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Innovation in Construction

Perspectives from AEC Innovation Leaders

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Insights from Innovation Leaders

Introduction

The conversations and insights that make up this report began with a simple question: How can we help facilitate an exchange of ideas to help architecture, engineering, and construction (AEC) organizations to cultivate innovation internally and to take advantage of new technologies/approaches? The answer was also simple: Let's talk to some innovation leaders, capture those conversations, and see whether we can generate even more ideas and engender a broader dialogue—and additional activity.

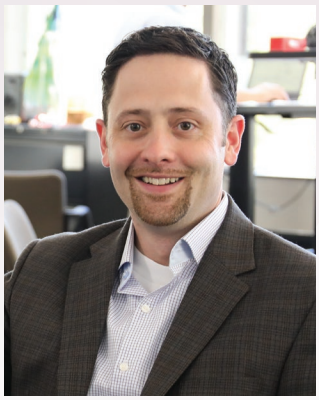
In my role as innovation officer for Oracle Construction and Engineering—and in previous roles in the industry and academia—I've benefitted greatly from conversations with likeminded peers interested in testing new thinking and approaches to shared challenges. Those informal discussions, many of them with people featured in this report, have helped to shape our "open innovation" philosophy as well as the recently launched Oracle Construction and Engineering Innovation Lab. This unique facility is a place where we can innovate with our customers, partners, and other industry leaders (see page 37).

As my friend Darren Bechtel of Brick and Mortar Ventures once said to me: "For an AEC organization to remain relevant, survive, and thrive over the next 10 years, they need to be investing in innovation right now. And much more than just talking about it; they need to be actively seeking out new technologies and learning how to work with the new generation of ever-improving solutions—or they will have a hard time remaining competitive."

I agree with Darren's assessment. I also believe that the change he describes is best driven by a collective effort, a collaborative approach to creative thinking and knowledge—both from within engineering and construction and from outside perspectives. It's that sort of open discussion that will elevate the best ideas and drive actual implementation.

This report comprises several interviews I conducted with an array of innovators in AEC for our ongoing "Trailblazers" series on the Oracle Construction and Engineering Blog. My hope is the contents of these conversations help to spark further discussions and show the way forward for your organization and the industry as a whole.

Burcin Kaplanoglu
Executive Director and Innovation Officer
Oracle Construction and Engineering



David Wilson,
Chief Innovation Officer,
Bechtel Corporation

Bechtel Corporation

DAVID WILSON, CHIEF INNOVATION OFFICER

What's your current role, and how has your career evolved since you started in the industry?

DW: I'm Bechtel's chief innovation officer. If you'd asked me five years ago, it's not a role I would have predicted existing—or that I would have been in it. I came into Bechtel as a college hire—17 years ago. I started as a mechanical system engineer at a waste treatment facility before joining Six Sigma.

Leading Six Sigma was a chance to learn how we could improve engineering, procurement, and construction. We also learned how we could structure a process around innovation and apply the scientific method to really drive innovative results to improve the business.

Six Sigma helped us structure an innovation program that drives process and disruptive change in a consistent manner—where mature innovation is delivered to our jobsites and innovation theater is discarded.

In Bechtel, because of the diverse nature of our work, businesses, and geographies, it's not unusual for people to stay the entirety of their career—it's easy to have a varied career within the single organization.

What's your view of the state of innovation in the engineering and construction (E&C) industry, both as it stands today and where we're heading?

DW: The industry is really accelerating. Two and a half years ago, there were only pockets of conversation about BIM (building information modeling), AI (artificial intelligence), ML (machine learning), MR (mixed reality), autonomous vehicles, or additive manufacturing in the industry. These terms are now all nearly ubiquitous in industry discussions, panel presentations, and keynotes—it's effectively become buzzword bingo.

Innovation is at the point where what was disruptive and progressive two and a half years ago is now table stakes. As the industry accelerates, it's increasingly difficult to disrupt and push the edge of the circle beyond the known and expected.

My job within innovation is to continually find the edge and push ideas even further toward the future.

> "As fast as the innovation discussions are progressing the problem quickly becomes… how fast can we convert discussions and discovery into deployment, adoption, and institutionalization? Adaptive speed and efficiency are quickly becoming the differentiator within the industry."

What are the biggest challenges to innovation and how did you resolve them for Bechtel?

DW: Innovation isn't inherent. It's not to say that people aren't born with the ability to be creative or innovative, but it's a muscle and a skill set that needs to be developed, flexed, and strengthened.

That's where "design thinking" can begin to help build the capability to create and innovate.

If the innovative skills have not been strengthened, it's really hard to create and discover the 10x ideas—10x ideas can be grown within the right structure, and with the right development of teams.

Innovation at Bechtel is a constantly changing landscape, as with most organizations. When you begin to innovate, a portion of the organization will be excited, another portion resistant, and a large portion will hedge.

The excited group

"The excited group" understands innovation and the disruption of tasks and work processes is not attacking them personally. The challenge can be around focusing their excitement and enthusiasm—they can become discouraged if their initial "great" idea is rejected due to merit—this is where we can begin to help the individual develop the creative skill and abilities, as well as connect them to ideas they can help develop.

Calibrating people who are excited to understand innovation is a volume game. It takes a quantity of colliding ideas to create high-quality ideas. It's like batting practice: You need to take a lot of swings before you hit a home run.

The resistant group

There's a small group that will actively work against innovative efforts. Some people see innovation as a threat to their career and job security, and so hold onto old processes. If you don't help articulate why innovation offers more opportunity for them, then you run the risk of creating resistors.

Innovation and disruption aren't about eliminating people; we're talking about eliminating tasks. And if we do this right, there's more opportunities for people to redeploy new skills, new technology, and new approaches to help them transition into roles that don't exist today.

We've done a pretty good job of addressing detractors, but as any organization evolves, the landscape constantly changes. If you're going to innovate, you need to continuously change the approach to stay ahead of resistors, while also reinforcing excited parties.

The hedging group

This group isn't initially supportive. At the start, "the hedging group" ignored us. They're betting innovation won't succeed and the status quo is going to overcome the change initiative—organizational immune systems are very strong.

For those betting against innovation, it's important to have them contribute to innovation as opposed to control innovation. The typical response from those hedging is— once innovation gains popularity and they see a chance to advance their careers, they'll shift from hedging to excited—or possibly worse, controlling.

We're now working to mitigate "the hedging group" from taking control and diluting innovation through over involvement—rather we're trying to align their newly formed interest to help drive innovation.

How do you foster a culture of innovation?

DW: At some point, others pick up the ideas of the innovators and the creatives and carry them forward. When someone comes and tries to pitch you your idea, that's something to celebrate—it means your idea is gaining traction and taking on a life of its own.

That's been tough for some folks to grapple with. It really helps to communicate this dynamic early and encourage creatives to keep moving towards the edge once their initial idea has begun to thrive within the broader organization.

One person may have had the idea, but, overall, it takes a lot of effort from many different people within the organization for the pieces to come together to make this a reality. It only happens as a team.

DW: That's exactly right. And, at some point in time, the organization becomes immune. You must constantly be changing if you're really going to innovate in a sustained fashion. The landscape has been very interesting.

What emerging technologies present the best opportunities for what we're trying to achieve in the industry?

DW: If we apply the Lean principles to construction, to engineering, where is the most waste? Where do we have unnecessary travel, process, or steps? What technology is going to help address that and how is that going to help?

One of the ways we've started to think about productivity is just simply looking at the availability and utility of resources at the workplace and how can technology help solve that.

Digital transformation

There are a lot of repetitive activities and a lot of hunting for materials that could be addressed through autonomous vehicles, RFIDs, computer vision, BLE (Bluetooth Low Energy), or other digital tools. When you think about the job site, if we didn't have to send the craft to hunt for material, but it arrived on demand—that's a huge aid in keeping the craft productively working at the workplace.

Furthermore, I think what we're seeing with drones and visual analytics is just the tip of the iceberg. With construction statusing and reporting, there's a lot of opportunity to use computer visualization to understand the work and automatically status progress.

Computers can take care of 80 percent of field engineers' repetitive work. This would free the knowledge workers to resolve problems as opposed to verifying status.

"There's also a huge opportunity for technology to enable the craft to become more efficient and effective—eliminating the waste of hunting, over processing, planning constraints, lack of resources, critical roadblocks, or design constraints."

AR, 3D printing, and robots

One example is when we deploy subject matter experts directly to the workplace through augmented and mixed reality, regardless of physical location.

I don't know if that's a huge transformational change, but it starts to get folks comfortable with working differently and shifting their thought process on a jobsite to, "I just need to be able to get the resources I need to the workplace, whether that's through augmented reality, autonomous vehicles, or whatever type of technology."

Finally, 3D printing, additive manufacturing is clearly on the horizon. There are still some questions around the structural aspects of it, but we'll get there. I do think we'll see more robotic assistance than 3D printing for a while.

For example, can robots do repetitive work like rebar tying? Can we place a robot at a jobsite to deliver material? These ideas really start to demonstrate the potential to aid our craft and knowledge workers.

Where do you see the biggest opportunity for AI and machine learning in the E&C industry in the short and long term?

DW: Short term, AI could be used to design simple optimization of facilities with standard volumetric components.

What hasn't happened yet is the process design component, where you add the complexity of process operations to the spatial constraints for optimization.

So, in the early design phase, I think AI is already being used by a lot of folks for optimization of design and seeking out the optimal scenario based on specific criteria. We're not yet at the point of push button design, constructability, and operations optimization.

The data challenge

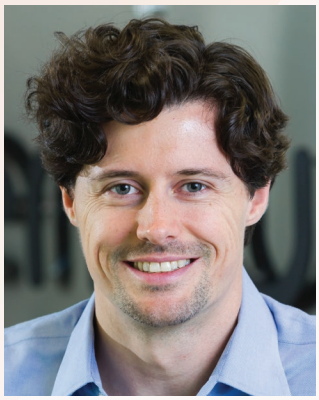
One key challenge is data. Every process plant is not exactly the same, every linear project is not exactly the same…the data isn't consistent, so it's very hard to compare projects and components.

