



CONSTRUCTION & TECHNOLOGY:
BUILDING FOR THE FUTURE

ABOUT THE AUTHOR

Navitas Capital is a venture capital firm focused on early-stage technology investments for the real estate and construction industries. Current and past portfolio companies include Katerra, PlanGrid (Autodesk), Matterport, Truss, HqO, Bowery, Aquicore, Livly, Gridium, View, Honest Buildings, Harbor, PeerStreet, Sweeten, Comfy (Siemens) and Can2Go (Schneider Electric). Navitas offers a unique perspective on the built world spanning multiple venture capital funds since 2011, as well as the partners' own experience owning, managing, and developing over \$1B in real estate assets.

Navitas' combination of venture capital & real estate experience, along with the ability to test and deploy cutting-edge technology across its own portfolio, creates a unique investment platform for its portfolio companies and limited partners. Beyond its own capital and real estate, Navitas helps startups scale rapidly by facilitating access to Navitas' network of industry leading LPs with global scale.

Navitas' investment strategy is to provide a combination of growth capital, industry expertise, and market access to high growth technology companies. Navitas is currently investing out of its second VC fund that includes anchor strategic commitments from a number of industry leading LPs.

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RETHINKING CONSTRUCTION

Construction is a key industry across the world, representing approximately 13% of worldwide GDP or roughly \$10 trillion in annual spend on construction-related goods and services. The sector employs over 7% of the world's working population. Despite its relevance, the industry has struggled to evolve its approaches, and its productivity has suffered as a result. In fact, construction is one of the only industries that has experienced productivity *losses* over the last several decades. Today, McKinsey estimates that the average large commercial construction project is delivered 80% over budget and 20 months behind schedule.¹

One of the reasons behind this statistic is that while projects have continued to grow in size and complexity, fragmented and misaligned contracts, as well as challenging and inefficient industry dynamics have not changed. Said another way, while engineering and design have evolved over time, producing awe-inspiring new skyscrapers and structural forms, builders still primarily use manual methods and operate according to established inefficient practices. This conventional approach to construction simply cannot achieve the speed and scale required to meet the demands of future population growth, global urbanization and customer project requirements for accurate and timely results.

Another key contributor to the inefficiency in construction is a general lack of technology innovation and continuous commitment to R&D in the space. Construction firms, on average, have invested only 1.5% of gross value added² compared with 5.7% in financial intermediation and 3.3% in manufacturing³. This relatively low rate of investment has not been enough to move the industry forward in a meaningful way.

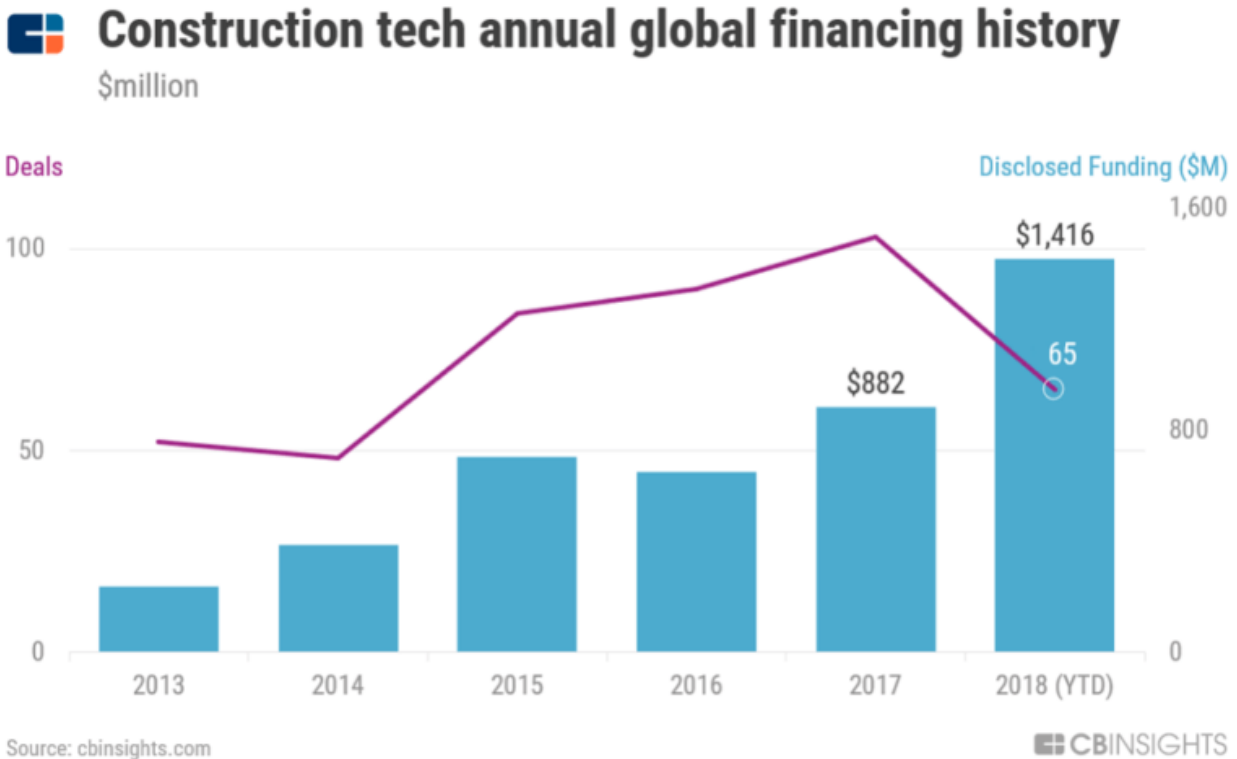
However, this “R&D gap” is in the early-stages of being filled by the Venture Capital and startup ecosystem, seeking to build a new generation of technology-forward companies in one of the largest industries on the planet. Many see 2018 as the inflection point for the construction tech sector, as investor momentum continues to build, including 324% annual growth to nearly \$3.1 billion in 2018 compared to \$731 million in 2017, according to Crunchbase. Major global investment firms including Softbank Vision Fund and Tiger Global Management are investing hundreds of millions in the sector given its size and global importance, backing “Unicorn” startups such as Katterra (Navitas portfolio company) and View Glass (Navitas portfolio company). In addition, recent high profile exits such as PlanGrid for \$875 million (Navitas portfolio company), Building Connected for \$275 million, and ViewPoint for \$1.2 billion have investors and industry leaders taking notice.

¹ McKinsey Insights, Imagining construction's digital future, 06/2016

² Gross Value Added is defined by McKinsey as the final value of the construction good (for example, the house) minus the value of the inputs required to build that house (for instance, wood and bricks) excluding depreciation of capital goods

³ McKinsey Global Institute, Reinventing Construction: A Route to Higher Productivity, 02/2017

Investment in construction technology has doubled over the past decade.



Along this line, construction firms have begun to transform and boost their productivity by embracing the digital age. New workflow & productivity applications, augmented reality design, sensors for material management, drones, and virtual reality devices have started showing up on jobsites as contractors begin to test and deploy “digital solutions” across their organizations. Software solutions, including Building Information Modelling (BIM), that have been used for decades have started to become more ubiquitous and advanced, while newer cloud-based software workflow solutions like Procore and PlanGrid are becoming industry standards for managing projects.

With large and more frequent investments from both technology companies and venture capital funds, there are a growing number of startups aiming to tackle inefficiencies in the industry given the massive market opportunity. As longtime investors in the space, Navitas witnessed first-hand how new companies like PlanGrid have been changing the industry since 2012 by bringing powerful, and easy-to-use mobile software to the project site. Other leading startups like Procore, Katerra and Uptake have raised 100’s of millions in venture capital as they seek to gain widespread adoption. Similarly, scores of new technology startups are looking to leverage the power of modern sensors, mobile devices, data networks and cloud computing to create a more automated and efficient construction industry. The result is a large and rapidly expanding universe of venture capital backed startups in the space.

CONSTRUCTION TECH MARKET MAP

COLLABORATION SOFTWARE

PROJECT & TASK MANAGEMENT



OTHER COLLABORATION TOOLS



MARKETPLACES

EQUIPMENT SHARE



OTHER MARKETPLACES



INVENTORY & SUPPLY CHAIN MANAGEMENT



DESIGN TECHNOLOGIES



RISK MANAGEMENT

MONITORING & SAFETY



SECURITY & COMPLIANCE



FRONTIER TECH & ROBOTICS

DRONES



AR / VR



CONSTRUCTION ROBOTS



DATA & ANALYTICS



FINANCIAL MANAGEMENT



In theory, selecting the right tools for a specific application should be enough to produce improved results. However, given the complexity of large projects and the various handoffs, the potential for silos to occur increases. More often than not, these solutions have only led to incremental improvements. Sometimes new construction technology, which is designed to make building projects easier, can raise project costs and cause inefficiencies as they do not integrate into existing workflows. Therefore, despite growing interest and investment in technology, most of the industry has struggled with formulating an efficient technology adoption strategy. As a result, construction continues to suffer from low productivity compared to most other industries.

In addition to exploring some of the broader trends and industry dynamics in this white paper, we chose to focus on the following, select opportunities to drive efficiency in the construction sector vs. trying to tackle the entire space:

- 1) Automation & Off-Site Construction
- 2) Digitization of Construction

As a starting point, we believe that one of the most meaningful opportunities for the industry in recent years has been the departure from entirely project-based approaches to a more manufacturing styled, off-site production. Here, the manufacturing sector provides an interesting parallel to the construction industry. Not long ago, trying to get ahead by squeezing suppliers on cost was the common strategy in manufacturing. However, manufacturing companies realized that a better option was to manage supplier relationships as long-term partnerships in order to drive higher innovation, productivity, and collaboration. Therefore, manufacturing's adoption of lean principles and aggressive automation has been transformative, increasing productivity 10 to 15 times since the 1950s.

