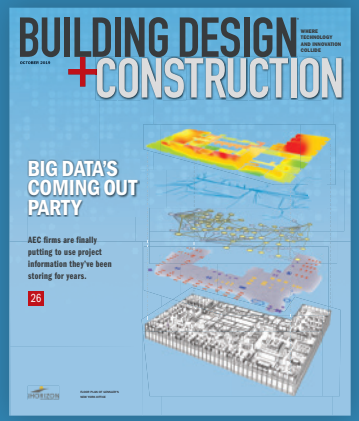
GIANTS 300

TECHNOLOGY + INNOVATION STUDY

ASSESSING THE STATE OF AEC TECHNOLOGY ADOPTION AND INNOVATION INITIATIVES AT THE NATION'S LARGEST ARCHITECTURE, ENGINEERING, AND CONSTRUCTION FIRMS



FROM THE EDITORS OF BUILDING DESIGN+CONSTRUCTION

BUILDING DESIGN +CONSTRUCTION

EXECUTIVE SUMMARY

THE STATE OF TECH INNOVATION AT THE AEC GIANTS

The great tech arms race is on in the AEC industry, and the nation's largest architecture, engineering, and construction firms—the AEC Giants—are leading the charge. These firms are implementing design and project coordination tools like real-time rendering software, VR, and 3D laser scanners on a wide scale. They are hosting innovation competitions and hackathons to create new and better tools and processes for the industry. They are exploring practical industry applications for novel technologies like blockchain, AI, robotics, and digital twin. We know this because we've spent the better part of the past 15 years covering these stories in the pages of the *Building Design+Construction.*

To gain a deeper understanding of the state of technology innovation at the AEC Giants, last summer *BD+C* launched the Giants 300 Technology and Innovation Study, a 12-question survey that asked firms to:

- pinpoint the tools they use most often
- identify their highest-ROI tech strategies and innovation initiatives
- discuss the business innovation initiatives their firm has successfully implemented
- identify "non-AEC industry" hires their firm has made in the past 24 months
- discuss the top business impacts of AEC tech implementations.

COURTESY CANNONDESIGN

The latest VR technology will introduce multi-user functionality, as well as advanced sound and haptics capabilities for AEC teams.

The online survey was emailed to firms that participated in *BD+C*'s annual Giants 300 Report. Of the 486 firms that made *BD+C*'s 2019 Giants 300 rankings (BDCnetwork.com/Giants2019), 130 firms participated in the Giants 300 Technology and Innovation Study.

We'd appreciate your feedback on the survey and your questions/comments about related issues and trends in the AEC market.

Please feel free to contact me.

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BUILDING DESIGN +CONSTRUCTION

EXECUTIVE SUMMARY

KEY FINDINGS

- Nearly half (42.3%) of AEC Giant firms feel that they are either "significantly ahead" or "somewhat ahead" of their direct competitors when it comes to adopting advanced AEC tech tools and processes.
- Improved project team coordination was cited as the most significant business impact from adopting AEC technology tools and processes.
- 3D laser scanning, real-time rendering, and design computation were mentioned most often as "high-ROI" tech strategies.
- The majority of firms (58.5%) report having a high "innovation conversion" rate (i.e., success rate) on technology and innovation initiatives.
- Two-thirds of responding firms have hired an "AEC outsider" within the past 24 months to help with their innovation efforts. The most common hire: software programmer.

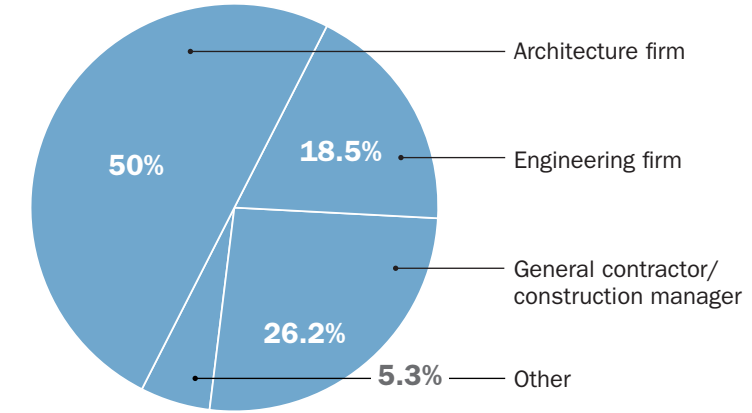
PURPOSE

- TO ASSESS the current state of technology adoption and innovation initiatives at the nation's largest architecture, engineering, and construction firms (the "AEC Giants")
- TO DETERMINE which tech tools and innovation initiatives offer the quickest return on initial investment (ROI)
- TO DOCUMENT trending technologies and tools among the AEC Giants.

METHODOLOGY

A link to a 12-question online survey was emailed to the primary contact(s) at all 486 AEC firms that submitted a 2019 Giants 300 survey for the July issue of *BD+C*. The *BD+C* Giants Report ranks the nation's largest architecture, architecture/engineering (AE), engineering, engineering/architecture (EA), contractors, and construction management firms based on design/construction revenue for new construction and renovation work in the commercial, institutional, industrial, and multifamily buildings sectors. No financial incentive was offered. A total of 130 firms participated in the 2019 Giants 300 Technology and Innovation Study, a participation rate of 26.7%

Chart 1. PRIMARY ROLE OF FIRM



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Half of the 130 firms that responded to the survey are architecture or architecture/engineering practices. Construction firms make up about a quarter of the responding firms. "Other" includes a design-builder and an interiors firm.