And so, until we start to establish standard components across the AEC industry, it's going to be hard to fully leverage unsupervised machine learning.

AI, or more specifically models, can be used when you structure the criteria, but to really understand history and create meaningful (real) AI, we need to address data inconsistency. And that's something I think we must continually work on, both as individual companies and as an industry.

The dream is to have a customer design studio for processing plants, linear projects, and vertical buildings—where we co-create the future of the industrial world. That's the payoff for AI.

"To really understand history and create meaningful (real) AI, we need to address data inconsistency. And that's something I think we must continually work on, both as individual companies and as an industry."



Curtis Rodgers,
Principal,
Brick & Mortar Ventures

Brick & Mortar Ventures
CURTIS RODGERS, PRINCIPAL

What's your current role, and how has your career evolved since you started working in the industry?

CR: My primary role is principal at (venture capital firm) Brick & Mortar Ventures. I work with a great team of limited partners, investors, and entrepreneurs who are passionate about revolutionizing the way we design, build, and maintain our environment.

In addition, I contribute to The Society for Construction Solutions, the U.S Department of Energy's Project Leadership Institute, the NASA 3D-Printed Habitat Challenge, Uncharted Power, and FBR—formerly known as Fastbrick Robotics.

Early interest in technology and process improvement

I graduated in 2009 with a Master of Science in Industrial Technology from Texas State University. I worked for Kiewit Construction at Plum Point Power Plant, a self-perform $900 million coal-fired power plant in beautiful Osceola, Arkansas.

My next project was on the DART Orange Line light rail expansion in Dallas, where I continued my rotations through the field, engineering, and project controls. After my first year in operations, I joined Kiewit's Solutions Team for three years. We focused on new technology and process improvement across the company.

After Kiewit, I moved to San Francisco to join the PlanGrid team, which was a great experience, and I eventually joined McCarthy Construction as their first hire dedicated to new technology and process improvement.

One year into my work at McCarthy, I found myself struggling to maintain relationships with all of the construction entrepreneurs in the Bay Area, so I founded The Society for Construction Solutions (SCS) to connect everyone.

Through SCS, I met Darren Bechtel, who had founded Brick & Mortar Ventures and was looking for a first hire. I pitched Darren an idea before he asked me to join his company and learn venture investing.

What's your view of this state of innovation in the industry generally?

CR: We're in a period of solution abundance. Technology has finally advanced to the point of addressing the unique challenges of construction. It marks the first time in construction's history that technology is a clear competitive advantage to delivering a project on time and on budget.

In the past, we were suffering from solution scarcity. We just didn't have the solutions. Moving forward, we'll see each market segment in construction seek vertical efficiency. In some cases, we'll see true vertical integration. We don't see construction as an industry—we see construction as a common process among many industries.

What do you see are the biggest challenges to innovation?

CR: If you don't have the proper leadership, then you're going to struggle to realize any benefit from technology. In addition, everybody's competing for top talent. This means "the leadership challenge" is the biggest opportunity to secure a competitive advantage.

How do you think talent can foster a culture of innovation within their organization?

CR: Every organization is motivated to solve problems. It's up to talented people to clearly articulate those problems and the order they need to be addressed. And it's up to management to support the evolution of the business.

For example, if document control isn't properly staffed, or if IT can't take care of basic issues, then project teams aren't going to care about some new technology because their more basic needs haven't been met.

What emerging technologies do you see representing the best opportunities in construction engineering?

Autonomous vehicles driving advancements in LiDAR and radar

CR: Autonomous vehicles are going to be interesting. Solid-state LiDAR development is being supported by the autonomous vehicle programs that need cheaper hardware.

Solid-state LiDAR doesn't have any moving parts and could be a major advancement for construction survey and construction robotics.

Safety and gait-tracking

By monitoring a worker's gait, I can determine if their posture exhibits an injury or intoxication. The challenge is in finding a suitable gait-tracking technology.

Smart tools

Smart tools provide quality data without requiring humans to actively participate in the capture process. This solves a lot of problems with data integrity and unlocks the potential for AI, etc.

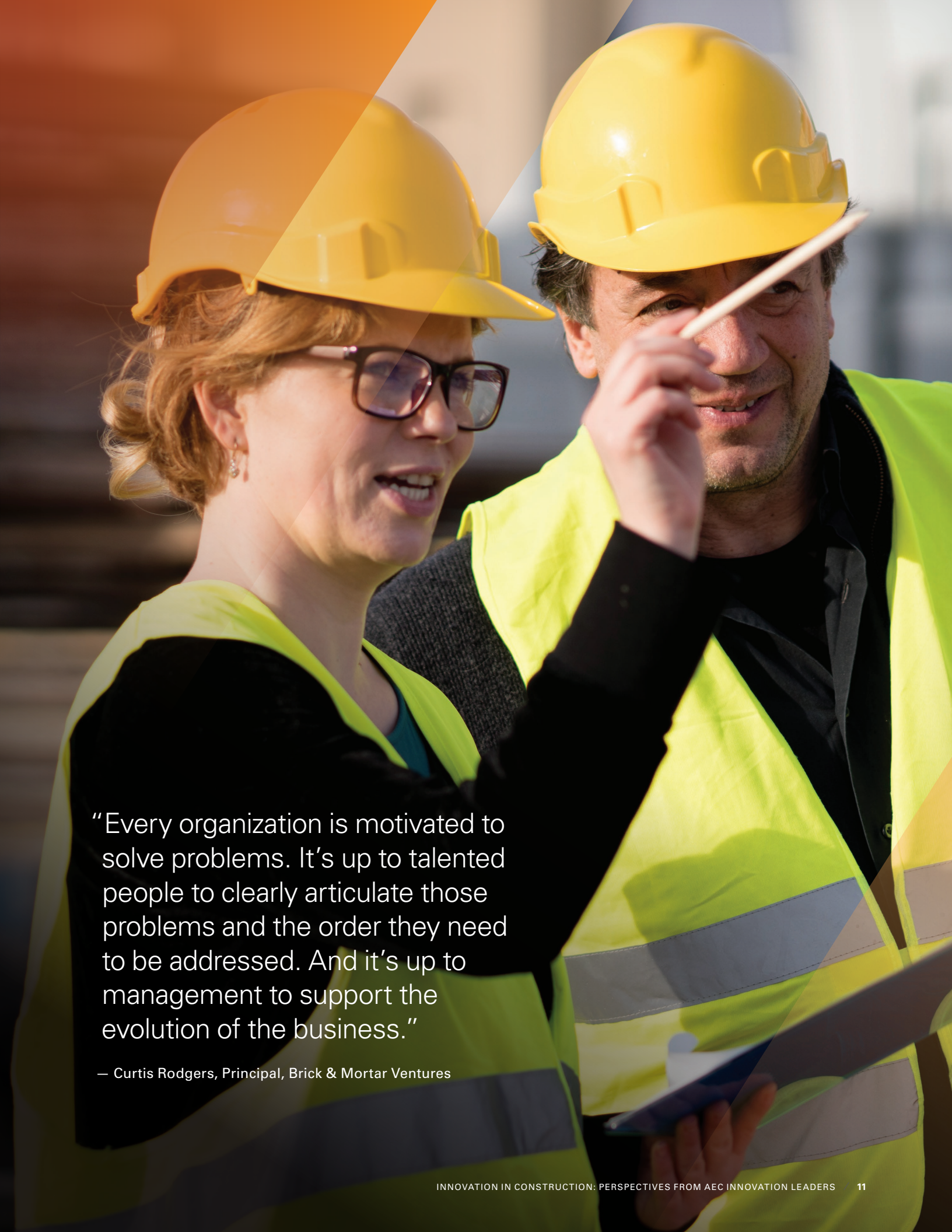
Communications: beamforming antennas

Fundamental things like connectivity are going to change. Beamforming antennas make it possible to connect to the next generation of satellite communications with very little setup and maintenance.

Which areas do you see as having the biggest impact for AI and machine learning, both short and long term?

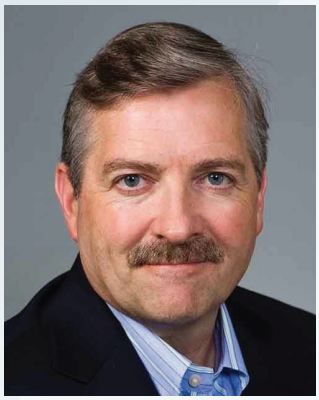
CR: Currently, there are many examples of AI automating repetitive tasks. Construction has an abundance of relevant problems. However, data still needs to be better organized and structured. Once this happens, we're going to see some very interesting applications for AI.

AI will increase the adaptability of construction teams. Construction struggles with high exigency—the challenge of dealing with incomplete information in a high-pressure situation—and AI will be a fantastic tool to aid in decision making.



"Every organization is motivated to solve problems. It's up to talented people to clearly articulate those problems and the order they need to be addressed. And it's up to management to support the evolution of the business."

— Curtis Rodgers, Principal, Brick & Mortar Ventures



Jesse Devitte, Co-founder of Building Ventures and Borealis Ventures

Building Ventures and Borealis Ventures
JESSE DEVITTE, CO-FOUNDER

What is your current role, and how has your career evolved since you started in the industry?

JD: I'm a venture capitalist and consider myself a company builder versus just a pure investor. I'm focused solely on start ups that can deliver material change and improve how we design, build, operate, and experience our world.

I've been an investor for the last 20 years, but the dozen years leading up to that were really my formative years. In the late 1980s, I wanted to be involved in the technology revolution.

