, and enables participants to focus on solutions to an actual design problem rather than the artistic component itself.

**From Prefabrication, Modularization to Assembly.** Technology advancements in recent years have helped prefabrication services and modular construction make a comeback at a time when lower-cost, resource-efficiency and sustainable construction are becoming priorities. In fact, more and more companies are implementing processes and materials to deliver more sophisticated and complex facility types using modular approaches, particularly in the residential, health care, educational and military sectors. Lee Smither, director at FMI, points out one such example: “The Performance Contracting Group, one of the leading specialty contractors in the U.S., has a plant that can manufacture a product that is approved for high-velocity/high-wind areas associated with hurricane-force winds. The product has Florida Product Approval and can be fabricated from 4 inches to 12 inches thick with an EPS core and steel exterior skins. The product has excellent R values, windows and doors can be precut at the factory or on-site, and a trained crew can erect a 1500-square-foot shell in one day. This is definitely the beginning of a long-term trend associated with green building as well as a new era in energy efficient structures.”

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Robert Prieto,
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Fluor Corporation
Prieto adds, “Some of the questions we hear more from owners are: How can you standardize more? How can you modularize more? How do you factor in life-cycle considerations? In sum, we’re seeing a lot more questions and discussions around innovation, systems-level thinking, manufacturing/modularization and associated standardization. Everybody wants everything smart, but I’m not sure anybody really knows what that means just yet.”

Phillip G. Bernstein, vice president at Autodesk, predicts that, “as concepts like three-dimensional printing mature, more components of buildings that have been predetermined by the digital models will be ‘printed’ on factory floors and then delivered for assembly into completed buildings.”6 Productivity increases, as well as reductions in job-site waste, time and money, will render construction processes similar to manufacturing techniques. Companies like Toyota are already bringing the knowledge and technology of the manufacturing industry to the housing market with Toyota’s “Skeleton & Infill” approach, for example. Experts predict that in the future “the most effective fabrication/assembly companies will service a globalized supply chain that delivers houses, schools and hospitals everywhere.”7

**Operating and Maintaining Smart (Building) Systems.** Many industry stakeholders interviewed over the past few years confirm that sustainable design and construction practices are creating novel opportunities for design and construction firms in the O&M space. Larry Melton, assistant commissioner, Facilities Management & Services Programs at GSA, adds, “Right now, there is a unique opportunity for the construction industry to partner with the O&M industry for the sole purpose of ongoing commissioning. Construction companies that have strong partnerships with O&M contractors are the ones being most successful in this (smart facilities) market.”

With rapid advances in cloud computing and smart construction technologies, buildings and infrastructure components alike are expected to function almost like complete digital “nervous systems” in the coming years. In this scenario, embedded sensors collect and exchange information on a continuous basis – all of which ties back to the original model-based simulation when the design was created. With easy access to the cloud, owners or O&M representatives can optimize facility/infrastructure performance and react to issues at any given time.

All three of these areas – systems design and simulation, prefabrication/modularization and O&M of (smart) facilities – are becoming increasingly complex yet at the same time also more connected and integrated with one another. While some firms are tackling all of these disciplines with internal expertise, others are collaborating closely with external partners. In either case, the master builder – reintegrated – functions almost like a brain in which all disciplines are connected with one another like neurons, working together as one entity. The winners will be those firms that remain agile, technically proficient and versatile and that have extraordinary capabilities in processing vast amounts of information and data.

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7 Ibid.
The Modern-Day Master Builders – Two Case Studies

Fluor Corporation: The Longtime Integrator

Vertical integration is a top-of-mind business strategy for Fluor Corporation that for 100 years has designed, built and maintained some of the world’s most complex capital projects. With a global client base in the energy, chemicals, government, industrial, infrastructure, operations and maintenance, and various other sectors, Fluor is working to create a “one-stop-shopping” environment for its high-profile customers.

“We’re getting better at vertical integration,” says Herb Morgan, senior vice president and head of Fluor’s infrastructure business. Within the firm’s traditional markets – such as energy, chemicals and life sciences – Morgan says that for years, Fluor has managed projects from the up-front legwork straight through to engineering, procurement and construction. “It gives our clients one place to go and an area that they’re comfortable with – especially the Exxons and Shells of the world.”

The scenario is slightly different in the company’s infrastructure division, where engineering is typically subcontracted to outside firms and third parties that partner with Fluor to handle design work. Morgan says Fluor’s mind-set is shifting on the infrastructure side as the firm adds design, fabrication and other functionalities to its in-house lineup. “In this world, we’ve been bidding, designing and building for the last 60-plus years,” Morgan explains. “But now we’re starting to see alternate delivery methods creep into the infrastructure side (design-build, for example).”

Recent mergers could be driving some of the vertical integration. Morgan points to Balfour Beatty’s purchase of New York transportation engineering group Parsons Brinckerhoff and URS’ acquisition of engineering, construction and management firm Washington Group, as two good indicators of what’s to come. “These companies not only gain capabilities,” says Morgan, “but they also get pricing and competitive advantages.”

Fluor, which recently hired its first O&M director, says it’s also increasing the level of vertical integration on the P3 side of the firm’s business. He points to the Fluor-led Denver Transit Partners (DTP) Regional Transportation District’s Eagle P3 commuter rail project as a prime example. DTP – which also includes Balfour and ACI – is designing, building, operating, maintaining and financing the Eagle P3 Project in the Denver metropolitan area.

“We’re going to operate and maintain those trains for 25 years,” says Morgan. “This is just one example of how we’re starting to bring more integration into our offerings.” From the project, Fluor gains earnings over the contract period, brand expansion and vertical integration capabilities. “We’re demonstrating our ability to manage total integrated design, construction and operation under one roof and leveraging it with other P3s and/or owners,” says Morgan, who expects more vertical integration in the future for the construction industry. “It’s definitely a sign of the times.”

