



A New Era for Modular Design and Construction

by Sabine Hoover and Jay Snyder

How today's modular design and construction can pull E&C out of its 50-year productivity rut and set the foundation for a new business era.

Today's worldwide capital projects are getting evermore complex and larger in scope, with many of these projects facing chronic cost overruns and schedule delays. In fact, as an industry, engineering and construction (E&C) almost just accepts the fact that nothing ever gets built on time or on budget. These conditions, combined with the ongoing exodus of industry knowledge due to retiring baby boomers, have pushed industry stakeholders around the world to take a step back and re-examine the status quo.

While offsite construction—including prefabrication, modularization, preassembly or offsite multitrade fabrication—has been around for decades, it is emerging as a critical method for delivering projects faster, safer and cheaper in today's labor-constrained E&C environment. In fact, according to one of [FMI's recent industry studies](#), two-thirds of E&C owner organizations acknowledge that today's offsite construction environment is much different than it was just three years ago—a shift that's due mainly to labor shortages and increasing cost and schedule pressures. And while change is happening in pockets across the country—in different market sectors and across a range of project types and sizes—there is no doubt that an underlying transformation is happening and gaining momentum each day.

Despite these business conditions, there is still a widespread reluctance among many North American owner organizations to fully embrace the manufacturing-like project delivery approach. According to FMI's research, just 38% of owner organizations have a high acceptance level of offsite construction, and nearly 50% still opt for the traditional design-bid-build approach—a process that simply doesn't allow for optimal project planning and execution of offsite construction. By contrast, FMI found that innovative owner organizations are pushing offsite construction aggressively across all projects and achieving great results through more collaborative and transparent delivery mechanisms.

The industry's low productivity levels are impacting all stakeholders in today's complex and fast-changing E&C business environment. In this white paper, we explore the “perfect storm” of factors that are suppressing productivity levels, show how they're impacting E&C as a whole, and provide a framework for overcoming these issues through the use of modular construction and other innovative techniques.



Source: 2018 FMI/CURT/CII Owner Survey



On the Outside Looking In

The E&C industry is at an inflection point right now with advanced technologies and digital tools allowing firms to leverage critical data to address some (or all) of its most pressing issues. Consider, for example, the fact that the sector's productivity has grown at a rate of 1% over the last 20 years and that increases in regulation are actually reducing productivity by 0.1% a year.¹

By comparison, the average productivity growth for the world economy is 2.8%, and manufacturing is growing at an annual rate of 3.6%.² Furthermore, construction's productivity gap adds up to \$1.6 trillion in additional value that could be added to the sector's revenues (via higher productivity). Digging down deeper, the research shows that small and specialized trades are nearly 30% less productive than large-scale firms and that the U.S. is a declining leader in productivity. Countries like China and South Africa, on the other hand, are both accelerating.³

A major contributor to the limited productivity growth in the U.S. is a lack of improvement in technological capabilities and innovation, production methods and scale. In fact, over 90% of all global infrastructure projects are either over budget or late, the "[Economist](#)"⁴ reports, due to the fact that:

- Labor costs comprise 20-50% of total project costs.
- Since 2009, labor productivity has declined, hours worked have increased, but output has decreased.
- Labor estimates are often inaccurate, suggesting increased project complexity or underperforming workers.
- Approximately 50% of current positions in the construction sector could be automated.

¹ Sveikauskas, Leo, Samuel Rowe, James Mildenberger and Jennifer Price. "Productivity Growth in Construction." *Journal of Construction Engineering and Management*. 142(10). 2016.

² Barbosa, Filipe, Jonathan Woetzel, Jan Mischke, Maria Joao Ribeirinho, Mukund Sridhar and Matthew Parsons. "Reinventing construction through a productivity revolution." McKinsey Global Institute. 2017.

³ Ibid.

⁴ "Efficiency eludes the construction industry." The Economist Group Limited. 2017.