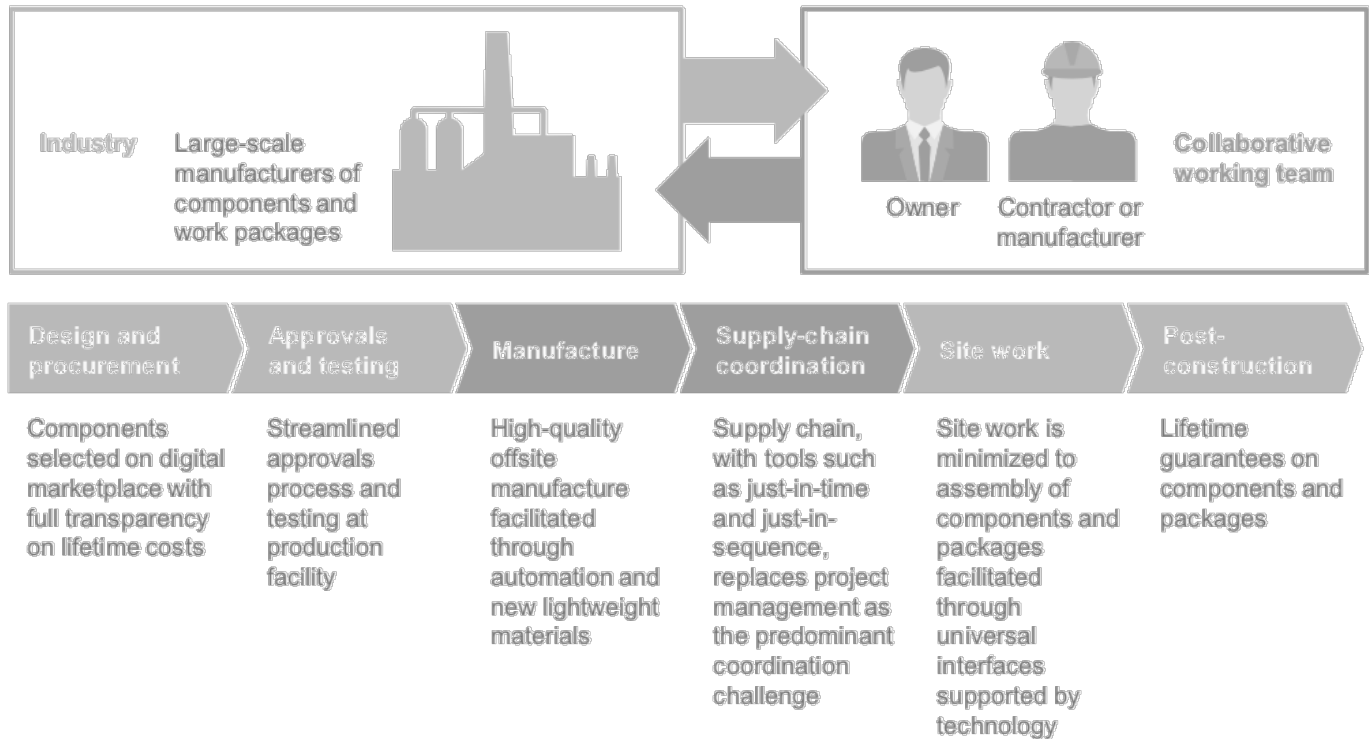
The convergence of manufacturing and construction created a process known as “industrialized construction”. This offsite factory-build approach describes an integrated process starting with material procurement all the way to the jobsite implementation, designed with the intent of closing the productivity gap and modernizing construction. This represents a wholesale shift from one-off projects to mass production of componentized buildings, which may help deliver accelerated project schedules and reduce waste — all while keeping construction costs more predictable. Consequently, we recently invested in Katerra's factory-centric and technology-enabled platform, which we see as a missing piece in the evolution of the sector towards industrialized construction.

Secondarily, we explore the growing use of digital solutions in construction that seek to drive more efficient workflows and data-driven decision-making. Off-site construction “manufacturing” at scale can only be achieved via the use of interconnected software platforms that combine new technologies like robotics, fully immersive mixed reality, digital twin models to map progress and intelligent infrastructure driven by IoT sensors. Combining these various technologies creates the potential for a future with fully automated and self-managing jobsites powered by autonomous vehicles, robotics and real time predictive analytics.

It is clear that there is no simple solution to the various challenges that are prevalent in the industry. Modernizing construction will require many small steps and incremental improvements. Adoption will only happen through gradual evolution as established practices and players aren't ready for a wholesale revolution in business processes. The industry is simply too fragmented, and each project is dependent on too many stakeholders to adopt major changes rapidly. Nonetheless, the path forward is clear, and technology, as a catalyst, is paving the way. There is a palpable opportunity to make the delivery of capital projects more efficient, more collaborative, and most importantly, more successful.

Therefore, we set out to write this report to provide a real time look at the current state of the "construction tech" sector, providing start-up case studies and discussing the biggest opportunities (and challenges) the space faces to increase technology integration, productivity and collaboration. The first part of the paper highlights some of the challenges restricting productivity and the industry dynamics which have historically slowed down construction's rate of innovation. The subsequent sections take a closer look at the two aforementioned innovation themes: 1) Automation & Offsite Construction and 2) Digitization.

A production system in construction would look radically different from the current project-based approach



SOURCE: McKinsey Global Institute analysis

SECTION 1: CONSTRUCTION'S PRODUCTIVITY PROBLEM

We have identified three key bottlenecks currently challenging productivity in the construction industry:

- Industry Dynamics & Cyclicity
- Labor Shortages
- Regulations

Industry Dynamics & Cyclicity

The sector can be characterized as among the most fragmented and least transparent industries in the world with the contracting structures which govern projects commonly having mismatched risks and rewards between different stakeholders. The industry suffers from vertical and horizontal fragmentation. The top four firms in the US construction sector control just ~6% of the market and even the top 20 firms account for only 8% of the market. This prevalent fragmentation in the construction sector prevents the development of sufficient critical mass among players necessary to catalyze major change. Therefore, most building owners lack the scale to drive change in the market or to spur the development of standardized products and the transformation of the contractor landscape by themselves.

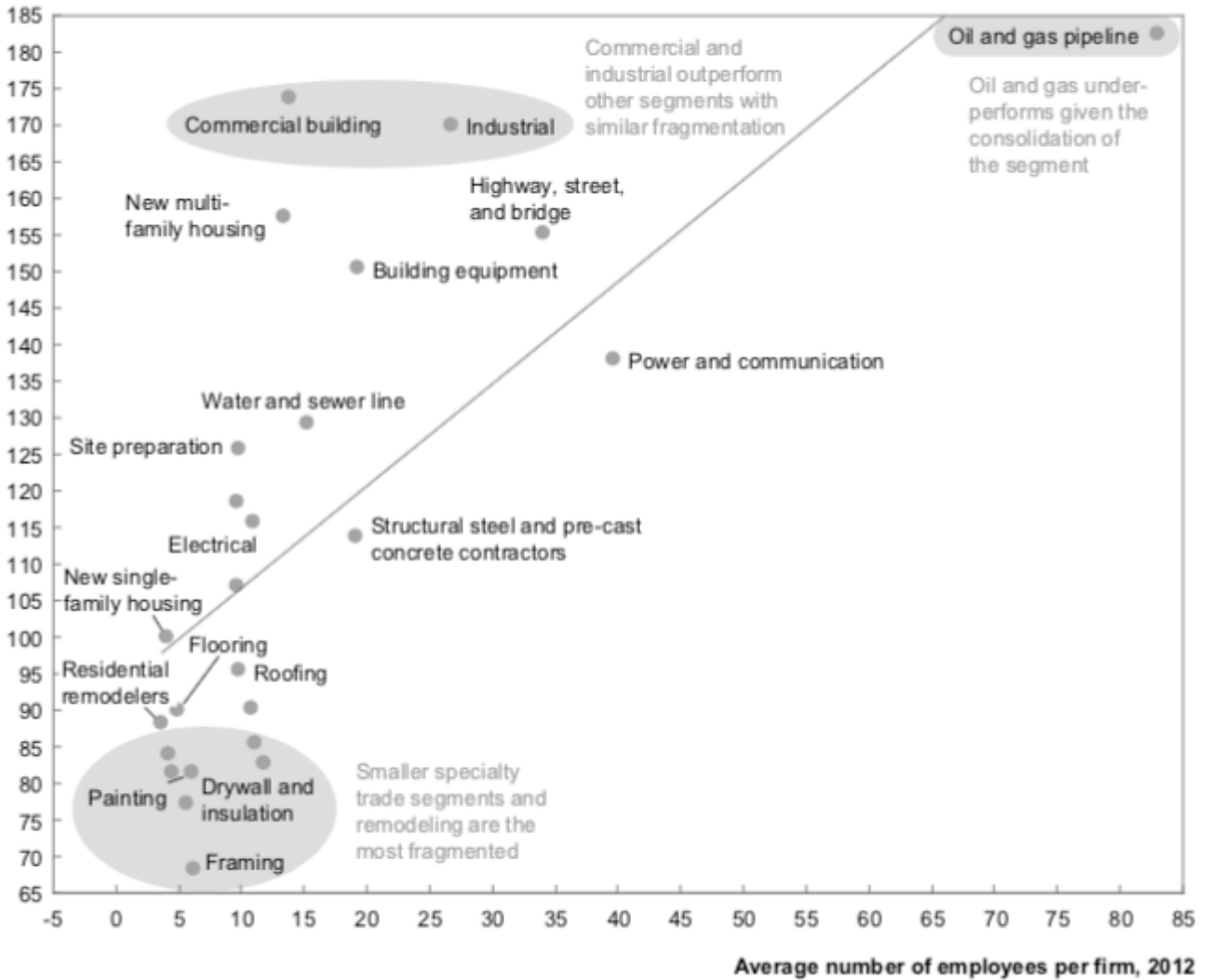
Fragmentation also exists on the project level, making coordination among different players - each with their own vested interests - difficult. This can make it harder to deliver a project on time and on budget. Projects are dispersed into multiple pieces with owners, contractors, and subcontractors carrying out specialized trades. A project typically consists of owners, who have their own financial obligations and timelines, architects/designers and general contractors who act as the project quarterback(s), and finally subcontractors, materials suppliers and other equipment suppliers who carry out specific tasks.

Recent US Economic Census data shows that smaller firms in particular who engaged in fragmented specialized trades tend to have the lowest productivity of any subsector. However, these specialty contractors also create more than 50 percent of the total sector's value added, as specialized trades are heavily involved in every category, typically acting as subcontractors for larger building and industrial projects. As a result, contractors end up delivering highly customized solutions without much standardization for each new project even when building for the same owner.

Fragmentation level among subsectors of construction is strongly related to their productivity

Level, 2015

2012 \$ per employee



SOURCE: US Economic Census; McKinsey Global Institute analysis

These inefficiencies and misalignments are deeply rooted in price uncertainty as most large projects utilize cost-reimbursable contracts awarded using a design-bid-build system instead of more collaborative “Integrated Project Delivery” contracts. Owners are generally risk-averse and tend to award contracts based on the lowest offered cost. When tendering is solely focused on cost, contractors are incentivized to submit bids as low as possible even when their projections may not be feasible and will require costly rework.

Due to general contractors holding a majority of the risk and liability involved in a project, concerted team efforts to improve productivity and project outcomes are more difficult, and the GC’s naturally tend to favor more conservative approaches over innovation. Therefore,

prevailing industry contracts have led to a lack of trust and transparency during the process and stand in the way of trying new productivity techniques.