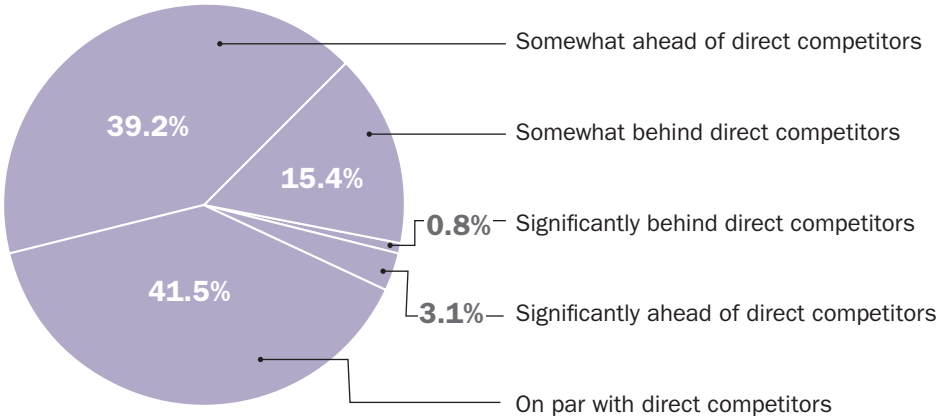
BY THE NUMBERS

Nearly half of responding firms (42.3%) said they are either "significantly ahead" or "somewhat ahead" of the competition, while 41.5% indicated that they are "on par" with competitors. However, that leaves a fairly sizable group—16.2%, or 21 firms—that believes their firm has fallen behind their key competitors on the AEC technology front.

Of the four firms that are "significantly ahead of direct competitors," three are architecture firms, the other is a general contractor. These firms are using a wide range of AEC tech tools on a large scale (five or more projects per year): 360 video/photos, 3D laser scanning, 3D printing, data analytics, digital fabrication, LiDAR, VR and mixed reality, photogrammetry, real-time rendering, and wearables

Of the 21 firms that are either "somewhat" or "significantly" behind their direct competitors, only a handful are using advanced tools like AI, digital fabrication, and LiDAR. However, 3D laser scanning, data analytics, real-time rendering tools, and VR are prevalent, just not at the scale seen with the leading tech adopters in the survey..

Chart 2. AEC TECHNOLOGY ADOPTION RATE VS. COMPETITORS



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OVERALL, THE AEC GIANTS ARE FEELING GOOD—BUT NOT GREAT—ABOUT THEIR PROGRESS IN ADOPTING ADVANCED AEC TECH TOOLS AND PROCESSES WHEN COMPARED WITH THEIR DIRECT COMPETITORS.

BY THE NUMBERS

When asked to select their top three business impacts from successful tech initiatives, respondents most often cited "improved project team coordination/ collaboration" and "improved client relations/vision meetings" (Chart 3). However, the responses varied by discipline, as shown in charts 3A – 3C.

Chart 3. TOP BUSINESS IMPACTS OF AEC TECHNOLOGY

(top 3 selected)

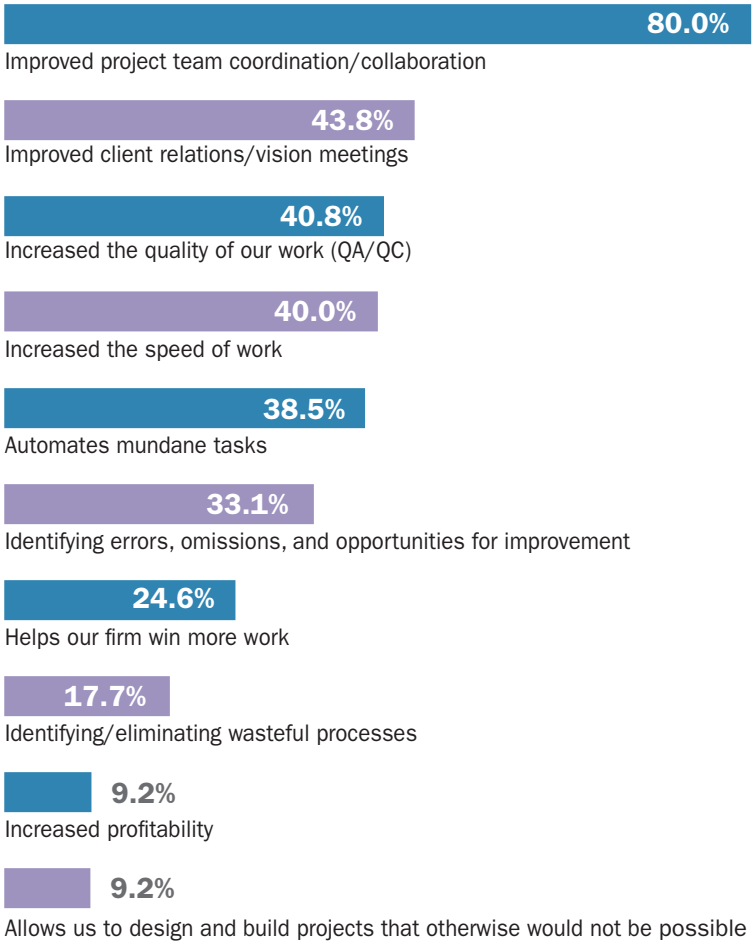

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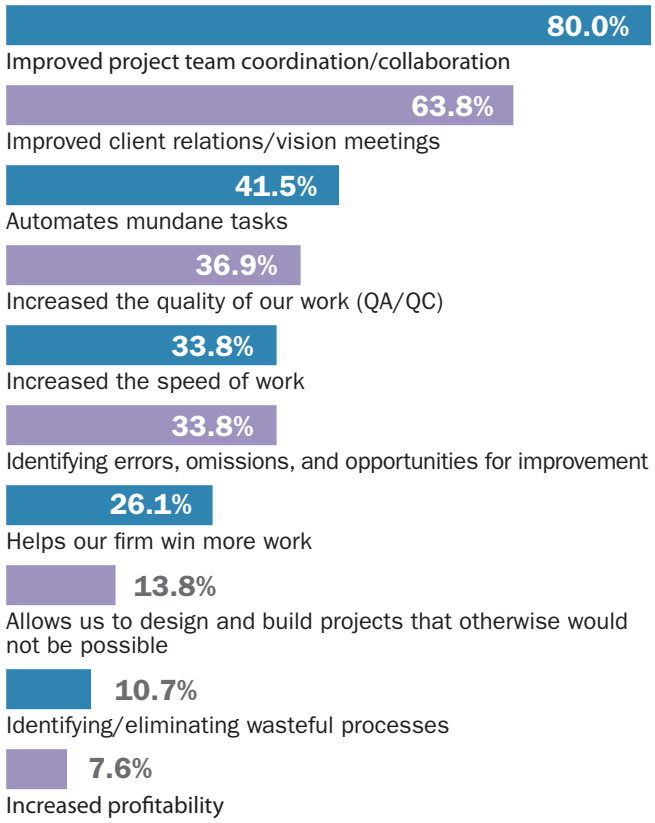
Chart 3A. THE ARCHITECTS