Autodesk and Softdesk

I ran into a little startup company by accident called Autodesk, which had developed a product called AutoCAD. I met some engineers who convinced me to leave my other startup and start a new company with them.

By 1991, we were Autodesk's main partner for applications on top of AutoCAD. Our company, Softdesk, went public in 1994. In 1996, we were bought by Autodesk and I was the remaining executive in the company. I helped them organize the Autodesk AEC market group.

Venture capital: the basis for building a company

For the first time in my career, we took venture capital to build the company.

That's when I began to believe through first-hand experience that venture capital can be something different than just writing a check and sitting in board meetings. It can be the basis for building a company.

Digital transformation and the perfect storm

The last three years have seen major change. We've seen this almost perfect storm of secular forces at work for digital transformation.

This includes a whole new generation of exciting technologies, including blockchain, AR (augmented reality), VR (virtual reality), and standalone data. There are so many new technologies.

What's proof of that unique window: we've had more capital than ever available to create startups in this space.

What is your view on the state of innovation in the industry generally today?

JD: This is a challenging industry to achieve technology adoption because of its project-based nature and the collaboration required to make it happen. Company building is important because it's very difficult for startups to enable the technology adoption by companies on live projects without the team and resources to support those customers at scale.

However, this generation of startups is that much more sophisticated. There's also a growing ecosystem to support them, including many more capital providers, which we welcome with open arms.

Customers must invest in innovation

It's getting better, but the customers must invest in innovation to realize its potential. In their case—and in many cases—it's not technology. It's the culture of the customer and their ability to commit to it, adopt it, and invest in implementing it.

So, I always remind our startups that it's not just the purchase price. In this industry, the biggest investment for your customers and the end users is the time and resources of their teams and the risks they take in their projects.

What are the biggest challenges to innovation for those customers and how do you think they could resolve that?

JD: The biggest challenge for customers is the requirement to invest time and resources while they're amidst a living, breathing project. To be successful, they must make an exceptional investment that's usually underappreciated by vendors. Vendors deliver technology, but the customers must deliver the adoption.

I see the customers overcoming these challenges broken down into two different models:

- The brave souls: There's two or three people in a company who educate themselves to be on top of the newest startups and lead the company towards adoption.
- Directors of innovation or designated roles: They can provide the company and its employees more confidence because of the risk they take with employing technology and new projects. That's happening more frequently.

Do you see those roles falling under IT or under operations in those companies?

JD: I see them increasingly falling under operations versus under IT. IT has a natural sort of "enforcement tendency" to it. That's not how you get this out of the box and help it fly.

There's one more element that's driving the change: the end user of the building process There is a new generation of owners. For example, if you're going to build something for a global internet company—Facebook, Google, or others—they're more involved in what you're building for them than any owner you've ever run into.

Technology enables more control

Whether it's a data center or an office building, they approach it the same way. They know how they want their building to be done. I believe there is, indeed, a generation of active owners that this industry has lacked.

Think about how healthcare systems are directly involved from the beginning. There are more owners acting like owner operators.

That's always been the case in industrial, but now we have it across more sectors including commercial, residential at scale, and even hospitality. Owners increasingly care more, as do the end users who have mobile devices to share their experiences.

Fortunately, technology can enable more transparency through the entire process. Hopefully we'll see more active engagement by stakeholders earlier in the process. This will foster improved decisions resulting in a better, more sustainable built world!

You mentioned the culture of innovation. How do you think companies can best foster this across their organization?

JD: It's a commitment at an executive level and an educational investment across the board. This includes supporting the risk of taking on projects and their willingness to try something.

Many of our investors are from the industry and from companies where we see executive-led encouragement to pilot new technology at its best.

As a first step though, it's very hard for a startup to convince one of these companies to pilot something. It's up to the company to decide if it's willing to take that time, make that investment, and assume some risk.

What emerging technologies do you see as being embraced right now or getting traction?

JD: This is still an industry that's building assets—which takes years to build and lasts for decades. The first order of business usually is solving for pain and integrating existing solutions.

Technology really benefits customers and obviously businesses. We need to leverage this in both directions—the upfront scheduling as well as the performance and progress.

Imagine, design, build, construct, and improve

We have a vision of: "design, build, construct, and then improve." Imagine a data flow—a data swoosh—that flows through all of those. This is the key to getting the systems used in those communicating and sharing data. That's really what it's all about.

I don't want to be dismissive of some of the more powerful technologies. There are game-changing potential technologies in AR, in VR, blockchain, AI, and many other areas.

As an investor, I see them in the early chapters ("early innings" in a baseball analogy). Many of these leading-edge customers are trying these technologies. However, the deployment of them—and even the business models that support the vendors who supply them and understand their real use—is still in development.

This industry is moving faster than ever before. There's outside capital and disruption coming in to really drive this and put more pressure on it than ever before.

You'll see more people increasingly investing in reality capture, AR, VR, and some of the more exciting technology. When these technologies find their way into projects, and as people understand the payback, then businesses can be built to meet that need.

That ties to what you mentioned about AI and machine learning. What do you see in terms of the shorter and longer-term value of these technologies?

JD: We're on a journey. For example, we're investing in a company that is doing an amazing job helping general contractors understand their images on a construction site and the intelligence about those images.

But realistically, we're on a journey. There's not a refined business model yet. Everyone is still learning the real value of being able to use those images. This is a good case study in terms of where the industry is.

Customers want to figure out how they can become more predictive. Fortunately, AEC technologies are also becoming more predictive. This is a game changer.

I remember tipping point moments in this industry where things like clash detection gained steam and began to change this industry.

"We're right on the edge of using many of these exciting frontier technologies to deliver more predictability and predictive developments in the future. That's the real potential of machine learning and AI."

One challenge we have is the data; we either have lots of it or we don't know what to do with it. It's great to see companies using these technologies to collect that baseline. If you don't have that baseline, it's hard to create it.

JD: As an investor, we are less interested in companies that create data now and more interested in companies that are going to provide the analytics for data and make it useful information.

You mentioned that our goal is to have predictable outcomes, including humans understanding data. But the challenge for machine learning is capturing and defining that predictable outcome. We also believe that these technologies are significant.

JD: Yes. Our mission as investors—if we can ever achieve it—is perfect information. If we could predict the future, we would know exactly who to give how much money to and when—imagine that! Likewise, customers in this industry are trying to get as far down the continuum as they can because building is an imperfect mission—it's the nature of it.

Building is challenging and different. It's also why technology and the use of data can make such a major difference. It's an exciting time. That's why our mission is to support the digital transformation for a better built world.

Tomislav Zigo, Vice President, Virtual Design and Construction, Clayco Construction

Clayco Construction

TOMISLAV ZIGO, VICE PRESIDENT, VIRTUAL DESIGN AND CONSTRUCTION

Tell us about your current role. How has your career evolved since you started in the industry?

TZ: I currently work at Clayco Inc. as vice president of virtual design and construction. I've been with Clayco, a real estate developer and design-builder, for over 10 years. In my current role, I'm responsible for leading and managing our technology team—specifically the VDC (virtual design and construction) group.

I worked as a registered architect for over a decade on large healthcare projects prior to joining Clayco. After transitioning to the design/build side of the business, I noticed the complexity in today's construction industry—including how technology and people shape project delivery and what we execute.

Clayco is focused on transforming the construction industry over the next five to 10 years into a comprehensive digital process, with the intent to capitalize on the vast amount of data we've gathered over the past 15 to 20 years.

As you stated, it's about making these three things come together—the people, process, and technology—to help these projects work. What's your view of the state of innovation in the industry?

TZ: The construction industry—as we know it today—is very transactional. We form relationships based on the projects we're working on. Until recently, we formed relationships for the sole purpose of becoming more efficient at our jobs. Clayco created a unique opportunity for a more comprehensive approach toward technology adoption within the Design/Build framework.

This industry still lags at directing a meaningful portion of our revenue towards pure, industry-focused research and development. The manufacturing industry invests five to eight percent of annual revenue into research and development. In comparison, the construction industry devotes merely 0.2-.3 percent of annual revenue into research and development.

It's relatively easy to explain why most of the innovation doesn't come from the construction industry. The good thing is, an increasing number of large companies and industry leaders are recognizing that growth potential is intrinsically bound to the level of research and development financing.

Do you believe that the challenges we faced back in 2008-2009 forced us to start innovating and forced the construction industry to look at things differently?

TZ: 2008-2009 shed light on the need to create a more efficient business model.

The economic downturn provided enough time for several of us in the industry to try to understand which direction the industry should move. Clayco decided to invest in innovation versus trying to stay afloat by cutting costs in innovation.

Those willing to take the risk of learning and innovating are typically bound to harvest the fruits of their labor down the road.

In one respect, those years have had a negative impact on our industry's income and our ability to retain jobs. However, this kind of lean thinking made us realize that we can't move forward unless we innovate and learn.

Those innovations and the challenges we had during those years forced us to stop and look at our business models. What are the biggest challenges to innovation you see?

TZ: One of the most fundamental challenges we're facing is misalignment between academia and the industry. Academia and the industry should collaborate more to develop apprenticeship programs and focus on problem-solving research opportunities.

Construction and engineering labor should also be ready to hit the ground running on their first day. Labor will be responsible for innovating and changing what we do within the next 10 to 20 years.

"However, it isn't solely up to the industry to make that shift. Academia must start playing a more significant role toward creating the future workforce. Innovative thinking—whether at the process, contractual, or financial level—must be woven into the fabric of design and construction."

How can you best foster a culture of innovation? How do you promote this in day-to-day life?

TZ: Innovation in our industry must capitalize on the legacy data that's at our disposal. We must radically transform how we transfer knowledge from the older to younger generations via technology.

At Clayco, we invested in adoption and construction of a new, all-encompassing knowledge platform. We're looking into the legacy of information associated with our projects over the past 30 years to deploy data-mining techniques and analytical practices.