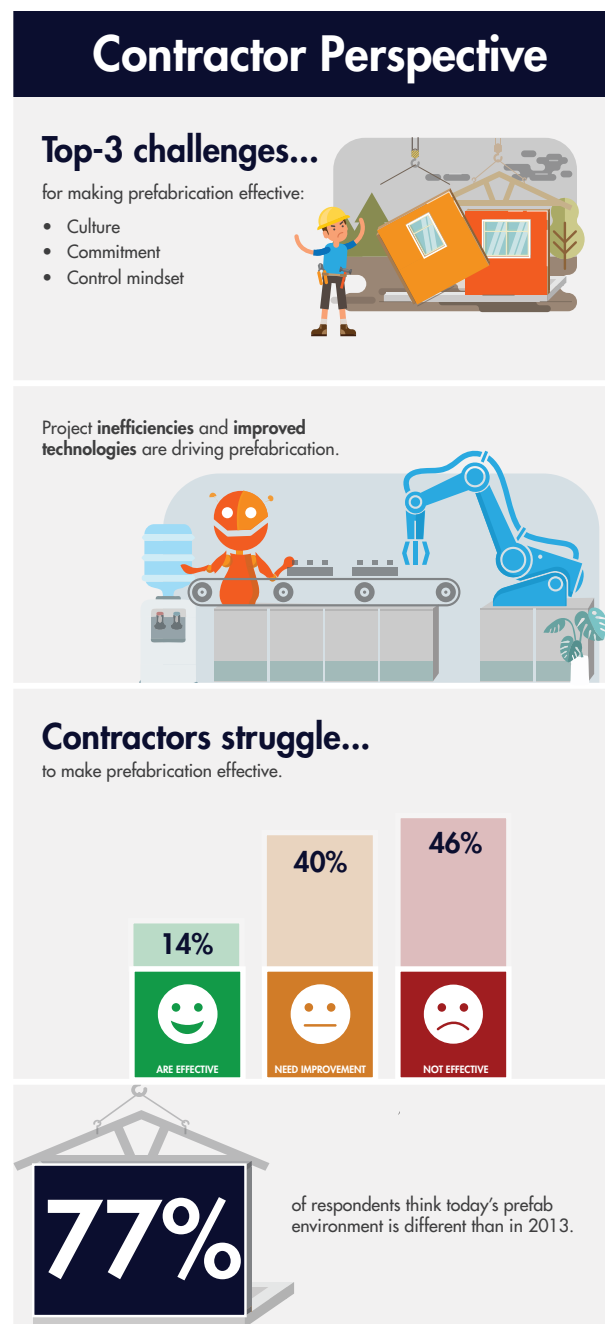
The E&C industry’s resistance to change could cost it dearly. Over the next few years, continued put-in-place growth is expected to be similar to that of the last few years, according to “[FMI’s 2018 Overview](#).” With the continuing industry growth trends, labor and productivity challenges, and retiring boomers, addressing the opportunities and challenges of the “here and now” would be the easy choice. However, “the risk in remaining solely focused on the short term is that the industry will likely look and operate very differently in 10 years than it does today. Firms that choose to ignore external trends—and then adapt their business models and approaches accordingly—may find themselves on the outside looking in,” states Scott Winstead, president of management consulting at FMI.

The fact that E&C is not viewed as a model of technology and innovation is a reality that leads many to assume that “it can’t happen here.” New market entrants such as [Katerra](#) represent potentially disruptive innovators that are testing that assumption. Katerra’s business model is to run a construction company the same way Toyota would operate a factory—fully integrated from architectural design through fabrication and installation. This allows the company to offer services faster, cheaper and safer than a traditional E&C competitor.

While it is still too soon to declare Katerra a successful industry disruptor, it does prove the case that disruption is possible in our industry. Katerra was founded in 2015 and booked \$1.3 billion in sales in 2017. While currently operating at a loss, it recently secured \$865 million in funding to invest in R&D and new factories and expects to become profitable as soon as 2019.

“*In order for us to have a radical change in productivity as an industry, we’ve got to revolutionize the way we deliver projects. And modularization is probably one of the key components in being able to take that first step.*”

Al Schwarzkopf,
Associate Director Merck and Co., Inc.



Source: 2017 FMI/BIM Forum Prefabrication Survey



Key Industry Drivers

Technology is evolving at an exponential rate. In fact, approximately 90% of the world's current existing data has only been collected in the last two years, with the amount of data being produced worldwide now exceeding 1.8 zettabytes (which basically means there are now as many bytes held electronically as there are stars in the universe).

For E&C firms, harvesting this data, deriving meaningful insights from it, and then using those insights to drive business innovation to increase productivity and profitability are all critical to survival. Of course, these imperatives wouldn't be as disruptive had the industry evolved and advanced over the last two decades. Unfortunately, most firms lack the vision, strategic initiative, will or expertise—and most importantly, the financial capital—to evolve at a rate to ward off disruption.