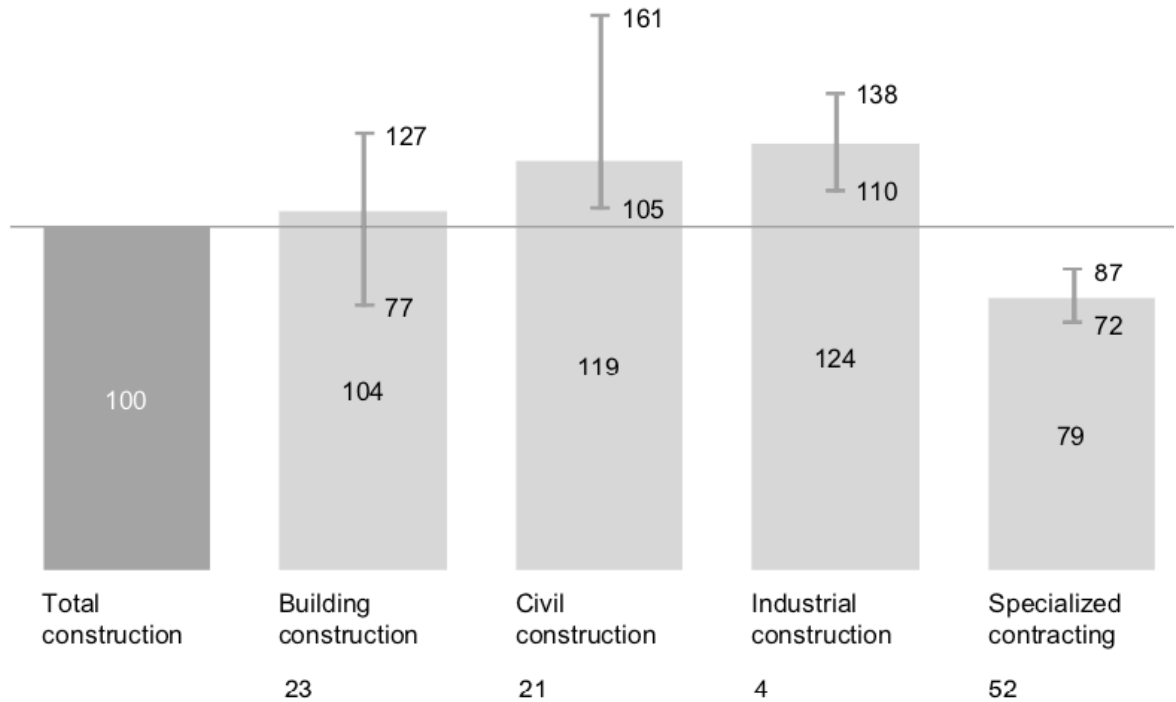
Another one of the primary issues plaguing current construction processes is that construction has followed a boom and bust cycle, which has kept firms from investing heavily in new process improvements and long-term technology initiatives. Given the misaligned incentives, most contractors prefer a conservative strategy in which they can preserve their project by project margins rather than experimenting with expensive new technologies, which often mostly benefit the project owner.

Specialized contractors across asset classes are the largest type of construction player—and have the lowest productivity

Construction productivity by subsector

Value added per employee, indexed total sector = 100, 2013

High and low outliers of countries in data set¹



% of construction sector value added

¹ United States, Canada, Australia, EU-15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom).

SOURCE: US Census Bureau; Eurostat; Statistics Canada; Australia Statistics Bureau; McKinsey Global Institute analysis

It is still common that contractors win orders in the current regime by optimizing upfront pricing and then making up for lost surplus via change orders and claims. Contractors are generally more focused on maintaining margins than on measuring and improving productivity, simply because there is not the incentive to do so once they have won a contract. These firms subsequently

experience operational failures and difficulties leveraging technology and digitization to aid their workflow.

Labor Shortages

One major concern is grounded in the fundamentals of execution, as the cyclical nature of the industry has often led to labor shortages, resulting in insufficiently qualified on-site staff. Recently, there's been a severe construction workforce shortage with an 81% increase in unfilled jobs in the last 2 years and 225,000 unfilled positions each month.⁴ There is also a chronic lack of vocational and on-the-job training in the sector, even though the opposite should be true given the diminishing supply of skilled labor. Around the world, the labor pool in the construction sector is both aging and generally lowering in skill, which makes implementing the changes necessary for achieving significant productivity improvements even more challenging. As a result, highly disorganized teams are tasked with building increasingly sophisticated buildings.

However, the sector has seen recent progress. Between 1995 and 2005, there was a 2% to 9% decline in low-skilled labor in many advanced economies. The exception was the United States, which experienced a 2% rise in low-skilled workers in that period.⁵

Regulations

Construction is one of the world's most highly regulated sectors. In the United States, for instance, the sector is estimated to be subject to seven times the number of laws directly or indirectly affecting its activities as agriculture or mining.⁶ Some of these regulations have not changed for decades or longer, as it is highly politically challenging to amend them. The amount of regulation alone is not necessarily the problem—and, of course, it is important for construction to have a robust regulatory framework so that consistently safe structures are built. Rather, the confusing and arduous bureaucratic processes through which regulation is administered cause delays and compromise coordination among owners, construction firms, and regulators. According to the Construction Industry Institute's benchmarking database, projects that experienced a "higher than planned for" regulatory burden had, on average, 13.8% slippage. The uncertainty introduced by regulation not only lengthens the time span of the project, weeks or months can be spent waiting for approvals, but also may make it difficult for firms to invest adequately in equipment that might not be used as planned.

In the MGI Construction Productivity Survey in 2017, respondents identified permitting and approvals as the top regulatory factor inhibiting productivity. Regulators are in a challenging position. They have to balance the need for increased productivity with sustainability, safety, and aesthetic requirements.

⁴ <https://www.usnews.com/news/the-report/articles/2018-06-15/the-us-construction-industry-is-booming-but-where-are-the-builders>

⁵ World KLEMs

⁶ McKinsey Global Institute, Reinventing Construction: A Route to Higher Productivity, 02/2017

Today we are beginning to see a move toward the digitization and simplification of permitting and other procedures, the standardization of building codes, the mandatory adoption of technologies such as BIM, and the consolidation of land markets. Digitization can specifically help inspections which are still mostly done via manually, paper-based and unproductive site visits. Automated reality capture over the entire project duration and digital twin technology (See case study on construction analytics on *page 21*) could improve visibility into progress and give inspectors a more transparent view into the project. This could make inspections simpler, more standardized, increasing volume. There is also a clear case for subsidiarity, avoiding regulation—and decision making—having to be duplicated at the federal, state, and local levels.⁷

SECTION 2: AUTOMATION & OFFSITE CONSTRUCTION

Automation applies to every aspect of construction, from design and engineering to onsite and offsite production processes. Two of the main drivers of increased automation are the growing trends of off-site and factory-build for commercial projects as well as new achievements in robotics technology, which is beginning to grow rapidly from single to complex multi-trade applications on and off the jobsite.

Moving towards automation entails an integrated assembly system that includes procurement of materials, supply-chain logistics, industrial design, inventory management, transportation, erection, commissioning and post-occupancy analysis. An integrated approach would eventually allow owners to buy from a palette of products that largely already exist and carry clear prices, reducing the need for complex contractual relationships and making on-site project management less complex.

The biggest challenge in this space is the ability to balance standardization and customization. The key is to find standardization of repeatable systems and components with the flexibility for design customization. While design and construction are full of highly repeatable processes, there is still no scaled systems approach to building. Instead most buildings start from scratch with every new project, sacrificing huge opportunities for time and cost efficiencies. The solution is to create a building design system that despite having a finite and controllable number of component parts— wall panels, floor panels, kitchens, balconies, and so on—still allows for a broad range of custom configurations. The goal is to achieve the ability to start a project with 90% of design and engineering documentation already in place, while also retaining the freedom to meet the design tastes of client, site, and region.

The challenge for broad adoption of this industrialized construction is the perceived limit to customization. Currently, the industry simply does not tend to reuse designs, and therefore is inclined to offer custom solutions to every customer, making it nearly impossible to automate

⁷ Francis Fukuyama, “Too much law and too little infrastructure,” *The American Interest*, volume 12, number 3, 11/2016

the build process through assembly lines. The vast majority of building projects are still treated as one-off prototypes or are completely mass-produced for the lower end of the market. Meaning buildings can either be highly customized or highly mass-produced but to get that in-between, the mass-customization at scale.⁸

Off-Site Construction

Off-site construction via prefabrication is an integral part of automation and can come in many forms. Prefabrication of utility panels in a subcontractor's warehouse, a bridge built according to accelerated bridge construction methods and entire modular rooms built in a factory setting are just a few ways contractors are moving their work off the jobsite. This allows project teams to save time by performing several tasks concurrently instead of one at a time, as in traditional construction. For example, during the course of building a modular apartment building or hotel, crews can start building hotel rooms at the same time that excavation and foundation work is going on.

Off-site construction can also offer higher safety, better quality, and lower rework rates since the manufacturing process enables more efficient inspections and quality checks. Moving to offsite automation would lead to a far greater use of repeatable design. Owners could choose entire designs or specific components from a suite of options offered on digital and offline marketplaces. Owners and developers would potentially contract with one turnkey solutions provider like Katerra (see case study below) that would connect contracting and manufacturing work, prefabricating repeatable modules in a manufacturing facility before assembling on-site. This ensures that prefabricated parts and units arrive on-site in a condition that requires little additional remedial work before or during assembly, thus reducing build time. McKinsey has estimated that this could reduce build time significantly because productivity is higher in a controlled environment such as a factory than it is on-site.

The increased use of manufacturing technology and automation can also reduce human error and increase consistency and could be the answer to the skilled labor shortage. By embracing an "assembly line" approach to building, efficiencies increase and can help compensate for a lack of tradespeople. Shifting the construction sector to a modern manufacturing model could transform the traditional construction job site and the skills required to run them. By shifting labor to controlled factory facilities, we can even reduce waste and provide greater schedule and product quality assurance.

Adoption

Off-site construction is nothing new. Looking back 100 years, off-site prefabrication became highly popular in the US. In the early 20th century Sears Modern Homes offered the latest technology available for building houses. These "Modern Homes" were similar to panelized homes and had to be assembled by the buyer at the final destination. Sears and others had a selection of over 400 different designs ranging from small bungalows costing \$450 to large two-

⁸ Michael Gustafson, strategy manager for structural engineering at Autodesk

story homes priced at \$4500. It was so successful that Sears sold over 70,000 of these “pre-fabricated” kit homes from their mail order catalogs. We are seeing a shift in the industry back to this ‘pre-fab’ model of home building as developers realize the efficiencies that can be recognized through a more streamlined build process. Only this time prefabrication has the opportunity to change the way the industry builds not just single-family homes but also large commercial projects.