We want to extract those useful bits of information, recreate and re-examine lessons learned, and weave them into our new knowledge-management processes. By becoming "knowledge stewards," we'll be better positioned to innovate at an accelerated rate and in more relevant ways—with hopefully lasting consequences for our industry.

What emerging technologies represent the best opportunities for our industry?

TZ: Machine learning—and artificial intelligence associated with machine learning—will hopefully accelerate our decision-making process and eliminate errors. But this is predicated on our ability to extract legacy information with relative ease.

I'm also quite hopeful about the proliferation of robotics in construction. Arrays of automated, closed-network devices capable of making logic-based decisions are already here. Some elements of robotics technology will help alleviate risks, injuries, and potential hazards on construction sites.

Clayco's UAV (unmanned aerial vehicle) adoption was our first step toward implementing the principles of automated/robotic data acquisition, eliminating human error, and ensuring that the project's visual intelligence is aggregated in a consistent way.

These technologies won't have as much of an impact as they should unless we start thinking about re-engineering our overall project delivery processes. We must think about the construction industry from a product/process-based perspective instead of from a transactional project-based approach.

One of the key components of an innovative practice involves the transformation of industry titles—such as project engineers or project managers—into process engineers and process managers.

Technology is catching up to industry processes, but we must think about how we deliver it. What use cases do you see in terms of machine learning and AI?

TZ: It starts with the creativity of design. For the most part, we all take pride in delivering iconic buildings and iconic pieces of infrastructure.

That said, there are huge opportunities to weave in artificial intelligence or machine learning in the design process. We're talking about intelligent and sustainable structures and understanding how we optimize precious material and energy resources. How do we reverse the clock through a truly sustainable approach?

Processing large amounts of information in near real-time is an additional benefit of these evolving technologies. Fifteen to 20 years ago, we marveled at our ability to generate a whopping 20 to 30 megabytes of project data to complete a large hospital project.

Now our projects are easily exceeding terabytes of useful—and not so useful—information. Every day we take hundreds of images, laser scans, and videos at each job site. It's humanly impossible to analyze this data in a timely manner and make any decisions in the time required.

Machine learning—and subsequently artificial intelligence—are hugely beneficial to processing large amounts of information to stakeholders in a (near) real-time framework. Conducting this type of analysis helps us to recognize potential risks and hazards on a jobsite prior to breaking ground.

For example, we leveraged 25 years of historic data to help us analyze equipment utilization and conduct predictive analytics based on past performance. This analysis resulted in higher-quality deliverables in a shorter period.

The manufacturing industry has been utilizing this approach for the past 20 years while the construction industry is just scratching the surface. Each organization must define how they want to use these specific tools—especially in terms of AI.

"Any AI-based decision process will only be as good as the information that we've aggregated. At Clayco, we take pride in being one of the safest—if not the safest—construction company. We've witnessed significant benefits from utilizing machine learning algorithms towards further improving our safety record."

I'm hopeful that we're on the cusp of enjoying the benefits of our technology vision: predictive schedules, risk analysis, risk mitigation, production in a controlled environment, real time QA/QC feedback loop, industry-wide adoption of Lean, more deliberate business integration, etc.

Anything that provides a greater dose of certainty ahead of time makes us better equipped to transform this industry from project-based to product-based. Hopefully we'll be in closer alignment when the fourth industrial revolution is upon us.

Dr. Atul Khanzode,
Technology and Innovation Leader,
DPR Construction

DPR Construction

DR. ATUL KHANZODE, TECHNOLOGY AND INNOVATION LEADER

What is your current role, and how has your career evolved since you started in the industry?

AK: I lead the technology and innovation group at DPR. I also co-manage our corporate venture group called WND Ventures with our board member Eric Lamb. My primary focus is to ensure that technology is used on our projects properly and delivers predictable outcomes for our customers.

Our group is responsible for preconstruction, operations, scheduling, VDC, and construction technology. We handle innovation efforts, including managing funding of innovative project ideas and implementing various pilots—whether they're technology or otherwise—on our projects. We also partner with industry players and have invested in ideas like digital prefabrication.

Can you share your background? How did you evolve into this position?

AK: This is my 22nd year at DPR. I have a construction and civil engineering background and joined DPR as a project engineer after school. I earned my PhD from the Center for Integrated Facility Engineering (CIFE) at Stanford University in California.

I've always been interested in figuring out how technology can help make the construction process more efficient. At Stanford, I developed a keen interest in the application of VDC, as well as Lean construction to improve the project delivery process.

At DPR, I naturally progressed towards managing projects, mostly in healthcare as well as mission-critical data center facilities. These technically challenging projects have complex mechanical, electrical, and plumbing systems. I applied VDC methods to ensure our projects were successful.

VDC, laser scanning, and field technologies

In 2005 I kick-started our VDC efforts across the company. Since then, I've been involved in pushing technology to improve project outcomes.

Once BIM and VDC became more mainstream, we eventually expanded to include laser scanning and field technologies in the construction technologies group I led.

I've also standardized our project management system, migrated our customer relationship management system to a SaaS (Software as a Service) platform, and developed an application for safety inspections.

About three years ago I combined our IT group, our construction technologies group, and innovation group under the umbrella of technology and innovation.

What is your view of the state of innovation in the industry, and where do you see it heading?

AK: Technologies such as BIM, reality capture, and mobile tools have matured quite a bit and are widely available. Our industry is ripe for adopting these innovative technologies.

"The industry is also trying to figure out how to organize project teams so that they can take advantage of current technologies. Collaboratively integrating and utilizing these technologies on projects will create the opportunity for disruption."

What are the biggest challenges to innovation throughout implementation? How do you foster a culture of innovation, and where do you see the biggest challenges?

AK: The biggest challenge is the way the projects are procured and teams are organized. Technologies have matured to a point where you can use them to deliver value—or as we like to call it "predictable outcomes"—for our owners. It requires a different way of thinking.

Teams need to leverage technology using an integrated process while keeping in mind a predictable outcome, like a high-performing building, for example. Teams who've set up a framework of integrated themes, processes, and systems to deliver value are seeing great results. The biggest challenge is the way projects are organized and procured.

I couldn't agree more—it's about the people and the process. How do you develop the right culture for innovation? How do you deal with resistance, and what's been your technique?

AK: We're promoting an open innovation culture. We need to create a capacity to foster innovation within the company.

For example, we've created an internal funding mechanism where project teams—or anyone on the team—can apply for funding for their idea. This traditionally isn't covered by our project budget. Management has committed to foster innovation by making this funding available and, more importantly, to encourage ideas.

We've also developed a process for supporting innovation. We use an internal system called Brightidea to shepherd ideas through the early stages, evaluation, funding, and pilot implementation. We track our funded ideas as pilots. During our pilots, we put more funding behind ideas that look promising while working with companies that have either developed the products or process.

Developing an innovative culture is based on two things:

- Creating the capacity for a top-down/bottom-up approach. The top-down is creating the capacity and providing the funding. The bottom-up approach involves creating a supportive workplace culture. We're encouraging everyone in the company to come up with ideas that provide real value to our owners and projects.
- The industry has been reluctant to accept failure—including safety—for the right reasons. You don't want failure when it comes to safety. But other areas, like experimenting with technology, should be open to potential failure. If some of these ideas fail, that's okay. Creating that sort of dialogue within the company has helped us.

What are the biggest opportunities for digital transformation within your company? Which technologies do you feel are the most promising for our industry?

AK: There are three major areas:

- Multi-trade prefabrication that's assisted by digital technology. Multi-trade prefab has a direct impact on improving quality and reducing time spent at the worksite.
- We're also paying a lot of attention to machine learning and artificial intelligence, including pattern matching or pattern recognition. We're seeing a lot of value from AI applied to scheduling.
- The other area we're beginning to see improve—especially with institutional owners who have a large portfolio of buildings—is energy performance, or what I call building performance management. These owners are utilizing BIM/VDC, IoT (Internet of Things), etc. We coordinate most of the information related to systems that go into a building. Owners are increasingly asking us to help them set up their systems so they can efficiently manage their buildings.

We're piloting many other things in terms of automation, but I feel most strongly about these three areas.

Which opportunities do you see are more on the short term? And which opportunities will impact us in the long term?

AK: We can potentially make the biggest impact on anything related to having large datasets. You could apply pattern matching or pattern recognition and train the models based on that.

For example, one area of our projects that we're looking at is contract review. Every time we have a contract—even if it's an owner contract—the types of reviews we do fall into a similar pattern to other processes. We are starting pilots in this area to see what we can learn.

We have a group analyzing large datasets on operations, job cost, preconstruction, and safety data and are developing predictive models based off this data. We hope to see good results on this shortly.

We're also doing a couple of pilots using reality capture combined with building information models. People can check the quality of work that's already happened—as well as the progress comparison between planned and actual—using these tools.

I don't know how quickly they could become mainstream, but with the tools that we've tried out, it's closer than a lot of people imagine.

I agree that this technology is closer than most people think. And it's all going to boil down to people and the process. It's great to hear like-minded people think the same way and that the industry is moving in the same direction.

AK: Technologies such as BIM, mobility, AI, and data analytics have matured. There's been good applicability in other industries like finance, technology, healthcare, etc. We need people with domain expertise to partner with technology players to solve these industry problems in a meaningful way.