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BY THE NUMBERS

Chart 3B. THE ENGINEERS

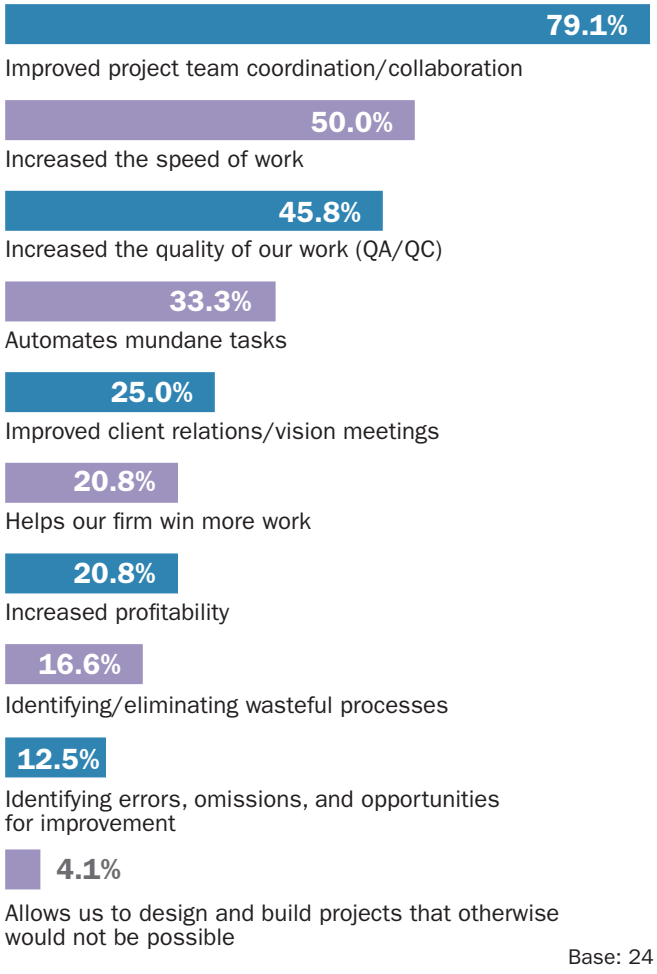

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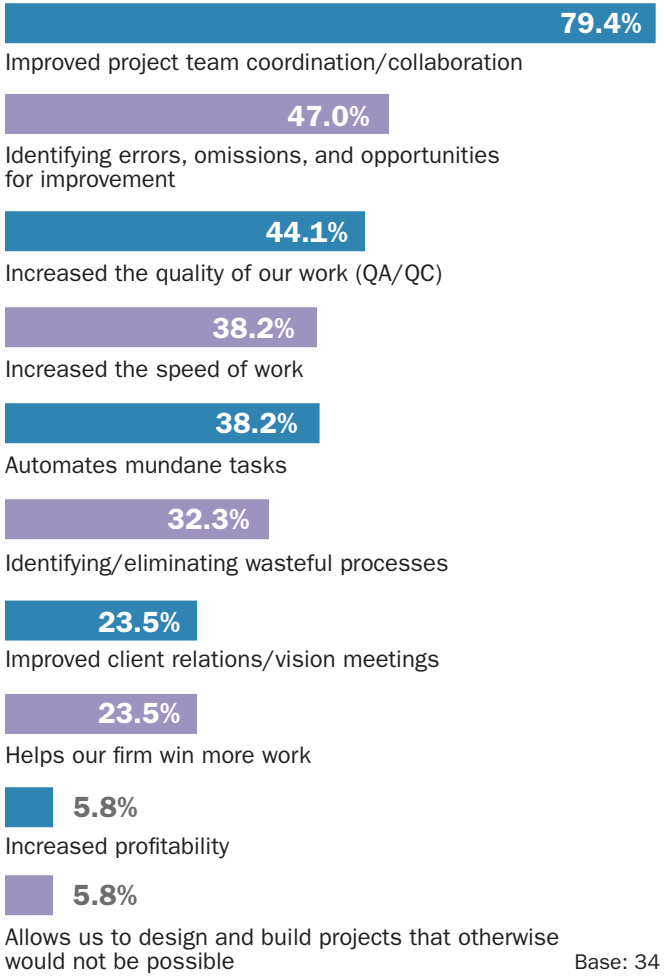
Chart 3C. THE CONTRACTORS



Base: 34

COURTESY SKENDER

A “smart” apartment prototype on display in Skender’s Chicago factory. The steel- frame module uses the Z Modular/VectorBloc, a Lego-like steel connection system that “pins” the modules together.

Contractor Giants are all in on offsite construction

One takeaway from this study that stood out to the *BD+C* editorial team was the astonishingly high adoption rate of offsite construction among the general contractors and construction management firms. Of the 35 GCs and CMs that participated in the Giants 300 Technology and Innovation Study, 25 firms (71.4%) indicated that they use offsite/prefab construction on projects, and, incredibly, nearly half (45.7%, or 16 firms) use offsite construction on “all” or “many” projects.

Of the 10 firms that currently are not implementing offsite construction on projects, three firms are pilot-testing offsite processes and four are considering the approach for future application. That leaves just three firms (8.5%) that indicated they have zero interest in offsite construction—which means we’re looking at an adoption rate of more than 90% among the nation’s largest GCs and CMs.

When asked to pinpoint the single most significant AEC technology innovation their firm has initiated in the past year with positive results, DPR Construction’s National Director of Innovation, Kaushal Diwan, cited the use of multitrade/ multiscope prefabrication through its strategic partnership with Phoenix-based prefab provider Digital Building Components: “The ability to take more complex work offsite while other work proceeds, then bring ready-to-install elements to the site is a significant advance in the use of prefabrication. With the existing labor shortage and desire to still have speed-to-market, we think we’re only beginning to see the possibilities.”

