BIM, Blockchain & Smart Contracts

*By Nancy Greenwald, Executive Director, Construction Institute**

Everything we know about our industry is wrong in terms of what we will be doing tomorrow.
- Jim Cramer, Founder, Design Intelligence

Consider the prediction: Blockchain and smart contract technologies will transform the construction industry. Similar statements were made for Building Information Modeling (BIM), an integrative project design and data platform that has become ubiquitous in the industry over the past several decades. Yet the construction industry's use of BIM has not come close to reaching its full potential. Why? The main obstacle is a stubborn adherence to inefficient processes and relationships that is driven by risk aversion. The result is a complexity of contracts among multiple parties and a lack of standardization in processes that diminishes the value of BIM. In other words, the same problems that the industry needs to solve to improve its efficiency have been obstacles to its use of the new technologies designed to contribute to the solution.

What is different about blockchain? Blockchain is a platform for collecting and sharing information from disparate sources that creates a secure, valid, time-stamped, and tamperproof record. For this reason, it has the potential to solve core industry communications problems in a way the inconsistent sharing of data through BIM has not. This article explores the questions: why BIM has not achieved its full potential and how might blockchain and smart contracts contribute to a solution.

Why the Value of BIM Has Not Been Realized

While in 2020 it is tempting to assume a uniform level of familiarity with BIM and skip the definition, it's worth taking a breath to ask the question: What is BIM? In simple terms, BIM is a 3D model-based process that is *object-oriented*, which means it is designed to capture data about the objects incorporated into the design, from dimensions, to manufacturing information, to warranty and maintenance requirements. BIM creates a *parametric digital representation* of the facility, which means that when one element of the design is changed, other elements of the design adjust automatically. Of course, a model is useful for more than the process of delivering the facility. When the model contains accurate "as-built" information about the facility, it creates a "digital twin" that can be used to test virtual commissioning and, when connected with IoT (Internet of Things) sensors in the building, can be used to run online diagnostics, allowing the facilities managers to employ condition-based rather than reactive maintenance.

The Promise of BIM

Let's start by reviewing some of the promises and predictions made about BIM in its early years and then look at what has actually happened. In 2008, it was predicted that BIM would:

- enhance the ability of architects, engineers, and other designers affordably to create numerous design alternatives, instantly showing the effect on aesthetics, cost, and operation and maintenance (life cycle issues);
- reduce the time and cost of preparing budgets and schedules as well as reduce the time and cost involved in design coordination and submittal review;
- reduce the errors, inconsistencies, and coordination problems with design and improve the detection of design omissions;
- facilitate the retrieval of accurate information by field level personnel; and
- provide an owner's facilities personnel and subsequent contractor firms with accurate, readily accessible, as-built data for more cost-efficient maintenance and less costly building repairs and upgrades.[1]

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The big promise of BIM was that it would change the working relationships among project participants and create a new, more collaborative way of working together and, in so doing, improve both the efficiency of the process and the success of the project. But even in the early days of adoption, commentators recognized that "the business realities behind the conventional methods of delivering projects will not change overnight."[2] Twelve years later, the main obstacle to achieving the full value of BIM technology remains the same—that is, the working relationships and the contracts that define them, for the most part, have not changed. As Steven G. Haines, Director, Technical Operations, at BVH Integrated Services, states it: "We're still playing by the old rules and we have a technology that drives a truck through it."

The State of BIM Adoption

The extent to which BIM has become standard practice depends on in which part of the globe you are located. The United Kingdom has been at the forefront, with the government making BIM Level 2 mandatory for use on all public sector projects beginning in April 2016. It has been reported that between 2009 and 2015, this policy saved U.K. taxpayers 15 to 20 percent in construction costs, slightly more than U.S.$1 billion.[3] In addition to being a leader in BIM adoption, the United Kingdom is also considered a leader in BIM standards.[4]

By contrast, while there is a requirement from U.S. governmental agencies to employ BIM, to date there is no single U.S. government mandate to employ BIM and no single set of standards. Most federal institutions have written their own criteria, many of which have been published by the National Institute of Building Sciences (NIBS).[5] These standards have been created independently and are not necessarily related to each other. The U.S. General Services Administration, the Coast Guard, the Army Corps of Engineers, and the Smithsonian are examples of government agencies that have their own BIM adoption program.