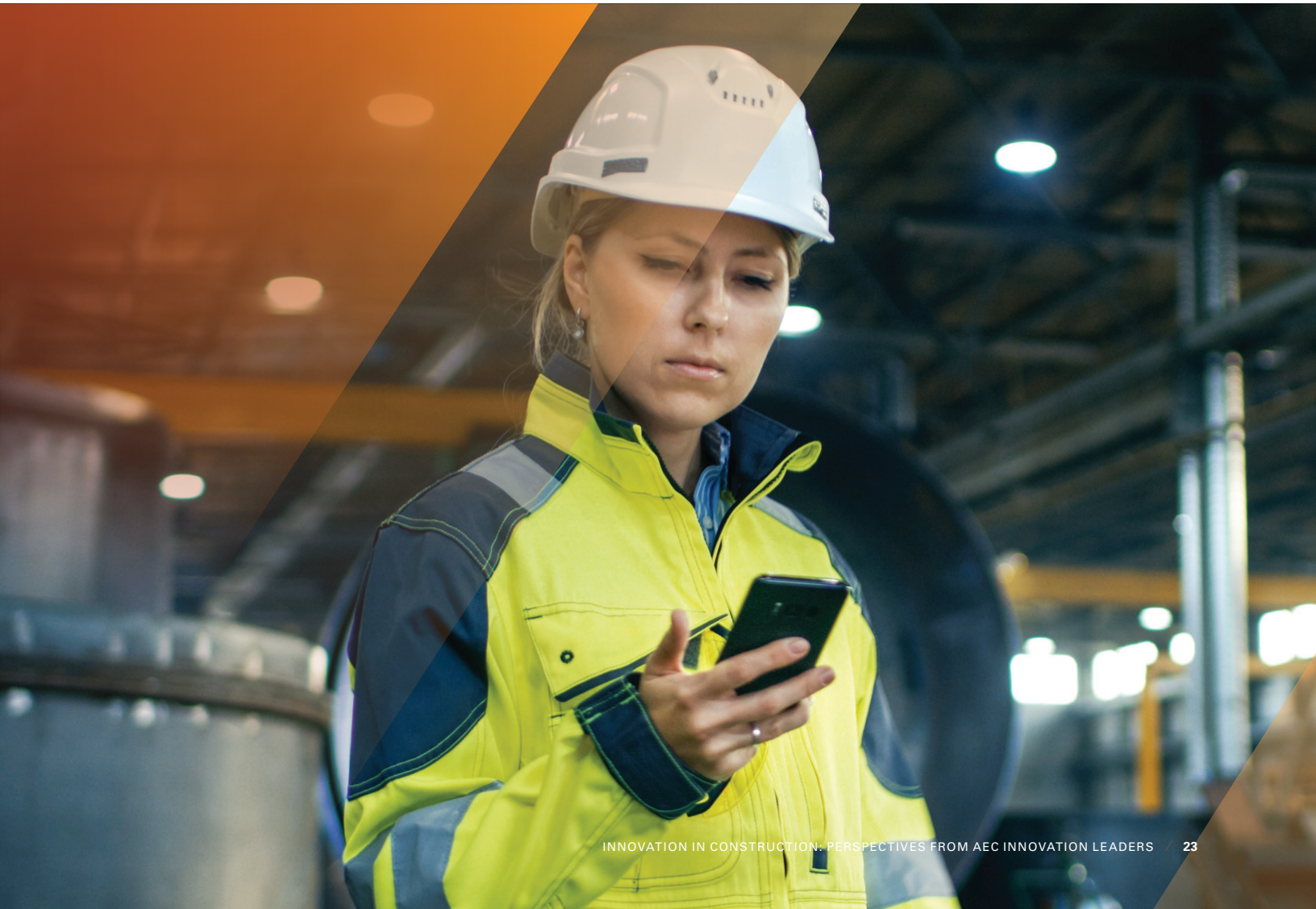
We're taking an open innovation approach by partnering with startups and industry players who're developing a variety of industry solutions. We know we can't solve the issues on our own, but we provide value to our partners by offering pilot opportunities on our projects.

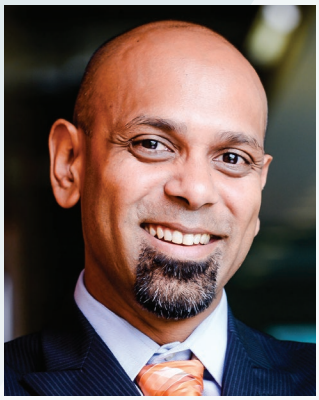
For example, we've invested in and partnered with a digital pre-fabrication company, Digital Building Components, which is using BIM and robotics to automate the metal framing process. We've also invested in and partnered with a company, VueOps, that's building an operating system for building performance management.

I know Oracle is doing the same thing—that's why you opened the Innovation Lab.

"People are taking an open, innovative approach from both the technology and company side.

Collectively, we'll move the industry forward in a much more meaningful way than we have in the past. It's a great time to be a construction technologist."





Ricardo Khan,
Senior Director
of Innovation,
Mortenson

Mortenson

RICARDO KHAN, SENIOR DIRECTOR OF INNOVATION

What's your current role, and how has your career evolved since you started in the industry?

RK: My current role is senior director of innovation at Mortenson. I lead our innovation program company wide. Like any other career, it's about a journey—following passion and taking opportunities when you can.

I grew up in a construction background. My father was a mechanical contractor in New York. Before he retired, I got my bachelor of architecture and practiced architecture for about four years. In school, I learned how to model in 3D back in the days of DOS and 3D Studio and found a passion in the digital world.

While I was sitting for my licensing exam as an architect, I decided to quit architecture and apply my architectural background to computer graphics. I focused on 3D modeling for web-based rich-media games, movies, etc. It was fun. I did that for about five years before my interests changed because I still missed the building world.

Leading the charge in virtual design and construction

I was hired at Mortenson in 2005 as one of the first VDC people in the company. Mortenson has always been innovative and forward-thinking. We were working to integrate BIM and VDC technology into operations to deliver more value to our projects and our customers starting in the late 1990s.

VDC has been a breeding ground for innovation—where our team found new ways to solve age-old problems like coordination and how we plan, visually communicate, and drive decisions earlier.

Our VDC team was comprised of a group of diverse people—from architecture, engineering, mathematics, computer graphic folks, like myself, and construction management. We all came from different backgrounds and we were all innovating on our projects.

Over the years we started to focus on bigger and broader business challenges. We now have a formalized innovation program within the organization that I have the opportunity to lead. It's been an interesting journey.

In your day-to-day role, what is the biggest challenge that you've faced, and how did you resolve it?

RK: At Mortenson, we're a company of entrepreneurs and innovators. Harnessing the creativity and innovation of broad and diverse teams on hundreds of individual projects is constant.

We are always challenged with ensuring we are not chasing "shiny balls"…. Innovation is about solving business problems in new creative ways, so we always start with, what problem are we trying to solve.

What's the business challenge? We approach innovation in different ways to help answer this fundamental question. It enables us to better focus our efforts and creativity on what matters to get to where we need to be.

Innovation is supported throughout our organization, across the company, and with support from the leadership team. This is a vital element that really enables positive outcomes.

Our innovation program's overarching purpose is to find new ways of creating value for our customers, within the organization, and for our business.

What's your view of the state of innovation in our industry right now?

RK: We're a fragmented, regulated, and old-school industry, which has not traditionally embraced R&D, change, and technology. To change this culture, we must identify the core challenges of the industry and approach it from that point with respect to innovation.

We're at a dynamic and defining point in our industry with the massive influx of venture capital funding, new start ups, digitization, and industrialization. And we're going from a digital transformation to a business intelligence era in a very short period of time, and it's really exciting.

The speed of change in the industry is creating a heighten sense of awareness, and we are focused on the next 10 years.

Do you see AEC disruption happening within or from external forces?

RK: There's this big debate going on about disruption in the construction industry. Some believe that it's going to happen from outside, and some believe it's going to happen within itself.

I think it'll be expedited through external forces—from outside the industry—and it will generate movement internally within the industry to keep up.

We're already starting to see that happen with companies using new business models within the construction realm. Industrialized construction and blockchain is being tested within the industry. Look at automation and industrialized businesses—like manufacturing and aerospace.

We've been learning from those industries and plan to be part of the next generation of industrialized providers of the built environment.

How do you drive the culture of innovation within an AEC organization?

RK: It starts with the company leadership, mission and objectives and is followed directly by our strategy for the organization. What are the key areas of focus for the organization, and how do we identify business problems that align with our strategy?

Culture is essential to drive innovation, and we are very focused on continuing to nurture our culture of innovation.

The Three Horizon Model

A formal way to describe this is with The Three Horizon Model, which allows us to identify key drivers that will impact areas of our business—whether it's financial performance, safety, customer experience, and just overall productivity.

And we start to understand what happens and what we need to do today, tomorrow and so forth. We assess where things are going to be for certain areas— like safety, finance, etc.— and then we need to build that pathway to get there.

That's what energizes me about what's happening across our business and within the industry. We're collectively starting to reframe how we look at these problems from a longer-term perspective, because innovation does not happen overnight.

It takes effort and time to percolate an idea into a solution and a scalable model. We're also finding champions at all levels within our organization who will encourage this kind of process.

Over the years, the response from our seasoned builders is shifting to, "help me understand" or "let's try it" or "I wish we had this 20 years ago!"

How are you fostering a culture of innovation at your organization?

RK: While it starts within the business process, we're multi-sourcing innovation challenges. It's been a success in a short period of time. We're pulling from cross-functional teams across the business—not just around operations—but all parts of the business.

When you have this top-down leadership for innovation, and you identify key business problems before opening it up to the entire company, it's amazing. There's an infectious energy created by people who think.

"Well, I'm not an 'innovator,' but I'm contributing to larger-scale innovation challenges within the business." Our culture promotes that every team member is an innovator!

I love seeing how much diverse talent we have within our organization. We're excited about what's to come in the next couple of years—and unleashing our own talent within our business.

We hope other companies do the same, because that's where the real solutions lie—within their own organization.

"When you have this top-down leadership for innovation, and you identify key business problems before opening it up to the entire company, it's amazing. There's an infectious energy created by people who think."

What emerging technologies do you see presenting the best opportunities for our industry?

RK: We start with those emerging technologies that target real challenges in our industry and within our business that require a new approach.