For example, research and development investments are not part of the traditional E&C industry's vocabulary—the vast majority of contractors invest 1% or less of their revenue compared to other industries that invest conservatively an average of 2-3%, and rightly so. After all, the average general contractor's net profit margin is 1.46%. As such, there is little incentive to innovate because there is no significant return on investment, given the limited financial resources.

Right now, FMI is tracking several other trends in E&C that support either an ongoing or a renewed interest in offsite construction. They are:

- **Geographical trends.** Over the next three to five years, nearly 50% of construction is expected to occur in just 20 metropolitan markets, and just five of these metropolitan markets will make up one-fifth of total construction in the U.S. These include New York, Los Angeles, Dallas, Houston and Washington. (See [“The Future Is Now: Setting Yourself Up for Success”](#) for more details.)
- **An influx of new entrants into the market.** The industry is also starting to see new entrants, new business models and a tremendous amount of venture capital coming into the industry—all designed to disrupt an industry that has long been accused of being stale and lacking in innovation. Alex Miller, managing director with FMI Capital Advisors, Inc., adds, “With more investor cash within a booming economy, private equity firms are ramping up investments and seeking new niches that are helping industry firms to change corporate directions.” (See [“FMI's 2018 M&A Trends for Engineering and Construction”](#) for more details.)

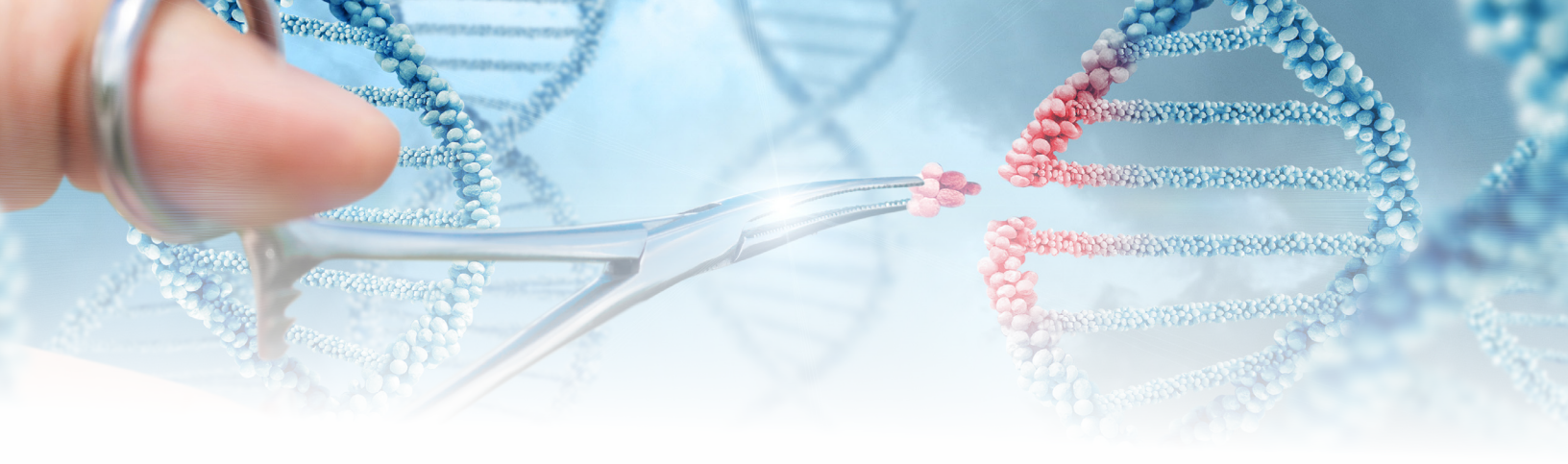
- **Increasingly complex buildings and infrastructure coming out of the ground.** This complexity not only involves the assets themselves, but also the expectations related to their delivery. (For example, the average project value among state DOTs has increased by almost 20% in a little over 10 years, while the average schedule duration has shortened by almost the same amount.) Fortunately, there are tangible ways to decrease project complexity, with technology being a key enabling solution accessible to any E&C firm. But this isn't just about throwing any device or software program at the problem. In fact, many times doing so only adds even more complexity, confusion and delays. For example, there is a high direct cost of implementing software platforms and devices that don't live up to expectations and that must in turn be "switched out" and replaced, usually resulting in poor user adoption due to technology or change management fatigue. (For more details, see "[Simplifying E&C Projects: Technology as an Enabling Solution.](#)")
- **Greater use of data analytics and actionable intelligence.** With greater access to data and data analytics, industry leaders are beginning to incorporate technology tools as a central aspect of their business and profiting from them. In most cases, profiting from data analytics means driving better results from more informed decision-making. But some firms are now employing characteristics of manufacturing and available technologies to improve project outcomes, both in the product itself and in the process. Moreover, some are finding ways to reduce costs or even create new profit streams from greater data insights.