Today the global precast / prefabricated-construction market is projected to exceed \$200 billion by 2020 and is currently growing steadily at a healthy 6.5% annually. Offsite construction has already become more common in industrial projects because of the challenges contractors face on those jobs. Industrial contractors have experienced increased productivity and a simplified build process, as manufacturing larger modules remotely reduces on-site complexity. This is particularly relevant for projects in harsh environments, such as Arctic oil production and mining in remote locations. The reduction in the labor force can be particularly beneficial in unattractive locations since off-site manufacturing can shift work to areas where there are more skilled workers or lower labor costs, to maximize productivity and reduce capital expenditure. This may raise concerns among labor unions, but these have been so far addressed by unionizing both on-site and off-site work. However, offsite construction is still encountering obstacles in the large-commercial industry.

The fragmentation among owners, contractors, and materials suppliers as well as the highly varying building codes make any type of standardization of the design process highly difficult. There are large gaps between schedule and actual progress due to delays and limited continuity. Further there is a persistent notion in the industry that repeatable design is bland and generic. Factory build is considered to reduce demand for standard housing in many more affluent and even middle-class residential areas. There is a persistent bias against uniform, standard designs and, instead, a preference for attractive bespoke options even though replicable designs have demonstrated that the resulting buildings can be aesthetically pleasing. Google, for example, is moving ahead with a new headquarters in Mountain View, California, which will employ modular construction and reconfigurable space while appearing from a distance to be an architectural focal point for the entire area.

Another major hurdle to successfully making the transition is that, unlike manufacturing that has steady demand for a repeatable design, construction is characterized by unpredictable demand. Predictability of demand is vital if companies are going to invest in productivity-enhancing capacity and innovations. The MGI has found that an automated facility producing sufficient cement slabs and walls for 12,500 housing units could cost about \$30 million. Only an assured level of demand can justify such an investment. Prefabricated elements tend to be more capital-intensive and therefore require certainty about the scale of demand in order to justify the capital investment. This hurdle has even manifested itself in the formation of one of Navitas Capital’s portfolio companies: Katterra. Given the large capital investment required to develop and deploy off-site construction technology, the founders of Katterra knew that they would only succeed with a minimum level of predictable demand which would allow for the intensive capital investment. With that in mind, the team lined up The Wolff Company, a large multifamily

developer, as their first customer and began taking over their apartment development pipeline. This forward-looking demand also gave Katerra a patient partner who was able to tolerate some of the startup hiccups that any new venture is bound to experience. Since their partnership with The Wolff Company, Katerra has similarly established a steady flow of future demand with other customers in order to have a predictable revenue stream to cover high capital expenditures.

These issues prohibit the sector from more effectively incorporating modular and prefabricated components into design and construction. As a result, while becoming a huge buzzword in recent years, modularization of designs has risen by less than 5%, from 1.7% to 6.2% since 2000⁹, as the industry still tends to offer bespoke solutions to most customers. For industrialized construction to take hold, the industry has to change from a project-based approach to a longer-term return outlook as economies of scale are not delivered through one scheme, but in the production of a number of them.

The best example of a company creating a path towards more standardized and effective construction in commercial construction is Navitas portfolio company Katerra, which is creating an end-to-end construction platform that is highly capitalized and blends off-site construction with tomorrow's technologies:

Case Study: Katerra

LOCATION: Menlo Park, CA



COMPANY DESCRIPTION:

Katerra's mission is to construct buildings more quickly and cheaply than traditional general contractors and subcontractors with the immediate goal to build garden apartment buildings in under 90 days by reducing the amount of on-site assembly time as much as possible. Its thesis is that when the entire building process is owned by a single team from end to end—bringing design, manufacturing, material sourcing, and construction together into one streamlined system—it is possible to build high-quality, beautiful buildings, faster and at a lower cost. Having a single, integrated team working from a standard kit of parts and products also provides transparency into material ordering, tracking, and delivery. This allows to aggregate demand for building materials, creating cost savings across multiple projects rather than having to buy key materials such as lumber and steel project by project.

To achieve a faster and more integrated process the company is designing new processes in the factory and the field, including software for component design and constructing wall panels on a factory assembly line. Its panelized design allows quick transportation and assembly, while the company's research and engineering efforts aim to shift away from drywall, cement, and other time-consuming materials. The company has already expanded rapidly, growing to more than

⁹ Construction Industry Institute Performance Assessment System.

3,000 employees after a slew of acquisitions of architecture, manufacturing and other construction firms.

FUNDING: \$1.2B

KEY INVESTORS: Navitas Capital, Softbank, Foxconn, Soros Fund Management, DFJ, Khosla,

KEY DIFFERENTIATORS:

- **Leadership/CEO** – Katerra’s CEO, Michael Marks, ran Flextronics (fully-integrated OEM supplier to Apple, HP, Cisco, etc.) for 13 years, growing the company from \$100M to \$25B in revenue and managing 25k+ suppliers, solidifying Flextronics’s edge as global and vertically integrated. Marks’ expertise in supply chain management, technological advances, and network of relevant contract manufacturing players are highly differentiated within the construction space
- **Access to Capital** – Katerra’s \$865M Series D round, including participation from Flextronics’ chief competitor, Foxconn, attests to Marks’ expertise in the OEM supply chain industry. We believe their access to capital is not only a barrier to entry to unlocking opportunities --as scale begets scale, but also a threatening deterrent to startups facing such a heavily-backed player, given that the largest hurdle most startups in the space face is being undercapitalized in a heavily capital-intensive field.
- **Market** – Katerra plays well within the growing trend of multifamily construction (estimated to be \$1T and quickly growing), given the trends of globalization and urbanism. As a massive, branded, low cost provider of Class B and C housing (largely undersupplied by developers who have focused on Class A housing opportunities in urban environments despite larger demands for more basic, affordable housing), Katerra is well positioned for the global demographic trends and defensible in cyclical environments.
- **Customer Traction** – Benefitting from the willingness of an initial launch customer, The Wolff Company, to hand over their pipeline of multifamily projects, Katerra has been able to act on the initial inertia to attract key customers including private owners and public REITs.
- **Team and Network** – Katerra has amassed a global team of more than 3,000 people, attracting senior leadership and talent from the likes of Flextronics, Apple, Google, HP and Nokia.

On-Site Automation

While a move towards off-site construction will most likely have the biggest impact on productivity, emerging robotics applications (include demolition and bricklaying robotics),

autonomous haulage and 3D printing can also significantly improve construction's core performance factors: speed, cost, predictability, and safety.

Today robotic capabilities are widening in functionality and improving, as well as becoming increasingly cheaper: the cost of industrial robot systems dropped by nearly 30% in the decade leading up to 2015¹⁰. Advanced robots can already accelerate on-site execution as shown by Australian startup Fastbrick Robotics, which has created a bricklaying robot that can lay bricks eight times faster than a human bricklayer. Today these robots are only able to do repetitive, relatively simple tasks. For this reason, robotics already has a real impact on manufacturing productivity. However, robotic technology will eventually get to the point where robots can assemble various different systems, both in a factory and on a job site. Companies such as Amazon have shown that these robotics capabilities already exist in specialized environments such as Amazon fulfillment centers.

The next major advances in sensors, computer vision and mobility will allow robots to effectively operate in uncontrolled environments and interact with human workers on construction sites. These new achievements will drive increasingly automated production processes for onsite tasks such as cutting, drilling, and fixing.

Robotics technologies are advancing rapidly but integrating robotics tech into an enterprise and subsequently running day-to-day operations is still highly challenging and expensive. Given that the industry operates on very thin margins and is considered to be conservative in their automation approach, it's difficult to predict how robotics will be integrated effectively into the jobsite in the near term.

SECTION 3: DIGITIZATION

These major changes to building methods need to go hand in hand with improving construction workflows through the adoption of modern software & data solutions. While land ownership will remain valuable, more and more value is shifting to data and platforms. Companies like Apple, Amazon, Facebook, and Google have all proven that the returns to scale for platform ownership are enormous. While historically developers have managed physical and financial assets, they will need to manage a third asset: data and intellectual property. This relatively new asset class will continue to grow as modern software tools organize construction data and harness the cloud for real-time analytics and insights on construction projects.

Again, similar to the manufacturing industry increased technology and more digital tools should be the most powerful way to enable significant productivity gains in an antiquated and traditionally low margin industry like the construction sector. However, the adoption process has remained lethargic compared to most industries.

¹⁰ BCG Report, Getting Ready for Robotics in Property Development and Building, 10/2018

There are certainly examples in the construction sector in which the use of digital technologies have had substantial productivity benefits. However, most companies have only seen very modest returns in their productivity-enhancing technologies. Some might even point out that the results have been adding to even more confusion and more inefficient onsite execution as there are more startups, more products, more competitors and more choices for customers than ever. There are so many startups and smaller companies in the industry that it's hard to pick between solutions and know who will survive the next downturn. For construction companies, it is therefore vital to identify the investments that will generate the most sustainable advantage.

Technology Adoption

Digitization in construction initially started with project design and the creation of computer aided drafting (CAD) to replicate “lines arcs and circles”. Then came the pen plotter to reproduce a blueprint on paper. A second generation of innovation saw the progression to 3D computer aided design and visualization to replicate physical scale models. Today leading design firms use sophisticated third generation BIM technology for multi-discipline coordination and managing complex geometry. They also use powerful rendering software to capture the texture and color of building materials to convey the appearance of incredibly realistic finished structures and spaces.¹¹