The one that first comes to mind is safety. It's the most important—and the only thing we benchmark within the industry that really means something—and yet, people are still getting hurt. We need to continue to move from lagging to leading and develop predictive indicators to improve safety performance in the industry. Safety is about behavior.

Technology can help us identify new ways to proactively drive positive change. We must consider automating how data is captured, analyzed, and processed in real-time.

For example, some of the emerging technologies that we are targeting are those that fall within the IoT category. There is an explosion of sensor and telematic technologies entering the industry.

As 5G enters our market and jobsite WiFi mesh systems become standard practice, we should see a major shift in automating data capture. This will help us focus on predictive models and driving change.

What do you see will be the biggest impact of AI and machine learning—in the short or long-term—in the industry?

RK: It starts with visual data. For years we've been documenting through photographs, and now video aligned with core business functions, including inspections, punch lists, audits, safety audits, and as-builts.

We have so much visual data today. The challenge is understanding how to manage or process that to create value.

Leveraging machine learning and AI will help the industry from the field perspective to better understand people's behavior, automate work status, or drive predictive models. We've been very reactive as an industry.

Someone identifies something on a job walk, snaps a photo, and corrective action is taken afterwards. The question is how much later is the corrective action taken?

In a proactive scenario, data capture is automated, continues through various sources, and is analyzed in real-time. AI and machine learning becomes your predictive analytical engine that reports potential areas of risk before issues arise. This sounds like science fiction, but there are emerging tech startups working on this today.

When you look at the overall AEC space, where are the first opportunities or low-hanging fruit? Is it the engineering side, architectural side, or the construction side?

RK: There are huge opportunities to leverage advanced computational models that could change the way we think about design and engineering. Most engineering systems are rules-based.

What if we could analyze the last 50 years of designs through learning algorithms? We could apply new rules through generative design that result in a completely new form of architecture.

Many people consider this inconceivable, but it's already happening with generative design processes.

I really like the quote I heard a few years ago that says, "We are moving from a point in time where we are telling computers what to do, to a world where we are telling computers what we want to achieve."

The global trends that are happening right now impact all industries. Construction is probably experiencing more dramatic change because we're still largely paper-based and not fully digital like other industries.

We're seeing more dramatic swings in our industry compared to others. But all industries are going through similar types of disruption and evolution; we're just on an accelerated path.

Digital transformation and collaboration in the AEC industry

There is also a massive cultural change happening within the industry. It's an interesting and exciting time. I feel really blessed to be part of this industry right now.

We are seeing much more diversity in the type of people who enter the construction space. At Mortenson, we correlate this diversity to the acceleration of innovation.

We are seeing more collaboration between firms.

Over the last decade, we've been witnessing a transition from using the term "competitor" to "peer." This is also compounded by the increasing amount of joint ventures on large complex projects.

We are getting to the point where we are sharing knowledge; not just internally, but with our peers. Why? Because, we are trying to solve the same problems with the same set of resources (design, vendors, and trade partners).

"The future is about connecting people with ideas and helping get to a common solution through collaboration."

The innovation trend—or the philosophy or process—has everything to do with collaboration and knowledge sharing that deals with inventing something new.

We're building upon lessons learned industrywide. We'll grow by sharing common data points that we're all facing and, if we want to measure across the industry, we have the benchmarks.

To benchmark, we must have a standard of work, and to have a standard of work, we must share knowledge. And to do that, we must have trust.

All these interconnectivity points are starting to mature, which is fueling innovation within our industry. The culture is changing through that knowledge share.

Dr. Mani Golparvar, Technology and Innovation Leader, Reconstruct

Reconstruct

DR. MANI GOLPARVAR, TECHNOLOGY AND INNOVATION LEADER

What's your current role, and how was your career evolved since you started in the industry?

MG: I wear two hats. In one role, I am COO and co-founder of Reconstruct, an early-stage company that offers a visual, three-dimensional command center for managing construction projects. The second role I play is Associate Professor of Civil Engineering, Computer Science and Technology Entrepreneurship at the University of Illinois at Champaign-Urbana.

My primary research interests lie at the intersection of construction project controls, building information modeling, and artificial intelligence.

Given my background in construction and technology research and development at Reconstruct, I lead and help with some of the day-to-day administration and operation aspects of the business, ranging from strategic planning, partnerships, and customer success management to technology and product development.

My career has interestingly evolved on both sides of construction and technology development and applications. In my teenage years, I was fascinated by the construction of civil infrastructure systems—particularly bridges and tunnels—as well as computer programming and software development.

Early experience in project delivery

I started my professional career in the oil and gas industry with project controls and developed construction animations—now called 4D (3D + schedule) building information models—to communicate work in progress to owners.

Later on, I moved into designing and constructing civil and infrastructure projects before eventually working my way into the commercial building sector at Turner Construction.

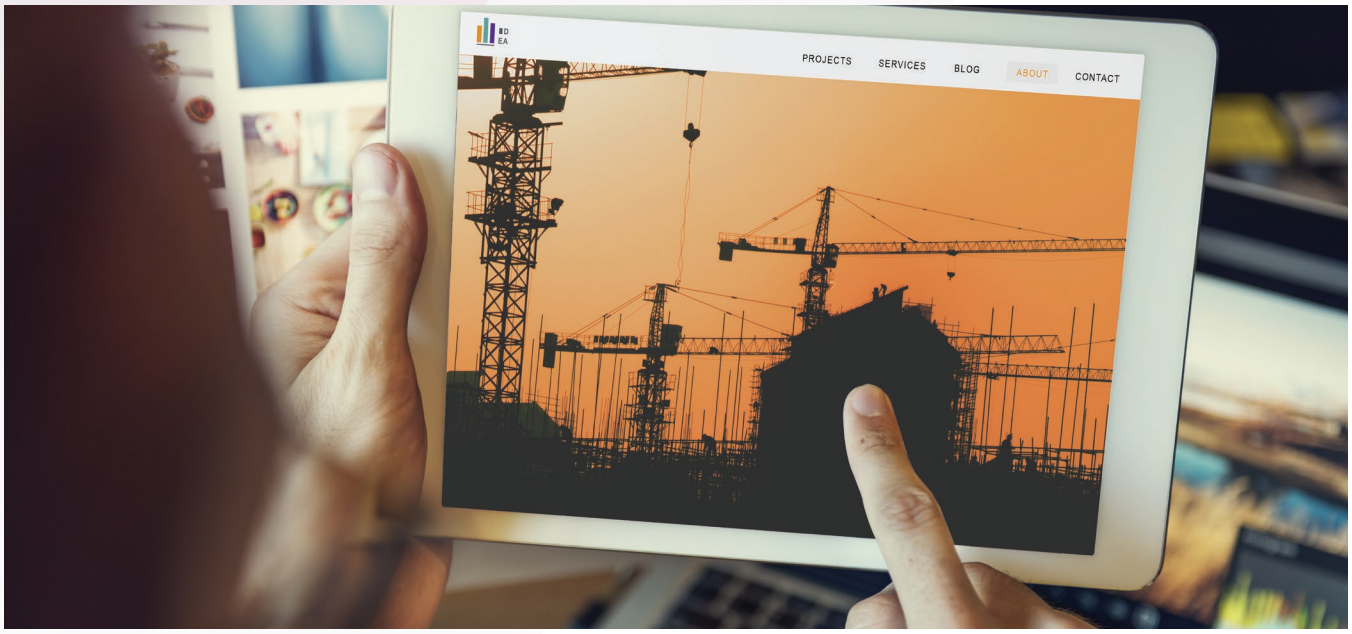
At Turner, I was focused in part on improving the process for capturing daily progress reports from subcontractors. I learned that inconsistencies in daily construction reporting can expose construction management and general contractor companies to a variety of risks.

Unfortunately, subcontractors frequently fell behind with their paper-based submissions. Our superintendents chased subcontractors for information that was generally insufficient to complete a useful and actionable daily construction report.

BIM and scheduling

Around this time, people had just started using 2-3 mega pixel consumer grade cameras. The applications of BIM for pre-construction cost estimation and constructability reviews was just emerging.

I was intrigued with the potential of how comparing images and videos to BIM connected to schedule could help visually document and measure work in progress. I was especially interested in how we could potentially address the pain points in daily construction reporting.



The interface of construction management and computer vision

My PhD dissertation and academic research at both the University of Illinois at Urbana-Champaign and Virginia Tech focused on the interface of construction management and computer vision. Reconstruct's visual 3D command center for construction projects emerged from this work.

Reconstruct was a prototype that we developed with Dr. Derek Hoiem—my computer science colleague at the University of Illinois and CTO of Reconstruct—as well as a talented group of civil engineering and computer science students.

We piloted the prototype at one of the largest stadium projects in the country led by Turner Construction. Turner gave us an award, and we received similar recognition from the World Economic Forum.

These recognitions—together with industry interest in using our prototype—gave us an opportunity to explore funding Reconstruct—including assembling a business-driven team lead by CEO Zak MacRunnels.

What is your view on the state of innovation in the industry today?

MG: The E&C culture has dramatically changed over the past 10 years. After 2008, we've seen a change in the generation of people who are working at construction sites.

Technology readiness has dramatically improved, especially in terms of how we model, simulate, and share project data, as well as how we capture information from job sites, including using the IoT.

Companies are witnessing a change in this generation because technologies have improved, and the price point is also lower. That's where the opportunities are emerging.

Increased research and development investment

The good news: Over the past five to six years, numerous companies have decided to invest in establishing central research and development or innovation divisions.

Companies want to ensure there is an internal process that can measure how new technologies fit into their processes and workflows and assess value. It's the return on investment that matters at the end of the day.

These technology assessments offer an opportunity for companies to either map them into existing processes or standardize new processes across their projects. However, the real challenge is that—similar to tech companies and university research teams—the innovation teams are not directly involved in construction projects.

Innovation teams must introduce new ideas and concepts to their project teams and get buy-in. Hence, for some companies the process of adopting and adapting technology may become a two-step process as opposed to a direct process.