Speed, quality, advanced coordination, and schedule gains are commonly cited as benefits of offsite construction. But what about hard-dollar ROI? “Our current metrics savings show that prefabricating with Digital Building Components offsite saves 10–20% on overall cost,” said Diwan. “It can save time by improving installation efficiency by 20–30%, and it increases quality by reducing rework to less than 1%.”

The caveat, added Diwan, is that these results “are only possible through deep adoption and integration with virtual design and construction and robotics technology, which Digital Building Components uses.”

BY THE NUMBERS

Firms are using VR, 360 cameras, real-time rendering software, and drones at the widest scale, but 3D laser scanners are most prevalent. Nearly three in four firms (74.80%) use 3D laser scanners on at least "some projects"; half (50.39%) use them on "many projects."

Chart 4. IS YOUR FIRM USING ANY OF THE FOLLOWING AEC TECHNOLOGIES ON PROJECTS?

▶ "YES, ON MANY PROJECTS"

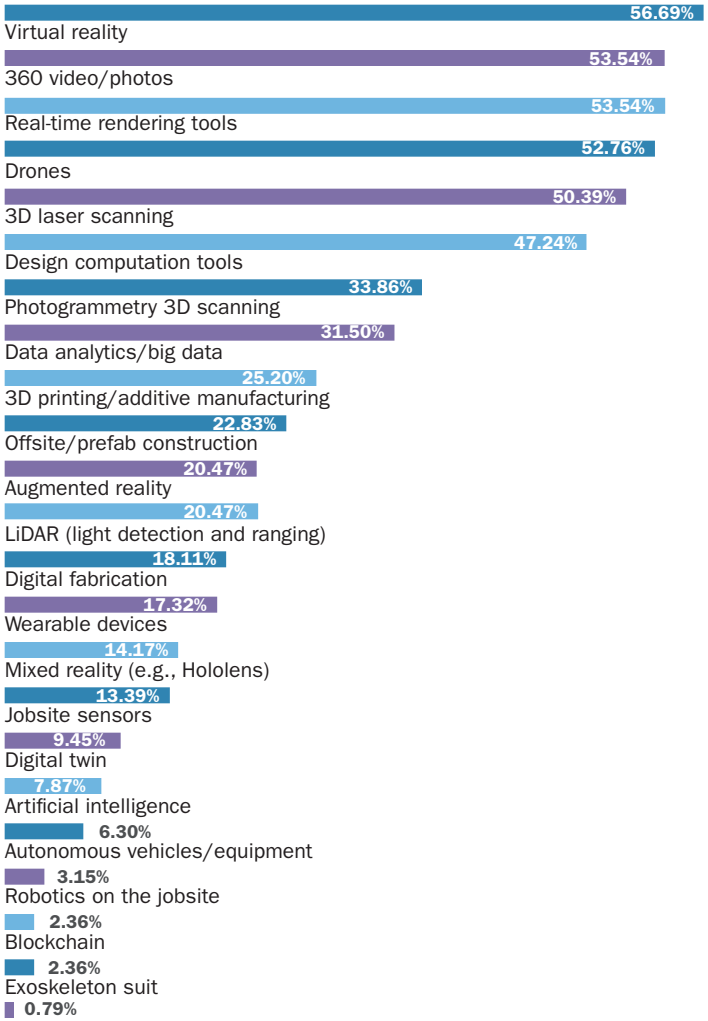


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Chart 4A.

▶ "YES, ON SOME PROJECTS" (LESS THAN FIVE)

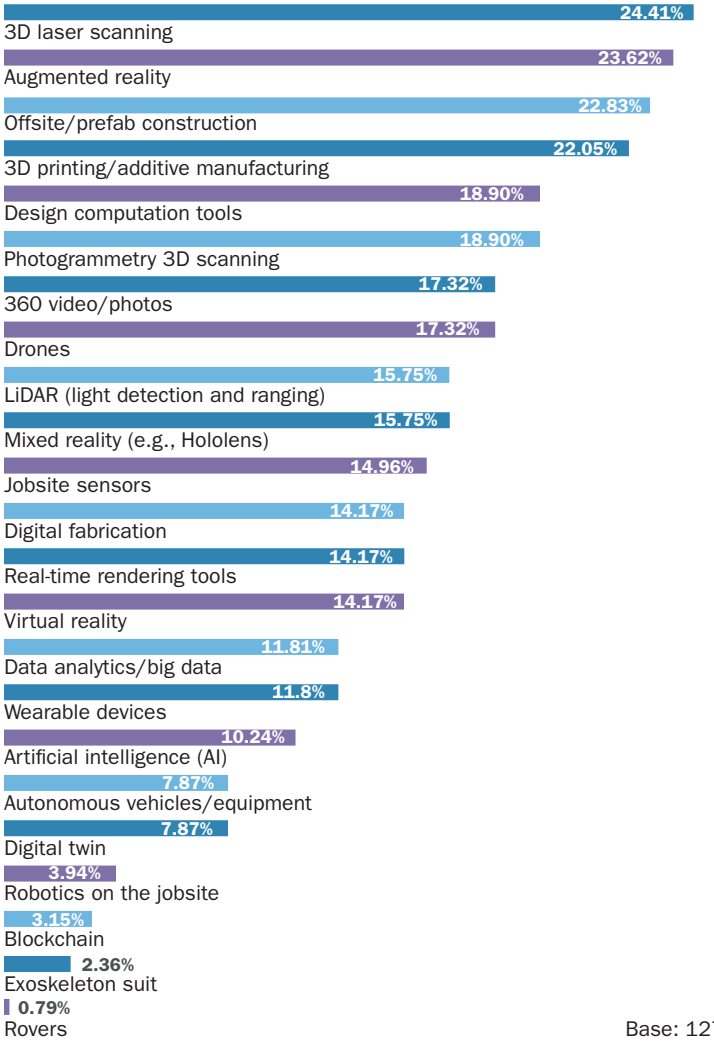

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Chart 4B.