Private sector adoption in the United States varies by company type and size. According to Autodesk, the adoption rate of BIM technology in architecture varies by type of architectural firm. The data show a 93% adoption rate by large firms, 75% by midsized firms, and 34% by smaller firms as of 2017.[6] The driving force behind its adoption is productivity gains.[7] Ninety-one percent of architectural firms are using BIM for 3D visualization, 80% for clash detection, and 57% for performance analysis.[8]

While BIM adoption began with architectural firms, its adoption by construction firms followed quickly. A recent Autodesk report suggests that the United States has a 70% BIM adoption rate among construction firms.[9] Those companies with a high level of BIM engagement report positive results from using BIM, including elimination of unnecessary rework, reduction of costs and material waste, and risk mitigation.[10] The main internal obstacles to the adoption of BIM at the firm level included cost and a shortage of labor with BIM skills.[11] The *2018 Construction Technology Report* by JBknowledge[12] concludes that BIM is "still not a priority" across a broad range of construction firms polled: 27.9% of construction companies surveyed do not bid on projects involving BIM; about half of the companies surveyed have employees on staff handling BIM.

The Potential Uses and Value of BIM Are Growing

The capabilities of BIM software continue to advance dramatically, and the integration with project management software and other technologies continues to extend its value. Dynamo is one example. It is open source graphical programming software that extends BIM with the data and logic environment of a graphical algorithm editor. It allows designers to generate thousands of potential geometries for a structure, and when linked with a model, it can, with the proper coding, calculate the costs associated with different designs. Connecting BIM to project management software is another line of development. In the last quarter of 2018, Autodesk acquired PlanGrid, software designed to improve communication during the construction phase, including communication to the field. Other recent Autodesk acquisitions include BuildingConnected, construction technology software focused on certain preconstruction tasks, and Assemble Systems, software that allows construction professionals to connect BIM data to bid management, estimating, scheduling, site management, and finance.[13] The sources of data that can be entered into a model have also expanded. Laser scanners, sometimes attached to robots or drones, collect data and create a point cloud that can be incorporated into a model, for example, to ensure the accuracy of as-builts for an existing structure on an ongoing project.

Potential uses for models extend well beyond visualization, clash detection, and improving the efficiency of the construction process. There is no theoretical limit to the information that can be added to the model. For example, seismic activity data and flood data can be input to run risk and building performance scenarios. BIM is being used by several large construction companies, including Skanska and Turner Construction Company, together with virtual and augmented reality tools to evaluate safety risks and to train workers in safety practices. Modeling allows for the growth of manufacturing processes in the industry, from offsite component prefabrication to modular construction. Combined with a virtual design and construction (VDC) process, models can be used to improve both the product and the process of construction. The VDC process analyzes the design and construction process holistically, considering construction methods, estimates, sequencing and scheduling, staging, and workflows.

Focusing on the potential savings of using BIM in the design and construction phase shortchanges the technology. The highest and best use of BIM is a fully integrated as-built model that contains information that facility managers need to operate the facility and to optimize the user-experience. Integrated with IoT sensors, the BIM model can become the basis for a plan of condition-based maintenance as opposed to reactive maintenance, which is more costly. The potential for savings, and improved performance and functionality that an accurate model can contribute to the operation and maintenance phase, is typically undervalued, and a collaboratively created, fully integrated model designed be used for life-cycle operations is still the exception.

Why the Industry Is Underutilizing BIM

Despite the clear value to be gained, the industry continues to fall short of achieving the full value of BIM technology. What are the obstacles to achieving the highest and best use of BIM?

Cost

In this economic environment, design professionals are pushed to achieve biddable designs more quickly and at a lower cost. Owners are generally not willing to pay for more complete designs. The short-sighted approach is to control design expenses at the front end without a sufficient appreciation that additional dollars spent in planning can avoid significant expenses during construction[14] and during the lifetime of the structure.