Due to dramatic improvements in technology, there's a lot of funding and startups. The concepts of digitizing job sites and industrialization have also matured.

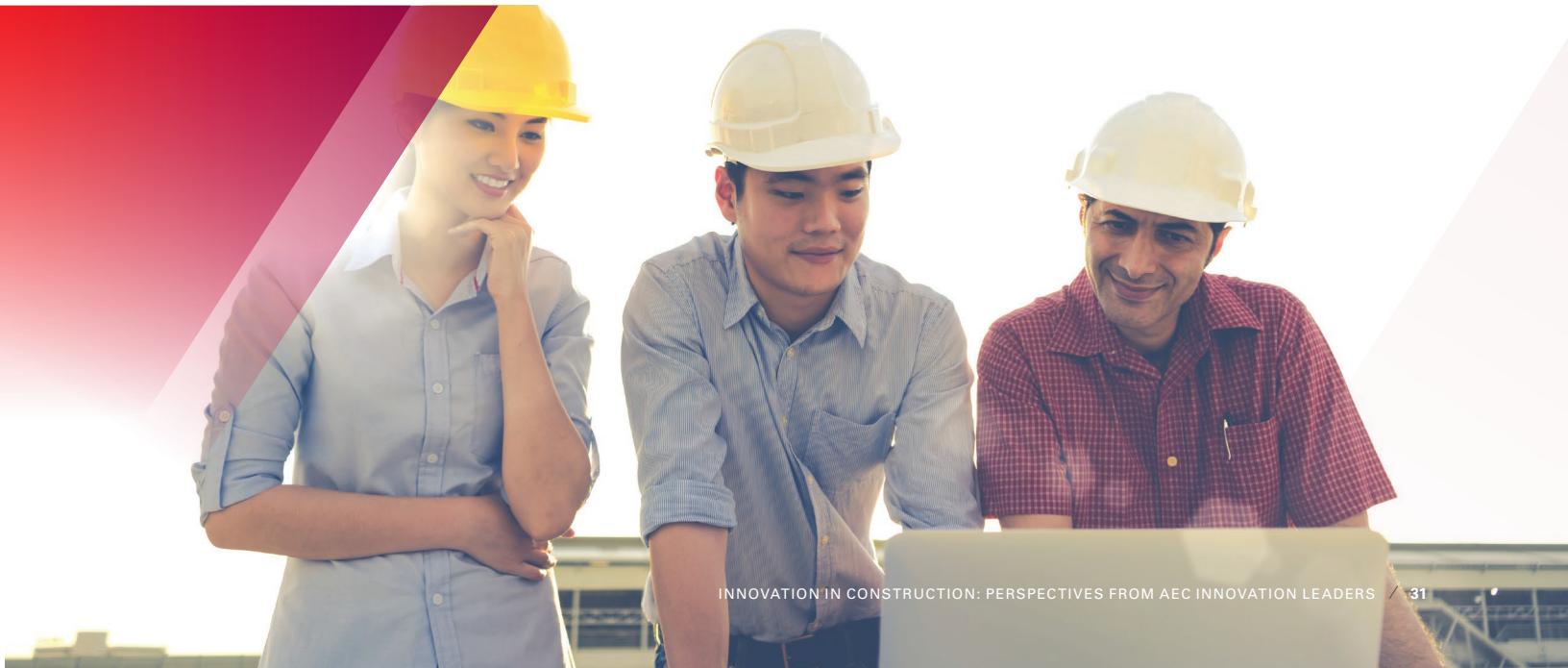
"In a short period of time we've seen digital transformation not only in terms of how we're adopting technology but also in terms of business intelligence."

You're in a unique position as both an academic as well as the founder of a startup. How can an academic organization help foster a culture of innovation in the industry?

MG: It's an exciting time to be in academia. There's an opportunity to bridge the gap in terms of what the industry wants—processes and products that work—versus what academics typically work on: theories, methods, and software/hardware prototypes.

Translating research into processes and products

My mission in academia is to devise problem-driven research and explore scientific solutions to problems that matter. I work with startups and advanced technology companies to translate the research into processes and products that the industry can ultimately use. This process is easy to explain but is very difficult to implement.



At universities, we receive funding from numerous national and local agencies—including the National Science Foundation, which has funded most of my work—to drive research that contributes to the body of knowledge in construction.

We use this as an opportunity to develop scientific concepts that are typically transformed into prototypes. We work closely with the construction industry and listen to what their biggest pain points are that we need to focus on.

Transforming software prototypes into products

The academic research typically stops at publications and developing prototypes. Because of this, we don't go the extra mile of transforming that prototype into a product or process that a construction company can use.

Universities traditionally don't support the transition of prototypes into a product or process. However, now that startups are adding excitement to our academic research, university leadership at our campuses are beginning to support this transition.

At the University of Illinois, our leadership recognized this opportunity early on. I was selected in the first cohort of faculty entrepreneurship fellows at the University of Illinois College of Engineering to transform our software prototype into products that can add value to the construction industry.

A prototype is great because it proves the concept and value. But construction companies should really interact with products because they have the potential to scale and be standardized across projects.

There must be a viable business case when assessing and testing a new solution before that opportunity can sustain and grow across your organization.

Entrepreneurship: bridging the gap between the industry and academia

In my opinion, startups are the best way to bridge between what the industry and academia both want. Numerous academic colleagues are interested in transforming their research into industry solutions through startups.

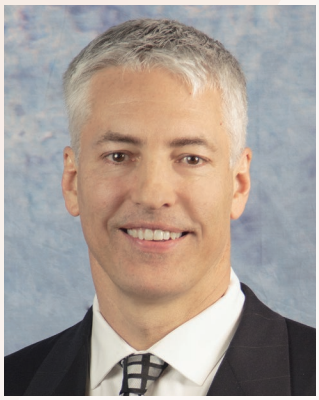
But this means that somebody must fund it, and these transitions come at a cost that's driven by venture capital firms.

"In the next few years, academia—particularly in construction informatics—will focus more on educating our students about how to develop internal entrepreneurial skill sets. This instruction will include new ideas on machine learning, artificial intelligence, etc., and how this technology can address pain points in the industry."

Interested students can gain a better understanding of industry pain points through conventional construction engineering and management education. They can also grasp new opportunities through data-driven courses.

Students will be well-equipped to establish business models with an academic background in entrepreneurship. They can transform ideas and concepts from the classroom and research lab into new industry-grade solutions.

Indeed, this is the right time and space for innovation and entrepreneurship in construction.



John Jurewicz,
Director of Technology Innovation,
Walbridge Building Design and Construction

Walbridge Building Design and Construction

JOHN JUREWICZ, DIRECTOR OF TECHNOLOGY INNOVATION

What is your current role, and how has your career evolved since you started in the industry?

JJ: My current role is director of technology innovation. It crosses both optimizing the tech we currently have while watching what new innovations are coming at us.

I was originally licensed as an architect in 1990 but played with super computers and digitized everything in CAD (computer-aided design). I also worked as a superintendent with survey equipment and as a project manager before things evolved into design build—designing and building things like radar stations and equipment.

My work was often something beyond just the building itself. In the mid-1990s, I learned early on the value of coordination modeling the systems inside the building.

In the case of radar facilities and air traffic control buildings, we often digitally modeled then built physical mockups to simulate what was about to happen for the Federal Aviation Administration and the Air Force. How you placed equipment and cable trays along with erection sequencing was very complicated. This experience would later be invaluable to me.

Walbridge and industrial design-build

Fast forward to my last few years working at industrial design-build contractor Walbridge. It's much more about what's going on inside the building than the building itself, including confirming the plant is kept up and running through multiple phases of new work.

The building itself is simply protecting very expensive equipment from the rain—equipment that generates a lot of money. More sophisticated technology is used inside the plant compared to the exterior.

It's not just how advanced technology improves productivity, safety, efficiency, or the construction of a building; it's also how you can most efficiently create the structures for production, whether it's an assembly line or manufacturing. It's really the next generation of building.

What are the biggest challenges to innovation, and how did you resolve them?

JJ: Meeting expectations is one of the greatest challenges. A lot of people on the vendor's side often sell what the software is going to do. There are these built-up expectations that the software, the systems, or the processes they're going to deploy are truly there.

Most of the time, anyone who has deployed technology realizes that it isn't all there because there are little bugs or integration problems that must be solved first. That's typically outside of the vendor's control. It's usually getting all the data organized in your house—or maybe the owner's house—so that you can deploy these cool new technologies.

These technologies already work, it's just that the culture—the organization of people—hasn't caught up yet. We haven't thought through what this all means. The greatest challenge is often the sociological aspects of trying to deploy technology and how the culture should change to become more optimal.

How can organizations create a culture of innovation?

JJ: How do you foster new ideas? We try to encourage and remove the barriers to try new concepts. These are usually applications people haven't thought of, combining two different solutions or using solutions that do a certain thing we like in a new way.

We get buy-in from the people funding this by taking it in steps. First, you must build credibility. This is usually done by getting teams to agree that this is the right thing to do and showing operations where the value is by taking it beyond the sales talk.

Capitalize credibility

After you get buy-in, you must offer proper support and follow up by taking things past demonstrations and teaching people how to use it. After a pilot with champions, we try to take it out further to the organization, although this takes more effort to spread across multiple jobs.

Building credibility amongst the operations side—with the people who are already controlling money and resources—to show that innovative technology is more efficient or optimal is the greatest way to build credibility. This is what fosters growth and trying new things.

What challenges have you faced so far in terms of implementation, and how did you tackle them?

JJ: We're currently facing a lot of demands to see if modular or offsite construction makes sense. The way I've personally tackled this is to break apart chunks of models that are provided either in-house or by outside partners and make the models more constructible.