▶ "WE ARE PILOT-TESTING THIS TECHNOLOGY"

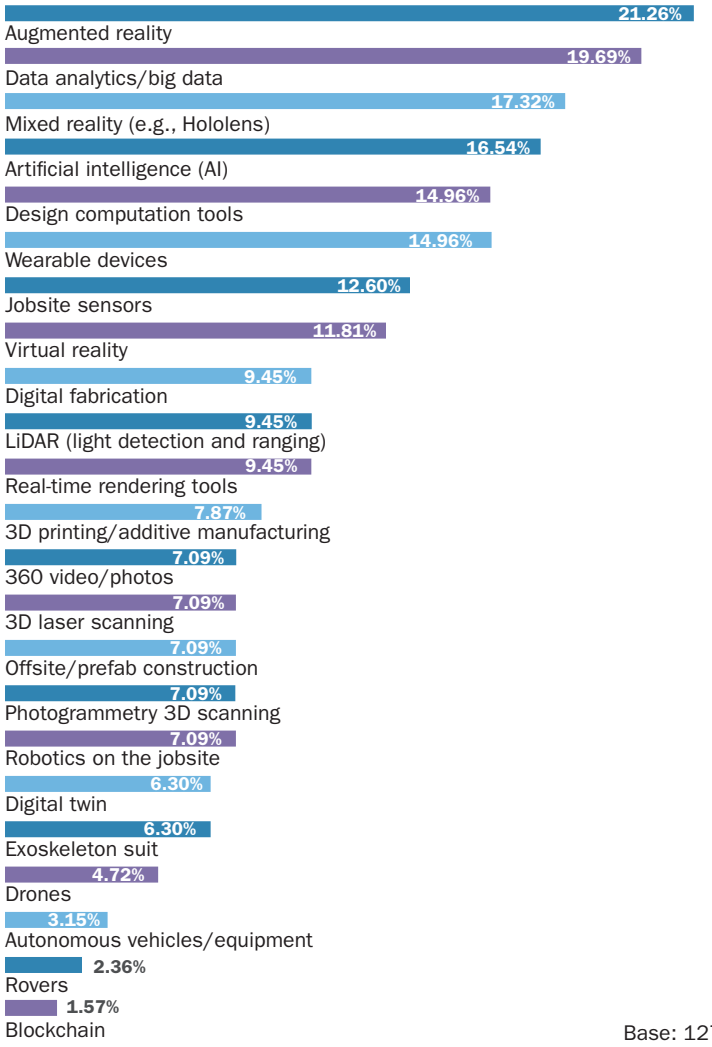

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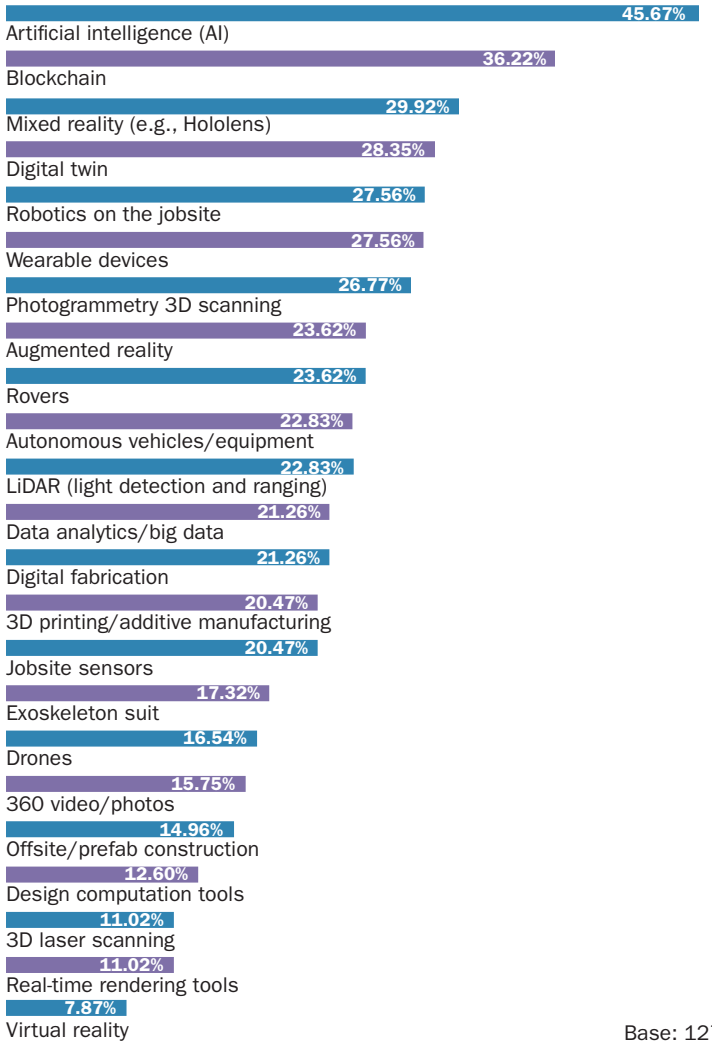
Chart 4C.

▶ "NO, BUT WE'RE CONSIDERING THE TECHNOLOGY"