Lack of Experience

Different projects may require the use of different software than a project participant typically uses. Frequently, companies maintain multiple licenses for different programs used by different owners they work with. Their staff may struggle to gain expertise in more than one program. In addition, the more senior professionals are less familiar with the technology and the younger professionals who are more familiar with the technology have less real-world experience to draw on.

Risk Aversion

Architects' models are typically accompanied by a long list of disclaimers that diminish the utility of the models to other project participants. Architects, engineers, and other participants inputting information into the model may be concerned that a mistake, omission, or ambiguity in one model will cascade into mistakes in the work of others and open them up to liability in excess of the fees they receive for their work.

Siloing

Design and construction professionals generally work separately, and the information included in a model shared by an architect or engineer with a contractor, or by a contractor with a subcontractor, may not contain the information the recipient needs to perform their work As a result, participants can end up starting from scratch to create a model that meets the needs of their workflow. Traditional contracts that prevent direct communication between the contractor and the architect and engineer, or between the subcontractor and the owner, contribute to the "silo" effect.

Lack of Interoperability of Software

There are multiple software platforms that support 3D models and a myriad of related programs that provide information that should ideally be incorporated into the model. Software developed for the needs of specific professions does not easily communicate with software used by other participants. For example, site engineering software, MEP software, and landscaping software have been developed seaprately from the 3D modeling software employed by architects and general contractors. Later incorporation into a unified model increases the risk of miscommunication.

Information Lost in Translation
The typical process involves passing model information between participants and translating it back and forth between 2D drawings and the 3D model. The conversion of 2D drawings to 3D models and back to 2D drawings is a process that dumbs down the value of the technology, creates redundant work, and introduces multiple information transfer points that can result in errors, omissions, and ambiguities.

Contracts
There is often a profound disconnect between contract requirements and the optimal, BIM collaborative process. Common mistakes when incorporating technology into contracts include (i) vague or missing BIM language, (ii) vague or missing project management system requirements, (iii) liability language that discourages effective model sharing, (iv) lack of deep technology and process understanding on the part of the people who write and administer contracts, (v) inconsistent or conflicting technology clauses in the spider web of contracts among project participants, and (vi) uncontracted deliverables, processes, and expectations.

BIM is a technologically enabled process for a multidisciplinary collaboration. Yet, traditional industry relationships drive how the technology is used, and they are blocking its highest and best use. As a result of these obstacles, more than a decade after BIM technology gained significant traction in the industry, its potential for collaborative information sharing remains unrealized.

New Technology Opportunities: Blockchain and Smart Contracts

Demystifying Blockchain

It's easy to feel lost in the dense vocabulary used to describe blockchain technology. At the simplest level, blockchain is a set of agreed-upon rules for managing a database.[15] Those rules create a consistent, reliable, and secure record that allows for the sharing and validating of data among and by multiple parties. The protocols governing the security and reliability of the data create a tamper-proof record that is the basis for trust in the information, even if the parties don't trust each other.

Each event is recorded as a "block" in a chronological "chain" that is time stamped, tied to the identity of the person who created the encrypted data, and once created cannot be modified. A "block" cannot be added to the chain absent verification. Once added, it cannot be changed. A blockchain "ledger" is the record created by the chain of "blocks." Blockchain creates a "single source of truth."

Rules That Make Blockchain Unique

Cryptography
Blockchain uses a variety of cryptographic techniques. There are two essential purposes to cryptography in blockchains: (1) securing the identity of the sender of transactions and (2) ensuring that the past records cannot be tampered with. Each user has a public and a private key to the blockchain. The private key, visible only to the user, is combined with each transaction (data) the user signs. The private key provides access to the blockchain. The private key is linked to the public key,[16] which creates an address that is visible to all users of the chain. The public key is anonymous, maintaining the privacy of the participant. Each transaction creates a "block" that, once validated, is added to the "chain" of transactions. When added, each block contains a cryptographic hash of the previous block. A cryptographic hash is a mathematical equation that converts data into a string of characters. Each subsequent block is tagged with its own cryptographic hash and the hash of the block prior to it in the chain. Because the data are a part of the digital signature, editing even the smallest aspect of the data reshapes the signature, rendering it false.[17] No single block or connection between blocks in the chain can be modified, and the "chain" can only be added to.