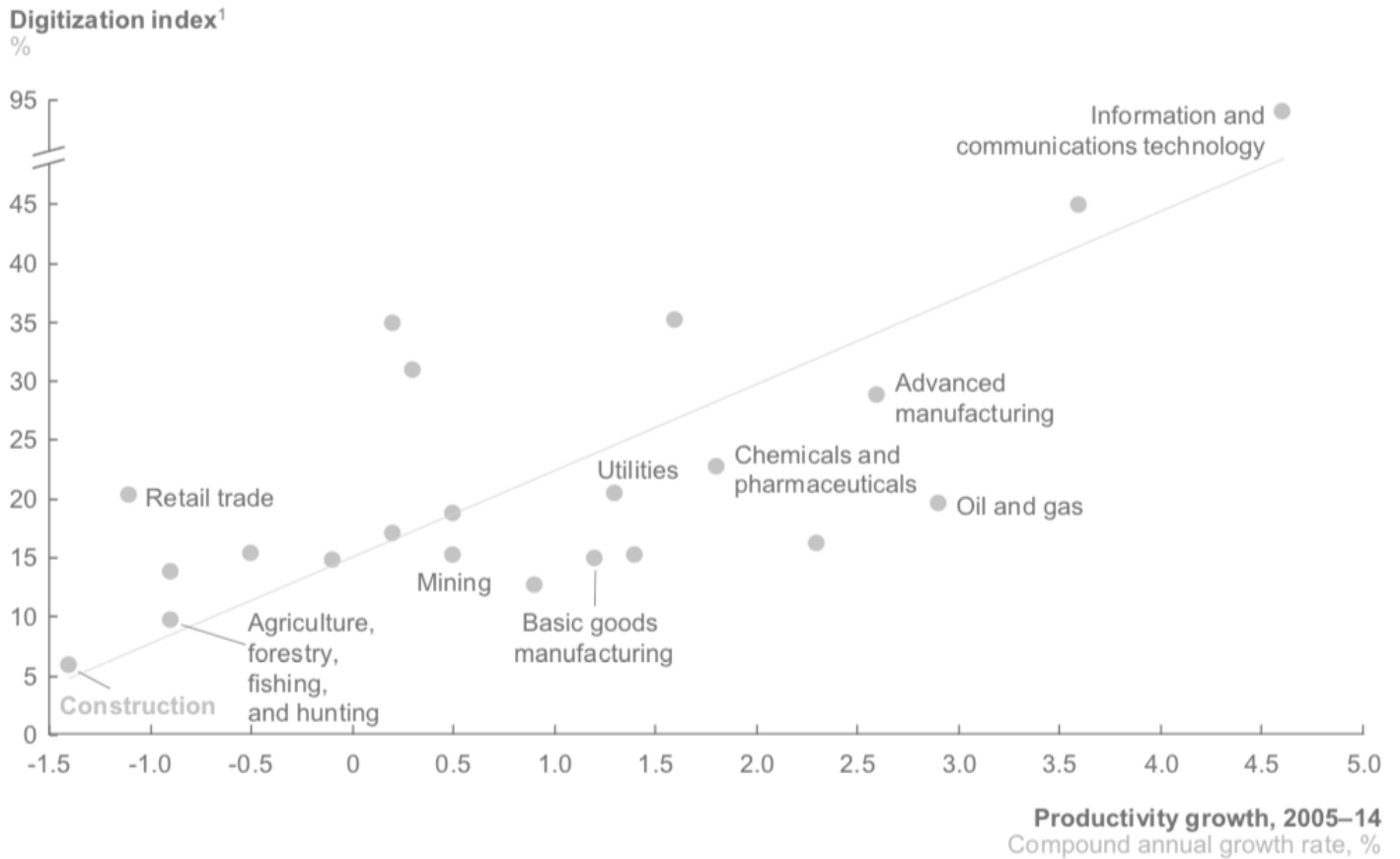
BIM now has been around for more than a decade and is heavily utilized during the initial design stage. However, most projects never see BIM models being updated during the construction project. Therefore, while design and bidding stages have been increasingly digitized, there is still a highly inefficient process around the jobsite. On the other hand, the project side has been all about tracking time, cost and materials. The result has been a history of project accounting software and scheduling systems.

The adoption of the internet facilitated new collaboration software focused on document sharing via project portals (like Asite, Aconex and Procore) that allow designers, GC's and sub-contractors to share documents and automate paper-based workflows for handling RFI's, submittals and change orders. Today, the most advanced project teams are using technologies to improve collaboration and more advanced analytics leveraging drones, sensors photos and laser scans to improve productivity.

Despite many companies in the industry incorporating new workflows and collaboration apps into their daily activities, construction is still among the least digitized sectors in the world, according to MGI's digitization index (See below). Commercial construction in particular has traditionally been known as a technology laggard with most companies still unfamiliar with many of the available tools and solutions. Companies want to lean into automation and digitization more than ever, however few are well-versed in scaled adoption. Right now, only a minority of organizations are deploying more than 1 digital technology use case at scale, which qualifies as implementations that go beyond pilot and test projects and are adopted at a larger

¹¹ See Building Ventures “Constructing” Whitepaper, 05/2018

Lower digitization in construction relative to other industries has contributed to the productivity decline



¹ Based on a set of metrics to assess digitization of assets (8 metrics), usage (11 metrics), and labor (8 metrics); see technical appendix for full list of metrics and explanation of methodology.

SOURCE: BEA; BLS; US Census; IDC; Gartner; McKinsey social technology survey; McKinsey Payments Map; LiveChat customer satisfaction report; Appbrain; US contact center decision-makers guide; eMarketer; Bluewolf; Computer Economics; industry expert interviews; McKinsey Global Institute analysis

scale across business units, functions, or geographies.¹² The tendency among organizations today is to sit on the fence and do a few proofs of concept in order to see what works.¹³

One of the main challenges is that the different technology platforms that are supposed to connect design with jobsite do not always speak to each other. Project owners and contractors often hear about various new options and possibilities of harvesting data but are unable to utilize and connect this data to their core system, ending up with so much, and such disorganized information that they are not able to leverage it at all. Therefore, while we have seen a rise in general technology investment, the most pressing challenge today for startups is the efficient integration of new technologies.

¹² Capgemini, Reshaping the future: unlocking Automation’s untapped value, 201x

¹³ Duncan Stott, CIO of Kier Group

Case Study: Digital Twin Technology

Most construction companies today deploy different solutions to capture images, from drones and cameras to simple smart phones, in order to optimize their workflows and give owners more accurate and easily digestible progress reporting. These images and videos are critical to help keep track of changes onsite, increase safety, reduce the risk of lawsuits as well as deliver a better product to owners at the end of a project. However, photo and video documentation are typical retroactive monitoring practices, which only look into finding problems in the past and do not enable forward-looking and actionable construction performance analytics.

Using point cloud technology, visual analytics platforms like OpenSpace, Reconstruct and others are able to analyze images and automatically create 3D reality models or so-called digital twins. These digital twins allow for the management of various trades engaged in a construction project to be more effective by ingesting visual data that can be almost seamlessly compared to schedule and BIM. As the majority of large-scale projects are finally utilizing BIM, 3D models representing progress on the jobsite can now be automatically aligned and connected to BIM models and project schedules to enable detailed visual progress tracking and greater overall project insight.

Using a wide array of different data sources that can be captured through various methods, from drones and laser scans to simple photography of a project site, the technology can automatically organize photos across locations and generate weekly or monthly 3D point clouds over the duration of the project. These 3D point cloud models are then connected to BIM using GPS or ground control points, to form a visual simulation of construction (4D BIM). This method allows an interactive display BIM, project schedule, point cloud data, images and other project information to produce analytics on actual and potential performance, creating a complete and comprehensive system of records over time.

Via clearly color-coded overlaid of “reality vs scheduled” teams can effectively measure progress. The 3D interface facilitates easier communication among contractors, subs, and owners as it tracks who does what work in what location and visually communicates performance problems, requests for information, and quality control reports.

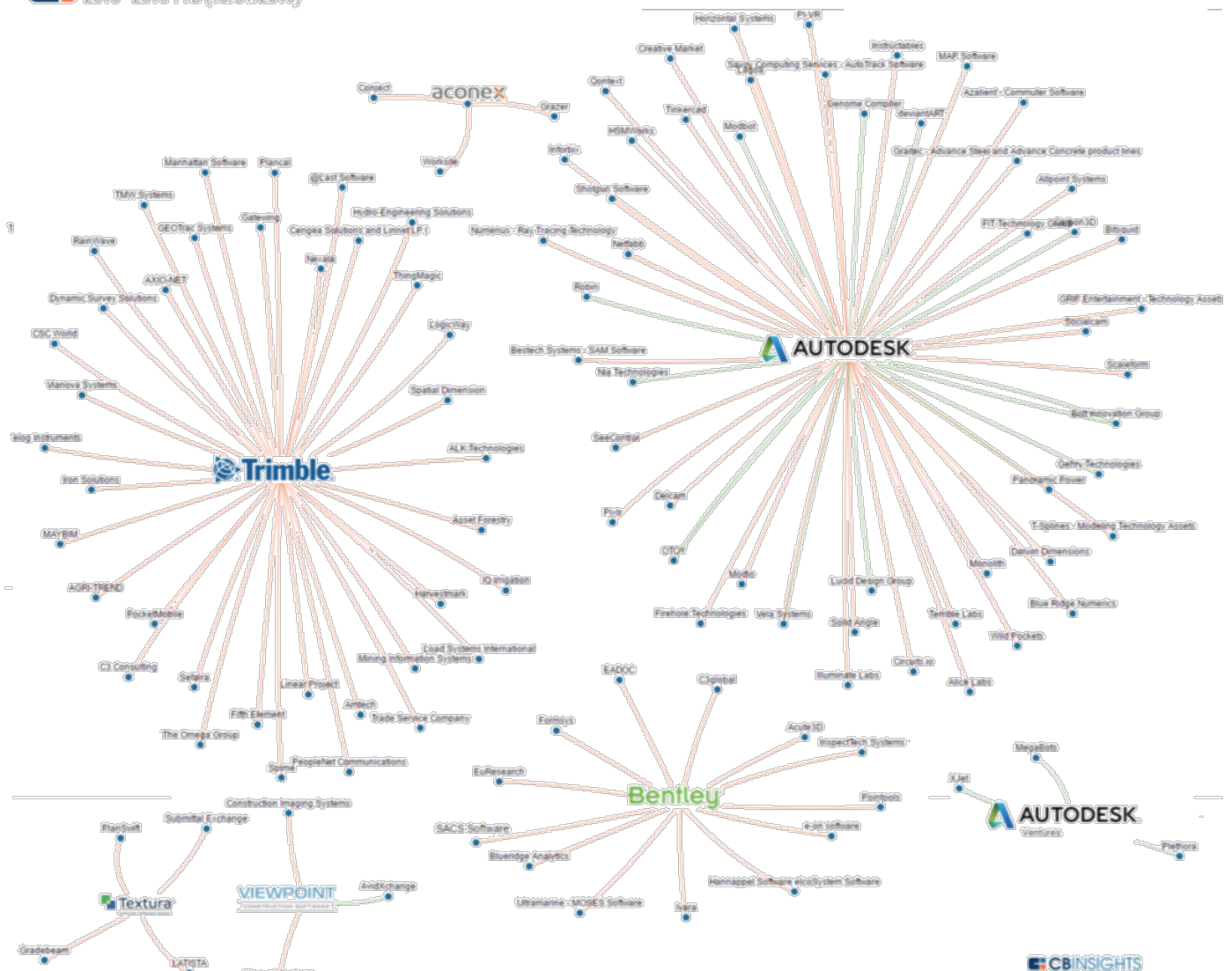
Creating simple and highly visual at-risk location also provides owners with a realistic view of total costs and project durations and therefore has the potential to enable better decision-making. Beside progress monitoring, it can also automatically analyze risk for delay at each location based on reported progress, past productivity, and schedule constraints.

There is significant value here even after project completion in the form of warranty and insurance for potential litigation policy, as litigation post-project completion is common in large commercial projects. We therefore believe that visual data analytics has the potential to provide deep insights and usability not just for construction companies but also for insurance companies and inspectors.

We believe that in order for new technology platforms to reach adoption, there will need to be open systems that allow for interoperable applications and easy integrations. Any new workflow solutions need to make sure the systems are integrated out of the box or at least very easily integrated. Any new initiative implemented in the field needs to create value from day one and rather than an additional one-off software that solves point problems and doesn't integrate with other systems.