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BY THE NUMBERS

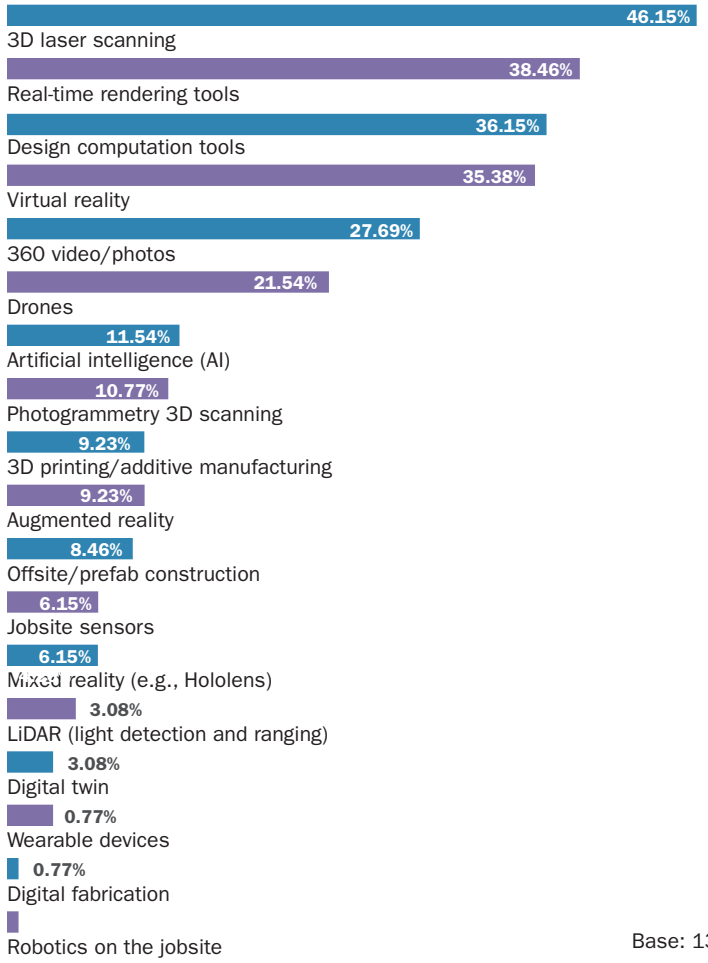
3D laser scanning, real-time rendering tools, design computation tools, and VR were cited most often as "high-ROI" tech strategies. Forty-six percent of respondents indicated that 3D laser scanning offered a strong return on initial investment; 38.46% for real-time rendering tools; 36.15% for design computation; and 35.38% for VR.

"**Real-time rendering** tools such as Enscape have been the easiest and most seamless for our firm to utilize. They have provided multiple ways for us to output information, static renderings, 360 renderings, and VR in 'real time' with a client," said an architect respondent.

"Documentation of projects with 360-degree photos reduces the time needed to take progress photos; offers greater capture of detail and the ability to look back in time and compare against current conditions; and provides owners with more information at turnover that can help with their future facility planning efforts," said a contractor respondent.

ONCE CONSIDERED TOO COSTLY AND COMPLEX FOR AEC FIRMS, 3D LASER SCANNERS ARE NOW A MUST-HAVE TOOL.

Chart 5. TOP ROI AEC TECH STRATEGIES
(TOP THREE SELECTED)



BY THE NUMBERS

Tech tools training, collaboration zones, custom tools development, and VR/AR/CAVE stations are the most widely implemented business initiatives among the AEC Giants.

Real-time project tracking is likely to grow in popularity as more firms look apply a "jobsite as a factory" approach to construction. Tech vendors like Reconstruct, which offers tools and services for near real-time monitoring of project schedule and quality vs. reality, are helping contractors track their projects more closely.

REAL-TIME PROJECT TRACKING, MAKER SPACES, AND INNOVATION COMPETITIONS ARE ON FIRMS' RADAR FOR FUTURE ADOPTION.

Chart 6. TOP BUSINESS INNOVATION INITIATIVES

BY THE NUMBERS

Chart 7A. NON-AEC HIRE IN PAST 24 MONTHS?

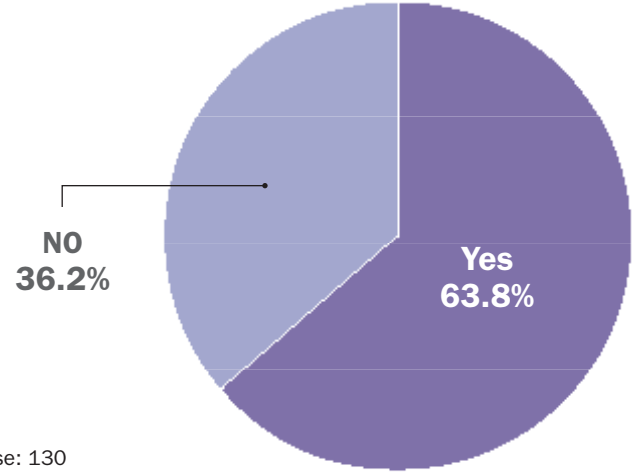


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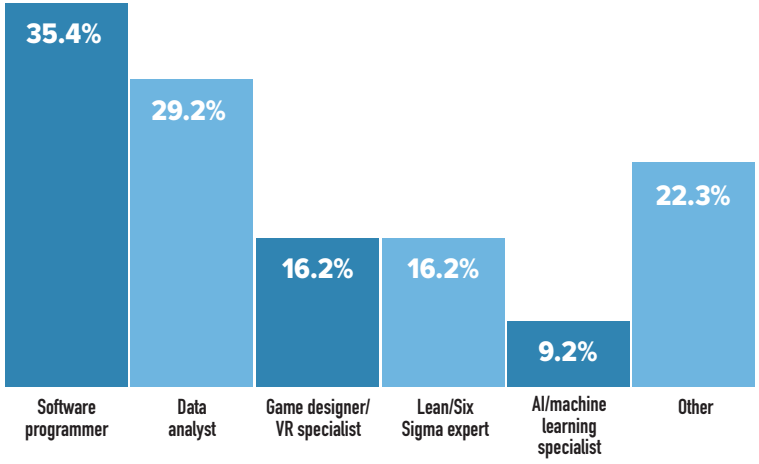
Chart 7B. TOP 'AEC OUTSIDER' HIRES



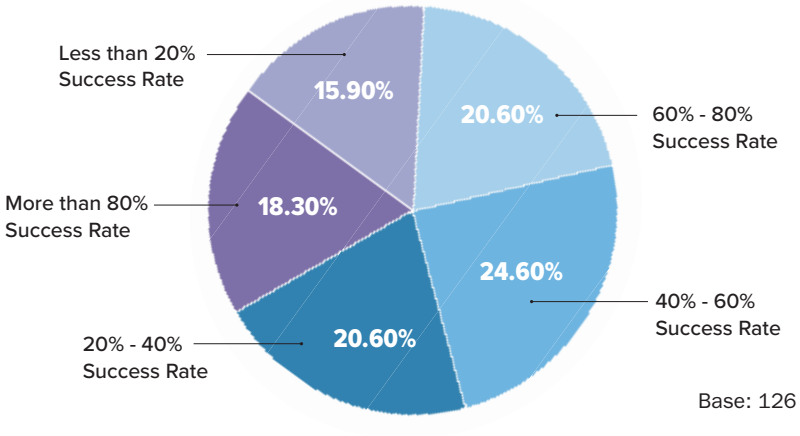
Base: 83 (multiple responses permitted)

Firms increasingly are looking outside the industry for technical expertise. Nearly two-thirds of responding firms have hired an "AEC outsider" within the past 24 months to help with their innovation efforts. The most common additions: software programmer, data analyst, and game designer/VR specialist.