Decentralized P2P Network
A key feature of a blockchain is that the database is shared. Participants can view the chain, add to the chain, and validate a block or the chain. The blockchain is not stored in a single place; rather, multiple, independent validated versions are stored across a variety of servers that participate in the network. Information can be added and verified by any entity among the group of participants, according to the rules of the blockchain, and there is no central source of control.

Nodes

"Node" is the term used to refer to any computer connected to the blockchain. The term "full-node" refers to nodes that review and validate all of the rules of the blockchain.

Distributed Ledger

As used in blockchain technology, "ledger" simply means the record of transactions created by the blockchain. A distributed ledger is a database of replicated, shared, and synchronized digital data that are geographically spread across multiple sites in a network. Each participant has access to an independent fully validated data set of the ledger.

Validity Rules and Consensus Mechanisms

A block of data will not be added to the chain unless it has been validated. How the information is validated is established by the blockchain rules. Once validated, there must be a mechanism for gaining the consensus of all participants as to whether the validated block should be added to the chain and in what order. In the exotic world of Bitcoin, validators are known as miners, and they receive compensation for their work validating blocks. The consensus mechanism for a blockchain is referred to as the "Proof of Work."

Public versus Private Blockchains

In a public blockchain, all transactions are public, all nodes are equal, and validation is a mathematical process. Cryptocurrency, one of the products made possible by blockchain, is an example of a public blockchain. A private or "permissioned" blockchain is an invitation-only network generally governed by a single entity with rules designed fit a particular purpose. Entrants to the network require permission to read, write, or audit the blockchain. As blockchain technology is employed to manage project data in the construction industry, the blockchains will be permissioned blockchains.

How Is Blockchain Technology Used?

Bitcoin and other cryptocurrencies were enabled by blockchain technology and are perhaps the most familiar applications. Blockchain technology provides a secure way to facilitate, validate, and track any type of transaction, and it has potential well beyond the universe of financial transactions. A transaction can be an event, such as the transfer of property; steps in a supply chain; votes for a candidate; or the addition or modification of information in a database (for example, a BIM model). Investment in blockchain technology is growing, and the players are leaders in the global market. Google, Amazon Web Services, IBM, and Cisco are among those investing in the development and application of blockchain technology. Here are just a few examples of industries that are using and/or developing blockchain:[18] mining, shipping, food safety, petrochemicals, energy utilities, insurance, health care, and government.

Some Current and Potential Uses of Blockchain in the AEC/O Industry

Blockchain is an integrative technology that can aggregate data across multiple entities and across multiple software systems into a single, verified, immutable record available to all. It seems a logical option for aggregating project information from the multiple participants involved in a construction project. Blockchain technology has the potential to provide a trustworthy infrastructure for information management during all building life-cycle stages. There are several industry companies already employing blockchain technology and more in the start-up phase. Here are a few examples. Intelliwave Technologies uses blockchain in its materials management software. Its product, SiteSense, utilizes RFID, GPS, barcode, drone, augmented reality, and blockchain technologies "tracking every activity for materials, equipment, workforce and the supporting record documents throughout the project's lifecycle."[19] Briq (formerly Brickschain) uses a combination of blockchain technology and machine learning tools to provide strategic insights into buildings and project developments.[20] HerenBouw, an Amsterdam-based company, is using a blockchain-enabled project management system on a commercial real estate development project.[21]

Perhaps the most exciting possibility involves connecting blockchain technology with BIM. By creating a secure platform for recording project information and providing a bridge from disparate data environments, blockchain technology can eliminate the inefficiencies in the fractured transfer of information in multiple BIM models. BIMChain is a small European start-up whose mission is exactly that: "By leveraging decentralized technologies to achieve open collaboration and data interconnection, the industry will achieve better Building Lifecycle Management."[22] DigiBuild, located in the United States, is currently working in partnership with IBM to develop blockchain applications for the industry as a productivity tool, for supply chain management, and for payment management.[23] Whereas BIM provided the industry with an *opportunity* for a collaborative environment, blockchain technology creates a data infrastructure that logically *requires* a collaborative exchange of data in real time.