The models become more valuable because you're doing this off-site, out of harm's way in an environmentally controlled facility. You're thinking through delivery in an entirely different fashion. You've got chunks of the building being delivered, and that doesn't always work with viaducts and bridges.

You're using these model chunks to think through rigging and installation—the logistics of how you're going to bring all this premade stuff to the site.

Obstacles to preassembly and prefabrication

If you're pre-welding with robots, weldments can be done much more accurately with an automated welding machine. However, you need to think: "Where do I need power, how am I going to build temporary facilities to pre-make the pipe, and what are the maximum ranges of delivery that will allow me to still ship and install it effectively while reviewing the safety aspects?"

For preassembly, when does it make sense to prefabricate? The question also arises, "Why don't we just do it the old way? Why does this new approach save that much more time?" If it doesn't save time, maybe you should do it the old way.

But then you realize sweating copper in the middle of a dust storm is hard to do. You've got to build a tent. Finding temporary enclosures sometimes closer to the job site is a viable alternative.

When you're doing modular construction, you must think fluidly and have an open mind.

What emerging technologies do you see representing the best opportunities, and what other technologies do you see helping us the most?

JJ: Within the past three months, we've noticed people agreeing that they can't conquer the world with sensor technology by building another proprietary database; they must build things on an open platform.

We've seen progressive movements in not just making construction trailers smart or the job site smart, which is always usually related to getting bandwidth out there early.

"It's more about putting the infrastructure in place earlier that will then benefit the owner running the whole building later."

Sensor and laser technologies

Sensor technology has a dual purpose beyond helping you create the building smarter, faster, and more optimally. The greater value is for the owner who's paying the general conditions for those sensors.

Sensor technology helps them track their workers and where things are, including long-term in the building itself. This is a trend that we are paying close attention to.

The cost of sensors is also dropping, and even the cost of automating things. For example, South Korea has new technology that hooks up to any light switch, making it easier to deploy a smart building even when you're retrofitting existing legacy systems.

The ball is rolling so fast and there's so much momentum that it won't stop and go backwards. That's what I find fascinating. You can just see everything that's going to evolve, especially with this innovative—what I'll call "millennial thinking"—of, "Well, why don't we just do it this way?"

What is the biggest value in AI and machine learning leveraging the existing data we're collecting in the short- and mid-term?

JJ: The value of machine learning—or algorithms that optimize—is going to first evolve in repetitive building types. For example, you're putting up data centers and modular construction in days instead of months.

You have a pattern of what we've done in the past, and now we want to increase efficiency or look at how to shave 30 percent off the schedule, which obviously saves money. The initial result you see is we're taking the patterns that you've already collected in your data and optimizing it with better intelligence.

It's usually experience-driven—people looking at the algorithms but also saying, "OK, if you're checker boarding the concrete pours to optimize how the concrete cures, what if you use two crews versus three?" Study how the crews affect each other's efficiency.

Monitoring patterns for optimization

For example, we can see the weather cycles and the predictability of rain. What if we build at a different time of year, when we're not as likely to encounter rain or flooding? You're going to see a mixture of weather data with predictability of patterns of how you pour concrete.

And you see some of these technologies we've been talking about. We've seen algorithms with recipes that can improve how you self-perform an activity.

But I'm thinking more holistically about the following optimization questions:

- Should you even be building like this?
- Or should you be building it at a different time of the year, and if so, how much money would that save?
- How can you optimize by evaluating four different sites where you could potentially build?

By observing the patterns of how to deliver concrete or build a batch plan, you can optimize the site selection based on the construction value or by lessening the environmental impact.

You're weighing both considerations simultaneously: "I've got less erosion and less impact to the environment, but am I paying a premium to deliver concrete or services to this site?" You can begin evaluating things differently.

Where do you see technology heading in the long term?

JJ: I foresee two trends in our industry:

- Constructors will become more technological in their approach to services.
- We'll also be more driven towards prefabrication. We'll partner with people who are very smart. Or we will become very smart at building portions of buildings, meaning we'll specialize in the prefabrication of certain building types.

For us on the industrial side, if we're designing and building data centers near power stations that are cogeneration facilities, we may start specializing in building just those because the cost of distributing the electricity is so much less.

We'll become advisors on how to build buildings for the biggest bang for the buck, meaning you build these factories close to where power's generated. And that isn't new.

If you build something near a hydroelectric dam, you could say it's going to be a lot easier to get reliable energy. But I'm thinking more in terms of looking at your existing nuclear assets.

The cost of energy is going to go down. They've got to do something with these nuclear facilities which are very expensive to run. Why aren't they locating the data facilities near the power stations? Or, why aren't energy-intensive factories that are producing gypsum drywall located closer to where the power source is?

Tracking emerging projects will become easier

Expensive tools are rapidly becoming more affordable everywhere. It's going to almost be an expectation now by owners: "Well, why aren't you tracking and doing things that quickly? Because everybody else is."

Owners are beginning to demand tracking work in place, using more meaningful dashboards, and telling you what's going wrong in terms of risk sooner. You can track bad news much more quickly. For example, Intel's RealSense sensors, which are under $200, are essentially doing what the $500 Tango did last year. And for quick little scanning studies, why not?

It's better to track work put into place. And once you know exactly what's put into place, what do you do with it? How do you adjust and start to optimize or reduce people working on top of each other—like you see with Oracle Prime Projects?

We can pull people apart so they're not working on top of each other. That's reducing our risk. There's a real value there.

Those construction advisors are going to evolve long-term. We're going to become better at giving good guidance on where to build in the future. And you'll be able to back it up with data using AI for sure.

Innovation in Action

Oracle Construction and Engineering is committed to helping drive innovation to improve project delivery outcomes in the industries we serve. The Oracle Construction and Engineering Innovation Lab is a unique facility designed to help educate and accelerate digital transformation by project- and asset-intensive organizations.

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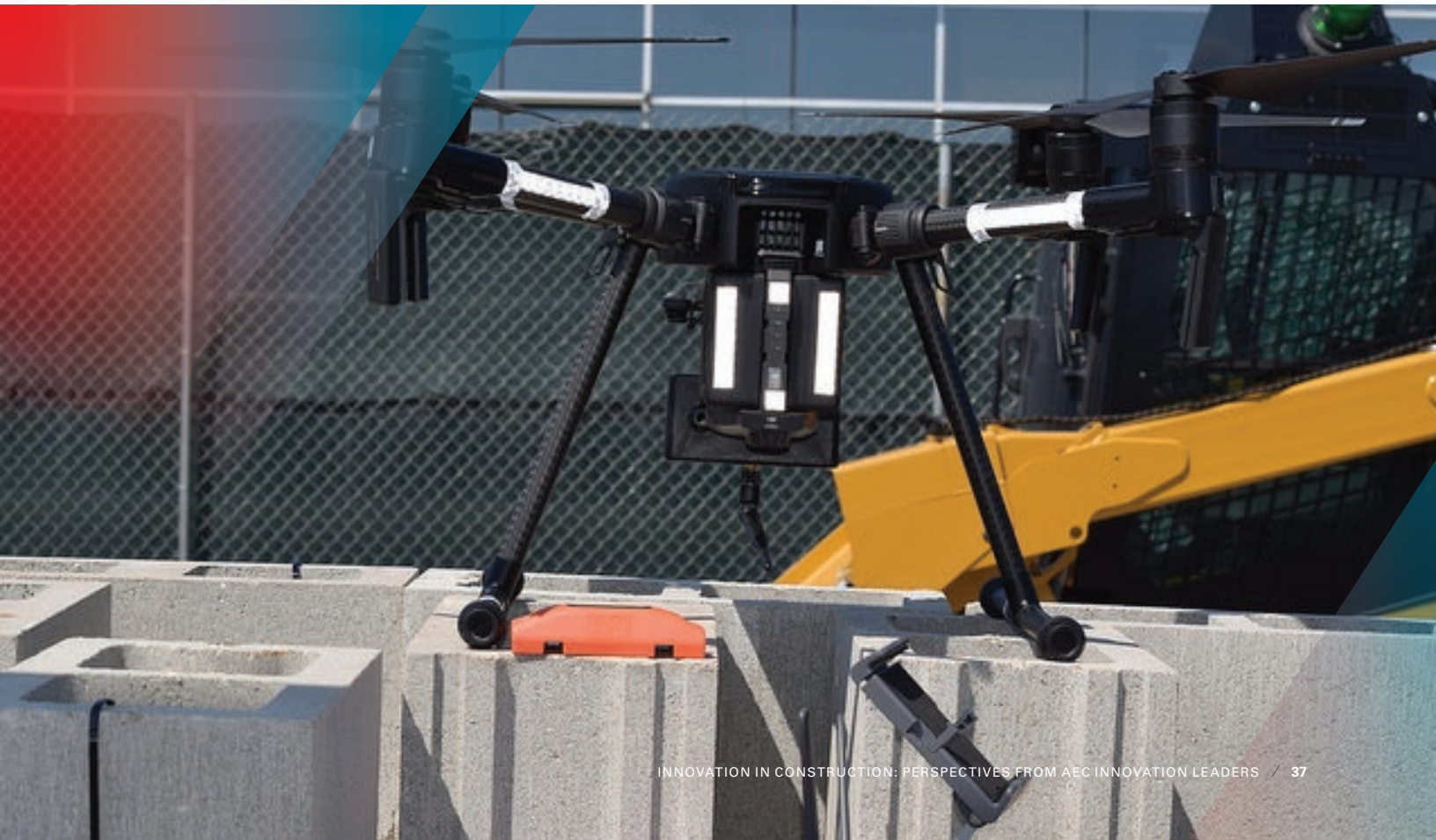
By presenting these experiences in a hands-on, real-world environment, the Innovation Lab powerfully brings to life the data insights and continuous operational improvements these technologies can yield in connection with Oracle Construction and Engineering solutions.

Explore our Innovation Lab online to learn more and schedule a visit.



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