There are good early examples of this, such as Assemble Systems from Autodesk, which bridges BIM from design intent to construction sequencing, provides mobile access, and integrates with estimating (Sage), scheduling (Primavera P6) and data management (Power BI) applications. There is also Procore, which has already achieved tremendous scale (estimated \$200M revenue) in a short period of time due to their flexible and open platform which aims to integrate with a vast range of other solutions, most notably Navitas portfolio company Honest Buildings.

CONSTRUCTION SOFTWARE CORPORATES IN PRIVATE MARKETS
2010-2016 YTD (10/31/2016)



However, the construction industry has yet to adopt an integrated platform that spans project planning, design, construction, operations, and maintenance. Instead, the industry still relies on bespoke software tools. We therefore expect that in the coming years there will be further cooperation among partners and vendors as well as continued M&A activity and consolidation.

This will likely lead to a few major project management solutions that become application layers and provide a level of visibility and control at every step of the process. Traditional design and project management companies like Autodesk, Oracle, Viewpoint or Trimble are already spending significant resources to acquire various emerging software solutions and are starting to position themselves to become full end-to-end software platforms incorporating technology solutions that span the enterprise for the GCs on and off the jobsite. How these company will be able to create a seamless experience and manage to provide true interoperability will determine who powers the future of construction. Therefore, given the race for more integrations and continued appetite for acquisition by major companies, it is an exciting time for construction tech startups that can drive value for owners and GCs.

The latest example of this trend is the acquisition of construction productivity software and Navitas portfolio company PlanGrid by Autodesk for \$875M in December 2018 to integrate into Autodesk's cloud-based construction platform.

Case Study: PlanGrid

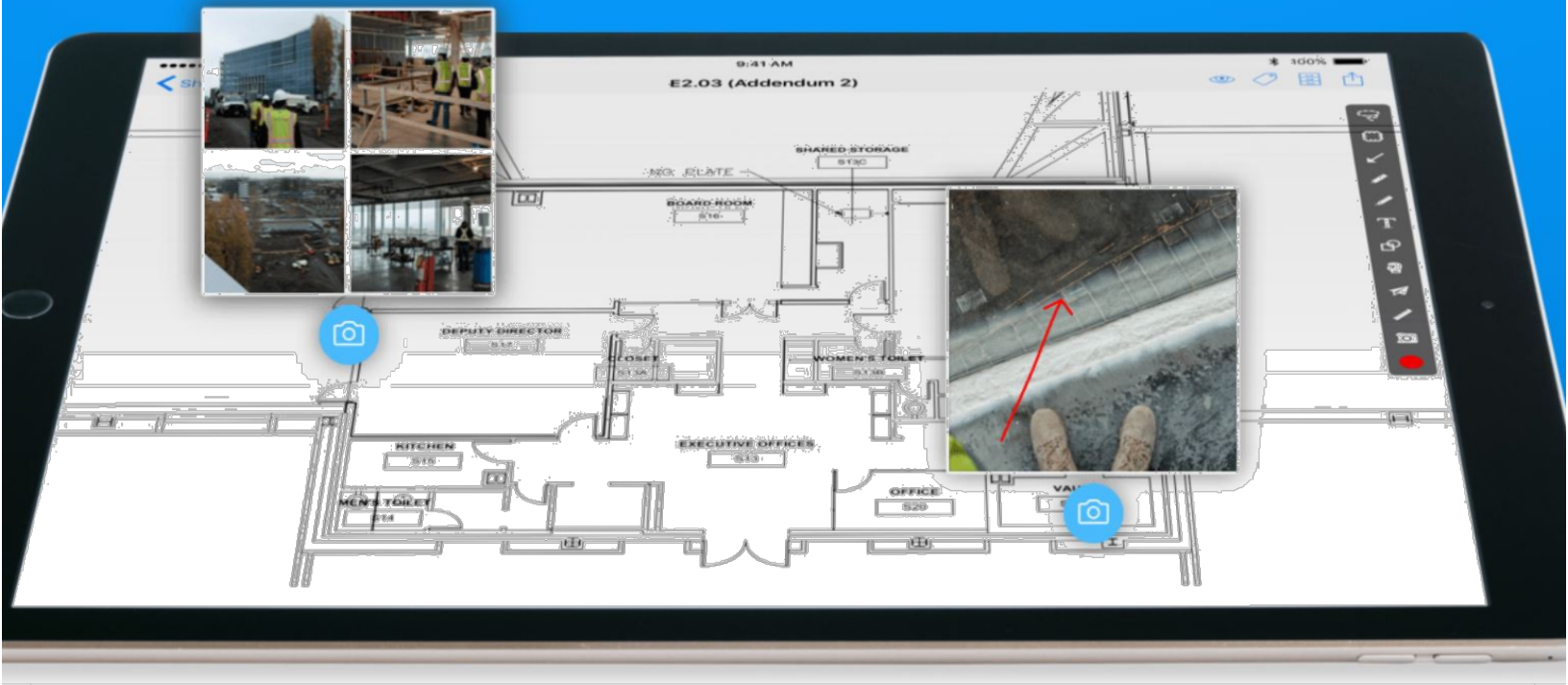
LOCATION: San Francisco



COMPANY DESCRIPTION:

PlanGrid develops mobile-based solutions for managing construction blueprints and other construction activity. Creating a tool that allowed builders in the field to easily manage, collaborate, and plan more effectively, the company was able to build a highly successful company that got acquired in November 2018 by Autodesk for \$875M after just 6 years since inception.

In practice, it's cloud-based service delivers blueprints as PDFs directly on a tablet allowing people working in the field to use an ipad rather than paper-based versions and communicate all of a construction project's information including: punch lists, drawings, specs, submittals), and progress photos (ability to pin photos taken with the iPad to blueprints). Today, PlanGrid is used on more than one million projects across commercial, heavy civil and other industries and is in 90 countries.



FUNDING: \$69.1M – Acquired by Autodesk in December 2018 for **\$875M**.

KEY INVESTORS: Sequoia Capital, Founders Fund, Y Combinator, Northgate Capital, Navitas Capital

KEY DIFFERENTIATORS:

- **Ease-Of-Use** - Its key strengths are its speed and the ‘natural’ feel of the software interface. The sheet-based format and swiping motions allows subs and superintendents to quickly flip through sheets and lets users find the sheet they need quickly. Its ease of use has allowed PlanGrid be the app to communicate from anywhere throughout the entire project lifecycle for contractors and owners. Similarly, with over 67 pre-built integrations Plangrid has been focusing on creating most seamless implementation that enables user easy access to critical data shared to and from Plangrid.
- **Go-To-Market Strategy** - PlanGrid has been able to deliver a clear value proposition to GCs and owners improving transparency, real-time communication, and collaboration across all stakeholders. PlanGrid quickly proves out its financial savings due to printing less paper, increasing labor productivity (people aren’t waiting around for the current set of blueprints), preventing re-work (PlanGrid’s current sheet syncs data automatically on and offline), and removing schedule impacts with real-time communication from the field to the office. That’s how PlanGrid has had strong success in selling directly to tier-1

general contractors to gain a critical mass and credibility to eventually build a standardized field platform that is trusted by general contractors, subcontractors, engineers, architects and owners alike.

- **Management Team** - PlanGrid's co-founding team is comprised of industry expertise and strong technical background. This has proven to be a powerful recipe as the team has been able to deliver product to customers early in the development cycle and continuously update the software with new features and integrations.

In another example of modern productivity tools for the construction space, Matterport has developed the industry leading platform for 3D capture. Founded in 2011, Matterport has amassed over 1.5M 3D models and billions of 3D data points with its solution and is poised to expand even more rapidly with its recent announcement of Cortex, an AI-powered software platform that converts 2D images into Matterport 3D models. Matterport's solution allows contractors and owners to create accurate and visually stunning models of construction progress as well as a point-of-truth for job sites.

Case Study: Matterport



LOCATION: Sunnyvale

COMPANY DESCRIPTION:

Matterport is the industry leader in 3D capture for the built world, spanning many industries including real estate & construction. With over 1M 3D models of real-world spaces and over 1 billion 3D data points, Matterport has experienced quadruple-digit revenue growth as the 3rd fastest growing private company in Silicon Valley according to Silicon Valley Business Journal. Matterport's broad expansion opportunities and technology offerings have attracted a significant amount of venture capital investment and world-class talent.

Recently, Matterport, announced the hiring of new CEO R.J. Pittman, who formerly served as head of product for eBay, Apple, and Google. Matterport also achieved a major technology breakthrough through its artificial intelligence platform called "Cortex", having reached a tipping point in deep learning performance. Cortex has trained on billions of 3D data points captured in Matterport Cloud, to construct stunning Matterport 3D models from 2D images captured from spherical lens cameras, commonly known as 360 cameras. Support for this new class of cameras provides a low-cost, entry-level solution to new customers.



With the recent advancements in Cortex and their 2D > 3D capabilities, Matterport is aiming to expand rapidly in the construction vertical, due to the dramatically lower cost of entry and ease of use by any field worker with a 360-degree camera. Matterport's solution has many productivity benefits, including helping streamline documentation, 3D scan as-builts, and collaborate with ease. Matterport's process is much faster and less expensive than traditional laser scanning and more complete than 360-degree video.

As Matterport looks to leverage its artificial intelligence and imagery technology, construction will likely be a major market as incumbent visualization companies do not have the technological resources to turn 2D imaging from third party devices into high-fidelity, 3D models which can be serviced and easily accessible from the Matterport cloud.

FUNDING: \$66M

KEY INVESTORS: Qualcomm, DCM Ventures, Lux Capital, Navitas Capital, Others

KEY DIFFERENTIATORS:

- **First Mover Advantage / Data** - While the true advantage for the ‘first mover’ is not always clear across different industries and services, Matterport has built a clear and tangible advantage being the first company to market in 2011. After years of capturing different spaces in 3D with Matterport cameras, the company can now use its billions of data points intelligently as it builds out Cortex, its AI and ML platform. Other companies will struggle to match Matterport’s technical abilities and product offering simply due to this critical advantage of moving first and reaching a key threshold of data collection. Most notably, no other players in the market have the ability to turn 2D images into high fidelity 3D models such as Matterport does. This aspect of “Matterport 3.0” is a key result of a high-quality data advantage.
- **Technology** – Matterport has been issued 17 patents with another 13 pending. These patents have broad coverage and early filing dates given Matterport’s early entrance in the 3D market. In addition to the high performing Pro2 and Pro2 Lite 3D cameras which Matterport has engineered and delivered to market, the company also has by an order of magnitude the largest database of 3D images, which consists of billions of data points accumulated over time in the Matterport Cloud. Matterport’s artificial intelligence and machine learning platform, called Cortex, is an incredibly difficult-to-replicate technology advantage which Matterport has over any of its potential competitors. The years of engineering and data collection at Matterport have provided a thick technical moat for the firm and barriers to anyone who wants to compete in the 3D visualization space.
- **Management Team** - With the recent additions of RJ Pittman (Google, Apple, Ebay), JD Fay (View Glass), and Chris Bell (Apple), the Matterport executive team now has a unique combination of top tier product, financial, and marketing leadership, with RJ previously leading Ebay’s product team and global growth, as well as driving key initiatives for Apple’s and Google’s e-commerce businesses. JD also has extensive experience leading capital-intensive companies through financially difficult times – being View Glass’s CFO for several years – and will help the company progress financially as it transitions into a new chapter of company life. Also holding onto co-founder and CTO David Gausebeck and his team of deep learning experts, Matterport has kept an integral part of the founding team and a highly sought-after deep learning advantage, which will be highly attractive to acquirers. In tandem, these key executives provide a formidable challenge to any new or existing company looking to beat out Matterport in its core competencies of 3D visualization and data processing.