The Art of Managing Change

Working with hundreds of E&C firms, FMI has seen a heightened risk awareness among business leaders and a certain level of unease about the future. Right now, over half of all firms expect more change in the next five years than in the last 50 years combined, according to FMI's latest research conducted with AGC's Surety Bonding and Risk Management Forum. **Those who expect change are over six times more likely to innovate** than those who disagree that disruptive change is coming. The question is, are these firms truly innovating, or are they simply modernizing, integrating new technologies into their existing processes and operating models.

Many E&C firms are, in fact, adopting technology and new systems and processes in progressive ways. However, this adoption often occurs without the proper procedures, processes and accompanying training to facilitate change management for successful implementation. FMI's research shows that in 90% of the company-failure cases, "too much change" was a stated root cause and a crucial element in the actions that led up to the disaster.

To avoid driving too much change in the organization and managing it more effectively, companies should make a list of everything that's new, including customers, projects, geographical targets, superintendents, project managers, systems, etc., to fully understand the speed of change the organization is currently going through. The more changes they can name, the higher the risk of failure. Yet, executives who don't leverage data management—and associated business intelligence—in strategic ways to improve productivity are putting their firms at risk. Therefore, it is critical to manage the rate of change on an ongoing basis, balanced with the necessity to adapt to irreversible trends.



Combined, these trends are all leading indicators of potential and current disruption. In this role, these trends are pushing companies to focus not only on how to innovate but also on how to compete with an outside “disruptor” that takes a fresh look on the industry that’s realized minimal productivity gains over the last 50-plus years.

Wanted: A New Business Framework

According to the 2018 AGC/FMI E&C Industry Risk Study, nearly two-thirds of respondents expect more change in how construction is put in place over the next five years than in the last 50 years combined. To leverage this opportunity while also staying relevant and innovative, E&C firms will have to adopt a new framework for success. This framework must include programs, systems and standardization—all of which will come together to support a more streamlined approach to the design-manufacture-construct process.

Consider for a moment the human body, which is made up of millions of cells—standardized building blocks that have different functions depending on how they are programmed. There are cells that carry oxygen to parts of the body and others that defend against bacteria and viruses. There are also cells that transmit signals (e.g., the signals from your eyes to your brain while reading). What all these cells have in common is that they’re part of a larger program and system. One such program might be the human brain, for example, that is made up of a complex neurological system, including all the cells (or building blocks) to support that system. And for each species, these building blocks are the same.

Now, how does this relate to design and construction? Chris Giattina, CEO at [BLOX](#), explains, “We think that we’re doing a service by rebuilding everything from scratch for each project. And I think we need a fundamental mind shift and need to start by first understanding what the program is (e.g., Marriott’s worldwide hotel program). Once we understand the program, we need to learn and detect how to remove unnecessary variation. And finally, once unnecessary variation is removed from the program, we can begin to standardize. Then we can create interchangeable parts, which allows us to build a supply chain that can work at many different levels efficiently. Only at that point can we begin to move the productivity needle.”

For example, someone who is building a home or office likely selected an architect to work around his or her specified parameters. But that's not the way you buy a car, iPhone or washing machine. That's because the latter have been industrialized and come with few (if any) customization options. Ford's popular F-150 pickup truck, for example, comes with a standard chassis and standard amenities that can be combined into millions of different combinations—from the basic XLT model all the way up to the Raptor. This allows Ford to create an enormous amount of variability using a standard set of parts.

The same philosophies can be used in E&C, where firms like BLOX have codified some of their programs to create the “DNA” of certain facilities. A patient room in a hospital, for instance, includes a bathroom, headwall, footwall and sinkwall, all of which come together to create the finished product. The same concept can be applied in the hospital's central energy plant, which—like a computer motherboard—is designed to accommodate a maximum and minimum level of energy (e.g., 16GB or 32GB of RAM).