When asked to rate the success of individual innovation projects/ initiatives implemented within the past 24 months, nearly two-thirds of responding firms (63.2%) reported a success rate of at least 40% on tech innovation initiatives. About a fifth of firms are hitting on 80% or more of their innovation projects.

Chart 8. "INNOVATION CONVERSION" RATE

(% SUCCESSFUL INNOVATION IMPLEMENTATIONS PAST 24 MONTHS)



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Most promising AEC tech innovation? Good luck trying to settle on just one

Which AEC technology application shows strong promise for the near future? The answer to this question depends largely on whom you ask. Those within the design community will cite "design automation," "AI and machine learning," and "real-time visualization."

On the construction side, responses like "real-time monitoring," "reality capture," "mixed reality," and "integrated design/construction/manufacture platforms" are more common.

In fact, if you asked chief technology officers from 130 different AEC firms to pinpoint their company's most-promising tech application for the near future, we'd bet that you would receive more than 50 different answers. We know this because we asked this very question to AEC Giant firms as part of the Giants 300 Technology and Innovation Study and found very few commonalities among the answers provided: Data transfer tools, safety tracking software, building sensors, self-driving equipment, IoT solutions, evidence-based planning, robotics, multi-user VR, digital twin, automated feasibility studies, business intelligence tools, and at least two dozen other emerging technologies and processes were mentioned.

The varied responses, of course, are reflective of the complex, convoluted, and somewhat tangled mess that is the AEC industry. See all responses to this question at right and on the next slide.

PHOTO BY TOM BONNER, COURTESY SUFFOLK

Suffolk Construction's Smart Lab in Los Angeles brings predictive analytics, advanced Lean processes, VR, and live jobsite feeds to the office.

Name one AEC-related tech firm or application that shows strong promise for the industry for the near future.

AI and robotics: "I think any company that is involved in AI and robotics will have the biggest impact on the AEC industry. Using artificial intelligence and robots will get work done faster and more accurately. In many areas, work can continue 24/7, greatly reduce waste, and cut spending. Having robots instead humans assigned to dangerous tasks in risky areas will reduce injuries and construction insurance costs, which leads to more affordable buildings."

Artificial intelligence: "Applications include schedule efficiency analysis, productivity tracking and analysis, and construction safety."

Autodesk BIM 360: "Based on Autodesk's history of tech company acquisitions, this suite of software is becoming a fully integrated soup-to-nuts tool for the AEC industry."

COURTESY CLARK CONSTRUCTION

Clark Construction's Turnover Vision is an interactive punch list management application developed by the firm's Research and Development Group. It combines punch list and scheduling data to optimize a project's work plan.

Bluebeam: "Went from being a PDF software with some collaboration on drawings to a full platform solution to manage drawings while keeping its cost lower than Adobe Acrobat."

Briq: "They're helping us expand our usage of AI and predictive technology. We're designing some new autonomous processes to save hundreds of hours per year."

Dassault Systemes' 3DExperience: "It's a PLM (product lifecycle management) solution with AEC-focused tools. It has the potential to provide the industry with true 3D collaboration and delivery in the cloud."

Dynamo: "The Revit plug-in allows users to create custom applications that follow and improve upon existing processes with the benefit of automation."

Enlighted: "Redefining what a smart building can be. Sensors can be installed in every light fixture with the ability to collect data 65 times per second to detect environmental and occupancy changes and react to lighting and HVAC needs in real time. The platform is able to locate people and assets within a building and analyze the occupancy of floors and rooms."

Enscape: "Allows real-time visualization outside our design models in such a way that we can keep our design models light and nimble, and focused on documentation. It is a game changer."

Finch: "A parametric tool for adaptive plans."

HoloLive3D: "This software allows us to leverage MR/AR with tools such as HoloLens and iPads to connect to our project management solution."

Hypar.io: "An alternative to help us create multiple iterations of a conceptual idea, without the excessive time involved to find the most efficient or 'best fit' for our design intent. Using this automated process, we can spend more time and expertise developing the nuances that make the design unique for us and for our clients."

InSiteVR: "InSiteVR collaborated with Autodesk BIM 360 to have real time, distributed virtual reality collaboration. This allows remote participants to look at the VR model together for design and collaboration, and interact with each other inside the model."

IoT + digital twin: "This combination offers one of the most exciting areas for improvements in built environments. Senseware and Awair are a couple that we are currently working with."

Katerra: "Vertical integration of design, procurement, and fabrication."

Magic LEAP: "AR/VR, drones, and big data. Streamlines project vision, client decisions, marketing tactics, operations, and overall profitability."

PlanGrid + Autodesk: "PlanGrid is one of our most widely used applications. With their incorporation of BIM viewing, PlanGrid appears to be positioned well to remain one of the most supportive technologies for our field teams."

Reconstruct: "Near real-time monitoring of schedule/quality vs. reality."

Smartvid.io: "Strong strategy around AI for construction."

Testfit: "For automated feasibility studies."

Trimble XR10 + HoloLens 2: "Brings reality and data to a worksite to increase efficiency and productivity while lowering safety risks."

VIM AEC: "What Enscape does for Revit and VR, this will do for Revit and AR."

What is the single most significant AEC technology innovation your firm has initiated in the past year with positive results? Please indicate ROI if possible (i.e., cost savings, time savings).

3D laser scanning: "40% time savings, increased accuracy, and improved collaboration."