OUTLOOK

Today, construction is opaque and highly fragmented both horizontally and vertically. Using a manufacturing production system, large players may eventually consolidate or coordinate the fragmented supplier base to deliver the full range of components. As a result, integrated construction processes will lead to increased resource utilization and reduction of waste on job sites, while also reducing human error and improving safety as a by-product.

Most new applications still have a high degree of uncertainty, making it hard for companies to predict which applications will take off or when to invest. These unknowns can easily lead to analysis paralysis. But construction and property development companies don't have the luxury of sitting back and waiting years to see which technologies pan out. By that time the first movers will have stepped in and captured the benefits while those that took a wait-and-see approach will find themselves at a competitive disadvantage for years. Many contractors fear that changing from an entirely project-based approach to a manufacturing-like system of mass production could lead them to lose revenue unless owners and the broader industry environment move too. A departure from the status quo is only likely possible if contractors can build the scale (and repeatability) needed to drive cost efficiencies from productivity gains, which outweigh revenue losses from lower price points and fewer customer claims.

Owners, in turn, should welcome a more integrated and transparent process as they benefit from lower capital needs and shorter project cycles and because they hold the scarce resource: land.

Integrating new digital technologies into the enterprise and then running day-to-day operations will also require completely new skill sets. Today, construction and property development companies have civil engineers, architects, supervisors, foremen, laborers, and mechanics. But going forward they are going to also need data scientists, analysts, and software engineers. Not only are these skills different, they are scarce and in demand by many companies in many different industries. Whether companies should acquire these skills or grow their own will become a pressing strategic issue made more challenging by the industry's reputation as conservative and as a technology laggard. This will require construction companies to develop new employee value propositions, make strategic acquisitions, and enter into partnerships and joint ventures.

In the longer term, as automation technologies like robotics and offsite construction are more commoditized and the early adopter advantage disappears, construction profits might shrink again. However, we expect a lengthy transition period for the industry, meaning early adopters are likely to enjoy a competitive advantage for 10-15 years. As automated technology applications become commoditized and profits are competed away, value in the industry will become even more concentrated in the hands of those who own the land and hold the IP. Construction could become more challenging as a standalone business, and looking forward, companies with integrated business models will have a natural hedge against this eventual commoditization and the redistribution of profits across the value chain.

APPENDIX

List of notable construction tech companies

Company	Description	Round	Investors	Investment to Date
3D Robotics	3DR makes advanced drone technology easily accessible to the construction, mining, and surveying industries for use in data analysis.	Series D	Foundry Group, SK Ventures, Qualcomm Ventures, Autodesk, True Ventures	\$179M
Acre Designs	Acre provides “zero-energy” prefab homes, assembling offsite and packaging everything including smart home technology into a single shipping container and partnering with local contractors to assemble onsite	Seed	Y-Combinator, Bodley Group, Vy Capital	\$1.7M
Airworks	Makes aerial data accessible and useful to decision-makers in the built environment.	Seed	MetaProp NYC, Rough Draft Ventures, Innospark	\$2.3M
Alice Technologies	ALICE is an intelligent software to help plan and schedule construction projects faster and cheaper by automating and optimizing crucial processes.	Seed	Merus, Lightspeed, Brick & Mortar Ventures, StartX	\$5.4M
Avvir	LIDAR based construction software tool	Seed	Undisclosed	Undisclosed
Blokable	Modular housing that manufactures from a single, flexible framework that can be configured and inspected at scale. Integrates hardware, software and services		Borealis Ventures, Puget Sound Ventures, and others	\$11.4M
Blueprint Robotics	Blueprint Robotics uses state of the art manufacturing techniques to offer wood framed construction solution			
Blu Homes	Blu Homes provides luxury dwellings in the Bay Area focused on customization and sustainability, with Blue Homes ~40% more energy efficient than standard homes	Growth	Brightpath, Skagen, Vision Ridge Partners	\$197M
Boxouse	Boxouse converts shipping containers into tiny off grid houses and promotes sustainable communities.	Seed	Y Combinator	Undisclosed
Branch Technology	Branch Technology combines novel 3D printing technology, conventional construction materials, & large-scale robotics.	Series A	S Ventures, Telos Ventures and others	\$7.2M
Bridgit	Building the world's most user-friendly mobile construction software.	Series A	MaRS Investment Accelerator, StandUp Ventures and others	\$3.3M
Build Up	Onsite Mobile Construction Management App Saving Your Project Costs and Time	Series A	TLV Partners and others	\$8.6M
BuildingConnected	provides builders with cloud-based bid procurement services.	Acquired	Autodesk	\$52.7M

CONSTRUCTION & TECHNOLOGY: BUILDING FOR THE FUTURE

BuildZoom	BuildZoom has a simple purpose: to help you find the perfect contractor for any job - commercial or residential.	Series A	Founders Fund, Formation 8 and others	\$23.7M
Built Robotics	Built Robotics modernizes construction equipment with sensors and developing a suite of autonomous software to manage fleets of equipmen	Series A	Founders Fund, Great Oaks, NEA	\$15M
BulldozAIR	BulldozAIR is a visual task management application for construction projects.	Seed	Y Combinator	\$1.2M
Busybusy	web and mobile app that helps automate time and labor tracking, job costing, and project documenting.	Growth	Caterpillar Ventures	\$8.5M
Cl3ver	cloud based platform that allows engineers, architects, and other design professionals to create interactive 3D presentations to engage clients and prospects throughout the complete sales and marketing cycle.	Seed	101 Startups, Wayra and others	\$2.7M
Concrete Sensors	Concrete Sensors helps contractors save money and move faster by providing real-time data on the curing and drying of concrete. We make wireless sensors designed to be embedded in concrete that are cost effective and just easy to use.	Seed	Arab Angel Fund, Requs Ventures, Tamarisc Ventures and others	\$1.7M
Connect Homes	Low Cost modern, smart, prefab home builder	Seed	Undisclosed	\$9M
Construction Automation	Construction Automation offers a range of 3D printing and robotics services for the construction industry.	Seed	Tim Draper	\$500k
Construction Robotics	Developing hardware and software for the construction industry, starting with SAM100, an autonomous bricklaying robot used for masonry	Grant	Grant	\$75K
Contract Simply	Helps banks expedite construction payments	Angel	Y Combinator and others	\$120k
CoolComposites	CoolComposites is a startup that is working to produce a phase change material (PCM) for energy efficient buildings. Competing PCM products are extremely expensive, require substantial modifications to building construction, or both. Our goal is to produce a drop-in additive for building materials based on inorganic PCMs, which are more than 10x cheaper than their existing organic counterparts. This will allow us to offer a 'zero-day' payback period enabled by novel materials synthesis.	Grant	Undisclosed	Undisclosed
Cover Technologies	Cover leverages algorithms to understand clients' lifestyle and structural needs, which are then fed into the prefab	Seed	Khosla Ventures and others	\$1.6M

CONSTRUCTION & TECHNOLOGY: BUILDING FOR THE FUTURE

	manufacturing facility. They focus on accessory dwelling units (ADU) within existing single family homes			
Disperse	Computer vision to transform construction project delivery and on-site progress analysis	Seed	Kindred Capital, Frontline Ventures and others	\$1.3M
Doxel	Artificial intelligence and computer vision-based system that delivers significant productivity increases to commercial construction projects.	Seed	Andreessen Horowitz, SV Angel, Alchemist Accelerator, Steelhead Ventures, Pear Ventures	\$4.5M
EcoConcrete	Bridging Development and Sustainability	Seed	Undisclosed	\$1M
Ecomedes	Sustainable materials procurement and project management SaaS solution	Pre-Seed	Undisclosed	Undisclosed
Einsite	Einsite is a startup building Internet-of-things technology to make the construction and mining industries smarter.	Seed	KPCB Edge	Undisclosed
Emagispace	Emagispace offers building technology that enables anyone to easily set up elegant reusable walls and spaces of all sizes.	Series B	Alpha Edison, Circle Ventures, 54 Madison	\$9.3M
Endless Robotics	Endless Robotics builds intelligent robots to solve dull and dirty problems for construction, maintenance and smart city management.	Seed	Indian Angel Network	\$100k
Envelope City	3D web app to help urban real estate professionals run scenarios on potential zoning developments	Seed	MetaProp NYC	\$4M
Eyrus	Real-time progress and updates for large-scale commercial construction projects.gathers data and provides analytics to improve the delivery, resource management, project safety, and efficiency of commercial construction.	Seed	Undisclosed	\$2M
Factory OS	Factory OS is a Bay Area-based modular housing developer with a 256k sq. ft. factory in Vallejo that started production in March 2018. Google announced it would buy up to \$30M of apartment units (~300) for its workforce housing.		Undisclosed	Undisclosed
EquipmentShare	EquipmentShare is a peer-to-peer equipment rental marketplace that also offers telematics and equipment utilization services.	Growth	Y Combinator, Insight Venture Partners and others	\$58.7M
Fastbrick Robotics	Fastbrick Robotics' bricklaying machine 'Hadrian X' is a patented 3D robotic bricklaying system and marks the transition to dynamically stabilized robots (DSR) operating outdoors in uncontrolled environments.	Public	Caterpillar Ventures, Hunter Hall, IPO	\$36.6M
Fieldwire	Construction management & field collaboration app for contractors.	Series A	AngelPad, Brick & Mortar Ventures and others	\$7.7M