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Herb Morgan, Senior Vice President and Head of Infrastructure at Fluor Corporation
Kiewit: Going Beyond the Call of Duty

An employee-owned Fortune 500 company based in Omaha, Neb., this national provider of construction services for the government, transportation, power, water and other major North American sectors changed its internal structure four years ago by creating four distinct groups: Kiewit Infrastructure Group, Kiewit Energy Group, Kiewit Building Group and Kiewit Mining Group.

Two additional groups exist under the Kiewit Infrastructure Group umbrella – Kiewit Infrastructure Engineers and the P3 Group – the latter of which is called into action when “pursuits associated with that type of market are required,” explains David Miles, senior vice president of Kiewit’s Infrastructure Group. “On some deals we serve as a full-service, vertically integrated organization that teams up with major financial contributors to bid on and complete projects.”

Miles says Kiewit Infrastructure Engineers supports the parent company’s engineering and technical challenges. “We established Kiewit Infrastructure Engineers because we knew that engineering was going to be a bigger part of our business going forward,” says Miles, “in terms of design-build and other, similar projects.”

John Donatelli, senior design engineering manager, says the engineering group interfaces with design subcontractors and operating districts to optimize design solutions. “We engage in the pursuit of work and work with design partners and the districts to identify the critical design elements of the project,” says Donatelli. “We also make sure that we’re developing those elements to the appropriate level of detail.”

Vertical integration also comes into play when Kiewit’s engineering group is called into projects, and allows the company to more effectively manage its designers and leverage the best technical solutions on the design-build side. “We entered into this process with short-term goals and a long-term strategic vision in mind,” says Miles. “Going forward, in some cases it may also make sense for us to control the design itself on specific projects.”

With two years of successful projects under its belt, Kiewit Infrastructure Engineers is now evaluating its role in future design-build projects and finding new ways to position itself. “We don’t intend to become a production shop,” says Donatelli. “We do want to have a critical mass of in-house engineering that can affect production. To get there, we’re actively evaluating alternatives and how to interface with our design partners going forward.”

Ultimately, Miles says the project owners are driving the need for more vertical integration within the construction industry. Whether companies like Kiewit answer the call or continue to work with qualified partners to complete projects remains to be seen. Kiewit’s current position on the operations and maintenance (O&M) side, for example, has been that “there are plenty of O&M contractors out there with existing skill sets,” says Miles. “But specifically in the P3 world, owners want contractors that can go beyond just design-build-operate-mainte-

“There are plenty of O&M contractors out there with existing skill sets. Specifically in the P3 world, owners want contractors that can go beyond just design-build-operate-maintenance-finance.”

David Miles, Senior Vice President of Kiewit’s Infrastructure Group
A Glimpse Into the Future

When and when not to vertically integrate – that is a basic strategic question that many of today’s AEC leaders are grappling with. Vertical integration is a risky business strategy – complex, expensive and hard to reverse. Moreover, it takes time and patience. Many of today’s large E&C firms have grown over the years into multibillion-dollar corporations and continue to grow both vertically and horizontally. These giants focus primarily on megaprojects in the infrastructure space where owners and market dynamics are pushing businesses to expand their portfolios along the infrastructure value chain.

Steve Blake, chairman and CEO at ARCADIS, states, “I see mainly the larger companies integrating vertically. Everyone else is partnering or teaming as a joint venture; and many do both. I think until the market swings one way or another (which is a long way out), you’ll see a broad range of products being offered in the marketplace.”

Kiewit’s Miles adds, “Engineering firms are expanding their service portfolio to include construction and, in some instances, have become competitors. Likewise, we are expanding our own capabilities on the design side.”

In the wake of the Great Recession, companies of all sizes have started to redefine themselves, looking at new and innovative ways to deliver projects and explore new “spheres” of the built environment. Today’s new technologies allow industry professionals to link up and share project knowledge across integrated teams. This represents more of a “cross-company,” or even “cross-industry,” type integration and is a fundamental shift to converging disciplines into deeper knowledge to create solutions for tomorrow’s challenges.

Although the primary theme for this research paper is the trend toward vertical integration, we have a much broader trend with implications for the global economy. When large engineering and construction firms merge to become mega-firms – that makes headlines. The technological capabilities of the firms we have looked at above are astounding, giving them the ability to tackle the largest projects owners can conceive. However, there is a distinct undertone of emergence here that presents growing concerns and opportunities for the next generation. It is more disruptive than tearing down a city block to make way for new developments. There are new questions and problems to be tackled and solved, like: Where did the jobs from the last generation go, and how will those displaced workers find new employment? Where will we find the talented people to work in the emerging world of integrated technologies?

The new master builders will need to solve these problems. Those in the sector we currently refer to as the “design, engineering and construction industry” will likely be positioned very differently in the next generation. They may, for example, be huge technology firms, manufacturers, social and environmental engineers. This is a dizzying idea – especially for the more traditional builders that are trying to make their way out of the recession.

Innovation that is systemic and sustainable needs patience and will likely involve multiple failures, which are a hallmark of a true breakthrough and systemic change. What we have heretofore described as evolutionary trends are on the verge of revolutionary disruption. It won’t all be pretty and it won’t be smooth. Yet it will sometimes be exciting and full of new challenges.
Imagine the feelings of those ancient master builders when the owner/kings/pharaohs said, “I want you to build me a wall the length of our land’s borders,” or “I want the largest tomb the world has ever seen.” That is the kind of vision and audacity that will raise the industry to new levels. Will you be a part of it? Only time and history will tell.

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