AI for automation: "Artificial intelligence to automate submittal register process; 200% reduction in time."

AI for construction safety: "Investment in AI and machine learning for our safety program."

Analytics for site selection: "Real estate analytics for lot/site selection with our developer customers. ROI: We're getting more work and projects have been accelerated."

Augmented reality: "The use of 3D cameras and augmented reality goggles has significantly improved productivity in the field while providing clients with additional peace of mind that projects will be delivered on time and within budget."

Autodesk BIM 360 Design: "It allows collaboration in the cloud; consistent real-time access to consultants' models; eliminates time to prepare models for exchange/transfer; efficient management/ administration of servers. Time savings are significant."

Building sensors: "Sensors are not new, but our process for collecting, analyzing, and visualizing the data has yielded positive results in both time and money. Data was collected using existing client security systems (proximity card systems), client scheduling systems (calendar applications), and via RFID tags and inexpensive infrared people counters. Significant data sets were generated, and customized extract, transform, and load (ETL) scripts were used to cleanse and migrate the data. A combination of geolocation, spatial syntax, and AI was used to generate travel paths, identify bottlenecks, and quantify space utilization. Models were developed using a combination of Rhino/Grasshopper, R Studio, Tableau, and SQL Server. Once the baseline models are created, future state options are analyzed in real-time based on metrics co-developed with the client. This methodology has proven to reduce the hours associated with data collection/analysis by approximately 30% on major projects, and the results are far superior when compared to traditional approaches. This data-driven design process also allows our clients to make informed decisions earlier in the project."

Custom computational design tool: "We developed a computational design optimization tool, called WindBuilder, which improves schedule and the design of wind turbines, roads, and substations. Time savings are in the magnitude from weeks to hours using computational design algorithms."

Data-rich modeling: "We've moved to a data-rich Revit model where the duct system information propagates from plan to schedule to analysis, allowing the engineer to optimize in real time based on velocity, flow, or pressure either by schedule or graphical display. With this data-rich model, processes that had been entirely manual move toward partial automation and eventually to fully automated."

Drones and 3D laser scanners: "Aerial data capture via drones and new additions to the laser scanning fleet. Both of these have helped our project teams document their existing conditions and progress to keep our projects' digital twin accurate."

Dynamo scripts: "We have benefited from the development of Dynamo scripts in the last several months alone. Return has been captured specifically on three points: duplication and model warnings, major vertical changes, and room height details. By implementing these customized scripts we have realized a notable time savings for our modelers."

Hospital asset and people tracking: "The technology utilizes sensors: WiFi tags for equipment and smartphone Bluetooth for people. The equipment tracking saves hospitals 5-15% of replenishment costs due to wasteful over-purchases. The people tracking ensures safety of the entire hospital."

Last Planner System: "Lean and software that support the Last Planner System; up to 10% savings in schedule."

Microsoft SharePoint: "Allows for easy access and collaboration with the office and the field without having to constantly email documents back and forth. For the field, they have access to the documents with or without Internet access. The time savings of not having to send back-and-forth emails, as well as superintendents not needing to constantly request information from the project manager, are an enormous ROI for us."

Mobile survey tool: "We worked with an app developer to create a mobile application, Work.Life.Now., for our in-house workplace strategy team. The application gathers live data as users move throughout a facility and asks for live feedback about the success of the space. The survey asks a few key questions: Are you working? Where are you working? Do you have the tools to succeed? And, most importantly, how engaged are you in what you are doing now? The app collects robust engagement data that provides indicators on where to delve deeper in data gathering. The app helps us better understand our clients' needs without time and effort wasted on surveys and hours of observation."

Offsite construction: "The use of multitrade/multiscope prefabrication. The ability to take more complex work off site while other work proceeds, then bring ready-to- install elements to the site is a significant advance in the use of prefabrication. With the existing labor shortage and desire to still have speed-to-market, we think we're only beginning to see the possibilities. Our current metrics savings show that prefabricating with Digital Building Components off site saves 10-20% on overall cost, can save time by improving installation efficiency by 20-30%, and increases quality by reducing rework to less than 1%. However, these metrics are only possible through deep adoption and integration with virtual design and construction and robotics technology."

Photogrammetry: "3D laser scanning combined with our drone operation for photogrammetry. The capability for one person to accurately survey a facility in a fraction of the time it used to take and with far fewer errors has proven to be incredibly valuable for us. It has allowed us to reduce the number of trips to a project site, especially on addition and renovation projects, and has given us more flexibility to share work across offices, as remote teams have access to a wealth of information digitally via our scans."

Plangrid: "With document control using Plangrid we're saving at least one hour per week per employee."

Procore: "Project management platform with various modules that bring documentation and BIM data to the field. ROI of hundreds of thousands of dollars by having real-time data available."

Pype AutoSpecs: "It utilizes AI to convert specifications into a submittal register in minutes. Previously, this task was manual and could take an individual multiple days to compile the data, which is prone to human error. Now users can focus on understanding the specifications' content instead of re-keying the data."

Real-time rendering: "Tools such as Enscape have been the easiest and most seamless for our firm to utilize. They have provided multiple ways for us to output information, static renderings, 360 renderings, and VR in real time with a client."

Robotic process automation: "RPA will have a financial impact of more than $1 million in time savings by end of the year."

Vista Viewpoint: "We have a much better sense of each project's finances."

BUILDING DESIGN +CONSTRUCTION

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MORE *BD+C* RESEARCH PROJECTS COMING IN 2020

Color Trends Survey, March 2020
Assessing the leading and emerging trends and drivers related to the use of color on building projects.

Office Amenities Survey, June 2020
Insights into design trends and the most popular amenities for corporate and speculative office developments.

Giants 300 Report, July – October 2020
The annual Giants 300 package offers exclusive AEC firm rankings across 30+ building sectors and specialty categories (110+ rankings in all).

Multifamily Amenities Survey, September 2020
Insights into the most popular amenities for rental and for-sale multifamily developments.

Giants 300 Technology and Innovation Study, November 2020
Assessing the state of AEC tech adoption and innovation initiatives among the AEC Giant firms.