CONSTRUCTION & TECHNOLOGY: BUILDING FOR THE FUTURE

Fieldly	Project management for smarter construction companies	Series A	Innuvik Ventures and others	SEK 24.9M
Finalcad	FINALCAD provides mobile apps and predictive analytics helping construction stakeholders to fix issues found during the building's journey.	Series C	Salesforce Ventures, CapHorn Ventures and others	\$62.9M
Form Found Design	Use programmable robots and fabric forms to create custom concrete			
Formdwell	Construction tools powered by intelligent robotics	Seed	Heart Investment Partners, Inc..	Undisclosed
Full Stack Modular	Provides turnkey modular solutions for developers of new multifamily high rise buildings	Series A	McCourt	\$6M
Gecko Robotics	Gecko Robotics make wall climbing robots for industrial inspections.	Series A	Founders Fund, Westly Group and others	\$7.1M
Getable	Getable serves the construction rental market with mobile tools designed for construction professionals and rental equipment providers.	Series A	Brick & Mortar Ventures, Social Capital and others	\$10.8M
Green Badger	SaaS platform that provides cloud-based automation and compliance solutions for the green construction industry.	Seed	Tummi & Slaam Ventures	\$165k
Green Terra Homes	Manufacturer of small steel frame Modular Homes	Series A	Undisclosed	\$2.3M
Helix	HELIX builds software that unlocks the true potential of buildings.	Series B	Far East Ventures, Borealis Ventures, Brick & Mortar Ventures and others	\$44.4M
Holobuilder	HoloBuilder is the fastest and most insightful solution for construction teams to document construction projects with 360° image technology.	Seed	Brick & Mortar Ventures and others	\$2.9M
Icon 3D	construction technologies company using 3D printing	Seed	Oakhouse Partners	\$9M
iDevelop.city	iDevelop.city is a platform for developers to test the potential under zoning scenarios. iDevelop.city is aggressively expanding its database nationwide and has focused on multifamily.	Seed	Plug and Play, FinSight Ventures, Edward Jung	Undisclosed
Indus.ai	Machine Learning Platform for Construction	Seed	UP2398 and others	\$3.7M
Intsite	Intsite develops a machine vision system that alerts construction machinery operators to risks in their work environment, aiming to make crane operations safer and reduce costs.	Seed	Terra Venture Partners	\$1.4M
IMERSO	Imerso is a computer-vision company that challenges the global construction industry with intelligent digital twins of building-sites.	Seed	500 Startups, Vito One and others	\$2.1M

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Ipsum	Lean-construction based construction management tool; recent traction in S. America	Series A	Wayra, Cemex Ventures and others	\$1.1M
Jacobi	Intelligence platform for investment managers.. Built with a multi-asset focus their platform facilitates the transfer of manager insights, generating better investment ideas and deeper levels of engagement between an investment manager and client.	Seed	PLG Ventures, 8VC and others	\$2.5M
Jabbrbox	Jabbrbox is focused on creating the modern-day phone booth in public spaces. Shipped as a modular container, they can be installed in 2 hours at \$13.5k / unit (base)	Undisclosed	Undisclosed	\$240k
Joist	Contractor Estimating and Invoicing Tool	Series A	Accomplce, Matrix Partners and others	\$14M
Jones	liability insurance for independent contractors payable only for specific projects	Seed	JLL, 5 Startups and others	\$2.8M
Katerra	Katerra applies a contract manufacturing approach to offsite, prefab construction.	Series D	Foxconn, Softbank, Paxion, Kendall Real Estate, GreenOaks, DFJ, Khosla, WRV II	\$1.2B
Kasita	Kasita takes a product-approach to modular construction, standardizing units for quick delivery and minimal on-site assembly time. Kasita has gained customer traction from disaster relief, temporary housing, and affordable workforce housing providers.	Undisclosed	Undisclosed	\$10.9M
Knowify	Platform for construction contractors providing productivity tools and real-time data so they can know and grow their businesses	Seed	Lighter Capital	\$2.6M
Kwipped	KWIPPED is a platform where companies rent you their equipment.	Seed	The Angel Roundtable and others	\$900k
ManufactOn	ManufactOn provides supply chain and production solutions, partnering with Autodesk's design and construction management platform for prefab workflow	Seed	Brick & Mortar	\$1.2M
Matterport	Matterport lets anyone create a realistic 3D model of the world around them that they can engage with & share over the Internet.	Series D	Y Combinator, CBRE, Greylock Partners, Qualcomm Ventures, Lux Capital, Rothenberg Ventures	\$66M
Mighty Buildings	Mighty Buildings is utilizing 3D printing construction technology and composite materials to build faster (10x), cheaper (50%), and more beautifully. Composite materials are resilient to fire, flood, wind, earthquake events and other environmental factors.	Series A	Khosla, Y Combinator, SV Angel and others	\$10M
Mira Labs	Mira is an augmented reality, B2B company focusing on solutions for the construction, telco, and industrial	Seed	Sequoia Capital, Founders Fund, Greylock	\$6M

CONSTRUCTION & TECHNOLOGY: BUILDING FOR THE FUTURE

	industries. The winner of the Red Dot design award, Mira has created the Mira Prism, a smart phone powered, low cost & hands collaboration tool for on-site workers.		Partners, 3 Rodeo, Marc Benioff (Salesforce CEO)	
Module	Module is a modular builder of single-family homes offering customizable and flexible solutions catered to grow as people move throughout different stages of life.	Seed	Techstars, the Robotics Hub, Innovation Works, IdeaFoundry, Alphaslab Gear	\$1.2M
Modumate	3D design tool for architects helping to modernize architects' workflows, including automation of drafting.	Seed	RiverPark Ventures, LaunchCapital and others	\$1.5M
Mycomply	MyComply has built out a hiring, training, and compliance platform for HR and recruitment within the construction industry.	Seed	Urban-X	\$850k
Onshape	Full-cloud 3D CAD system that lets everyone on a design team work together.	Series D	NEA, A16Z and others	\$169M
OnSiteIQ	OnSiteIQ provides an automatic safety analytics platform to the construction industry. Visual documentation and safety analytics platform to help our clients improve the construction quality, safety, and progress monitoring.	Seed	MetaProp NYC and others	\$2M
Ontarget	onTarget is a visual collaboration solution for construction industry. onTarget provides a single interface, with real time project management integrated with 3D BIM models, to ensure the entire team can execute the projects on time and on budget.	Seed	Acceleprise, MetaProp NYC, Unshackled Ventures	Undisclosed
Openland	Openland is a platform to help owners connect with builders, tenants, lenders, investors, brokers and local officials to structure more transactions, provide research, aid deal sourcing, and enable better transaction management.	Seed	Sinai Ventures, Y Combinator, Cantos Ventures, Liquid 2 Ventures, and others	~2.3M
OpenSpace	machine vision company for large scale construction	Seed	AngelList, Foundation Capital, Sterling.VC and others	\$3.5M
PlanGrid	Plangrid is a cloud-based workflow software with ~1M+ projects across 84 countries with an annual subscription model of \$49 / yr.	Acquired	Autodesk	\$69.1M
Plant Prefab	Plant Prefab is the first prefabricated home factory in the nation dedicated to sustainable construction.	Series A	Alexa Fund, Obvious Ventures	\$9.7M
Prescient	Prescient, an Arvada company, uses BIM design, leveraging robotics and laser cutting systems, for modular buildings.	Series E	Eldridge Industries, Kanusul and others	\$103M+
Procure	Procure is a cloud-based software for construction- specific functions such as submittals management, job costs and punch-lists.	Series H	Tiger, Dragoner, ICONIQ, Bessemer, & others	\$304M
Proto Homes	Offers patented technologies to home builders to develop low cost, high quality prefab homes	Angel	Undisclosed	Undisclosed

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RAD Urban	RAD Urban is a SF-Bay Area based offsite construction firm specializing in urban high-rise construction.	Growth	Undisclosed	Undisclosed
Reconstruct	Reconstruct provides easy and quick access to actionable and predictive construction performance analytics via already-existing images captured with drones or ground cameras and 3D building models.	Seed	Serra Ventures, Harbor Street Ventures and others	\$850k
Rhumbix	Mobile platform moving paper processes digitally and providing productivity tools for the construction craft workforce	Series B	Autodesk, Greylock, Brick & Mortar, & others	\$28.6M
Safesite	Streamlines safety tasks. Allows to log safety hazards instantly and automatically notify responsible parties for resolution. Progress is tracked and logged the entire way. upload and conduct checklists and inspections with greater accuracy in a fraction of the time.	Seed	Brick & Mortar Ventures and others	\$225k
SenSat	uses drone imagery and spatial data to create a real-time simulation of a real-world location. Its product can learn design requirements for a particular project and in minutes, select the most efficient design approach out of thousands of options.	Seed	Force over Mass Capital and others	\$5M
SiteAware	Sense-and-avoid technology that will allow drones to fly autonomously among obstacles. With Dronomy's technology, the drone flies itself.	Seed	31 Ventures and others	\$1.5M
Skycatch	Skycatch builds technology to autonomously capture, process, and analyze 3D drone data.	Series B	Riverwood Capital, Autodesk and others	\$46.6M
Struction Site	StructionSite saves contractors time and money by allowing them to rapidly digitize jobsites using 360 hardware, enabling teams to manage their projects from a browser or mobile device.	Seed	500 Startups, Cemex, WND, Social Starts	\$1.5M
Sustainer Homes	building sustainable for both you and the world.	Crowdfunding		\$611k
Theta	Theta is a cloud-based blueprint analysis and cost estimation tool for the construction industry.	Seed	Entrepreneurs Roundtable Accelerator	\$100k
Tobly	Construction equipment rentals	Angel	Green Egg Ventures	\$547k
Toggle	Toggle is a construction robotics company focused on automating the steel rebar process, with its first project at the Brooklyn Navy Yard. Incubated under Autodesk	Seed	Undisclosed	~\$1.5M
Tommy Run	Construction materials delivered on demand	Seed	Undisclosed	\$550k
Triax	Wearable IoT devices to improve the safety of construction workers and keep productivity moving forward.	Undisclosed	Undisclosed	Undisclosed

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Unearth	improves productivity in construction by providing collaboration software powered by IoT and remote sensing	Seed	Madrona Venture Group and others	\$4.3M
UpCodes	UpCodes helps the AEC industry deliver code compliant buildings.	Seed	Foundation Capital, Y Combinator and others	\$785k
Uptake	Uptake is a Chicago-based industrial IoT analytics provider with a platform for equipment monitoring, diagnostics troubleshooting, event and condition prediction, and task management for workflow and productivity.	Series D	Revolution, Caterpillar Ventures, Greatpoint Ventures, NEA, Lightbank, and others	\$218M
Veerum	Platform enables project teams to predict and resolve issues in the virtual world before they impact cost and schedule in reality. The ability to dynamically match reality to project plans means project teams can eradicate rework.	Seed	Brick & Mortar Ventures and others	\$6.5M
Versatile Natures	Versatile Natures' crane-based technology transforms any site into a smart, data-collecting field, allowing detailed analysis on the project's status while drastically improving onsite safety.	Seed	Urban-X, Urban Us, MassChallenge (Grant)	Undisclosed
YardClub	Yard Club builds integrated web and mobile apps for construction professionals to better manage their owned and rented equipment fleets.	Acquired	Caterpillar	\$1.6M