“Without changing the architecture of the motherboard, all I have to do is take the component and plug it into that socket,” says Giattina. “At a central energy plant, all of my engineering works can operate in Las Vegas' hot, arid climate; Miami's hot, humid climate; or New Hampshire's cold climate. This is just one way you can design and engineer a tool that can be used to develop a product iteratively to make it better, while also removing waste.”

Disruption Is a Hurricane (not a Tornado)

Disruption is more of a hurricane than a tornado—destructive, but offering sufficient time to respond if industry participants are willing to do so. This is not to say that disruption doesn't happen fast. Disruption can happen quickly, but rarely faster than a company could respond during a traditional planning cycle of three to five years. In fact, incumbents often fail to identify or respond to disruptive forces fast enough to stave off potential value destruction.

Only when your business model is obsolete do you realize disruption has occurred. Back in 1900, for example, Fifth Avenue in New York was filled with horse-drawn buggies. By 1913 the horse-drawn buggy had disappeared from the picture. A similar disruption took place in the photography industry, where Kodak's inability to adapt to digital photography (a technology it created) as a disruptive technology led the company to filing for bankruptcy.

But disruption is rarely led by the current industry experts or insiders. Ice harvesters did not innovate to become ice factories, and ice factories did not innovate to become refrigerator makers. “Most companies define themselves in terms of what they do, not as the benefits they provide,” [Guy Kawasaki](#) points out.⁵ Thus, most disruptors are innovators from outside the industries that they disrupt. There

⁵ TEDxBerkley talk. “The Art of Innovation.” Guy Kawasaki. 2014.

are indicators that a similar “outsider disruption” is occurring in the E&C industry today. If you narrowly define yourself as a contractor who builds buildings, then you may be destined to stay on the builder’s curve.

Innovation occurs on the next “jump curve,” not simply by modernizing, but by creating an entirely new business model. This opens the possibility of being a disruptor by moving from defining your firm as a builder, for example, that stick-builds projects using craft labor, toward becoming an innovative construction manufacturer that leverages technology to reinvent the entire construction value chain.

What’s Around the Next Corner?

Today’s fast-paced E&C environment is pushing firms to reinvent themselves, not only to keep up with the competition, but also to stay relevant in the future. The productivity status quo is demanding a better approach to designing, manufacturing and constructing projects, and requires a tight focus on the present while also keeping an eye on long-term positioning.

And while technology and innovation are clearly industry disruptors, the most important thing to remember is that the core success of a business—its people—remains its greatest asset. Where outsiders are historically the disruptors, **E&C firms must prioritize technology strategies to innovate corporate cultures and antiquated mindsets to buck the status quo and embrace disruption as an opportunity to win in the future in order to remain relevant.**

For much of 2017, offsite construction and investment in the delivery method were key trends, and we expect the momentum to continue through 2018 and beyond. “With companies like Google, Marriott, Starbucks and other high-tech firms like Autodesk embracing offsite, there is much investment money looking to revolutionize the construction industry,” Tom Hardiman, executive director of the Modular Building Institute, told “[Construction Dive](#).” “It’s going to change so fast in the next year.”

Working with condensed construction schedules and controlled environments, E&C firms that leverage offsite construction can not only avoid weather delays and create a safer environment for workers, but they can also improve productivity, increase project efficiency and enhance collaboration between offsite fabricators and general contractors.

Finally, offsite construction and related systems thinking and integrated design are key milestones in moving the industry forward to a more efficient, predictable business environment. This will require innovative thinking and patience and will likely involve multiple failures, which are a hallmark of a true breakthrough and systemic change. Now is the time to take charge.



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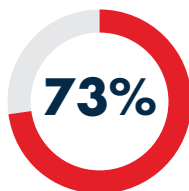
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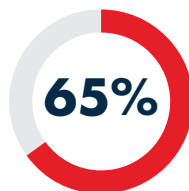
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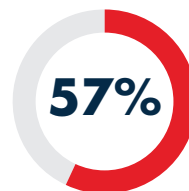
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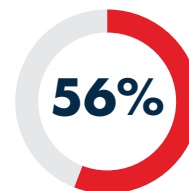
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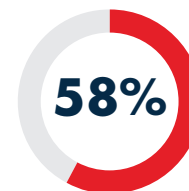
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