Smart Contracts

A smart contract is a "computable contract" with self-executing steps written into lines of code. The idea of smart contracts was first publicized in 1994 by Nick Szabo, a computer scientist. He describes a smart contract as "a set of promises, specified in digital form, including protocols within which the parties perform on these promises."[24] Szabo refers to the vending machine as the "primitive ancestor" of the smart contract. Once the customer enters money into the vending machine and makes a selection, the transaction cannot be interrupted, and the machine automatically delivers the desired product. The terms of the deal are written into lines of code, and the smart contract becomes a self-executing mechanism for enforcing the terms of the contract. Smart contracts are designed to increase efficiency and certainty by eliminating the need for human intercession.

Smart contracts are a tool that can be used to effectuate the transactions on a blockchain, such as transferring a payment when a triggering event occurs. Smart contract code is recorded on the blockchain, which gives smart contracts some of the same characteristics as blockchain, including a high level of security. In a procurement process, delivery of materials would automatically trigger a payment through traditional methods or by employing cryptocurrency. The delivery and the payment would be events recorded in the blockchain.

A crucial step in a self-executing smart contract is verification that the triggering event occurred, which is where something called an "oracle" fits in.

> *Blockchains and smart contracts cannot access data from outside of their network. In order to know what to do, a smart contract often needs access to information from the outside world that is relevant to the contractual agreement, in the form of electronic data, also referred to as oracles.*[25]

Oracles are the entities that verify the information that a smart contract needs to execute the required step. Returning to the vending machine analogy, the smart contract requires the input of an oracle to verify that the requisite payment has been made. Oracles can take many forms and collect information from many types of sources. They can provide information from online sources or gather information from the physical world using the drones, robots, and other devices that are a part of the internet of things (IoT). Some oracles are consensus based. A smart contract may make use of several oracles.[26]

Some Current Uses of Smart Contracts

The potential of smart contracts is best understood by reviewing current examples. They range from simple to complex. Share&Exchange uses smart contract technology to automate the process of paying to rent electric vehicle charging stations. Fizzy AXA is a smart contract used by the French airline AXA. If an individual's ticket details are entered into the app and the flight is more than two hours late, the individual is automatically notified with compensation options. Once an option is chosen, it is automatically transferred to the individual (for example, money can be sent directly to a credit card). Propy is an "across borders" market designed to allow owners and brokers to list properties and buyers to search and negotiate the sale. The smart contract process ensures, for example, that a buyer's deposit will be returned automatically if the seller does not go through with the sale. Populous uses smart contract and blockchain technology to support invoice financing. PolySwarm helps enterprises defend their networks via direct access to a crowdsourced network of security experts that compete to accurately identify malware and provide actionable intelligence. The company employs blockchain and smart contract technology to ensure the accuracy of information and to facilitate transactions with contributing security experts and users.

Investment is growing. There are many companies already in and entering the business of creating platforms for smart contracts. The best known among these include Ethereum, Stellar, EOS, RSK, Cardano, and Tezos. There are numerous other platforms that are less well known, and many more in the planning stages.[27] Still other companies are working to create platforms that allow for interoperability between smart contracts written on different platforms.[28] As with blockchain platforms, there are smart contract platforms that can be used by developers and start-ups to create a myriad of applications.

Potential Applications in Design and Construction

The question we need to ask is what problems or issues can be solved by introducing blockchain and smart contracts technology? Let's start by considering what the technology does. Keep in mind that BIM is a database technology. Seeing buildings through the lens of the database contributed to the breakdown of architecture into its components, necessitating a literal taxonomy of a building's constituent parts. Similarly, employing blockchain technology as a record of the design and construction process will require the breakdown of that process into discreet, verifiable steps.

There are multiple potential applications to the life-cycle process of a construction project. To the extent that project data (design, construction status, etc.) are added to a private project blockchain, every participant in the chain would have verified, complete, updated, and accurate project information to work with. This approach has the potential to reduce ambiguities, improve efficiencies, and avoid errors. Because the blockchain contains information about the identity of the person who created the block, the blockchain can also identify responsibility for specific information. Blockchain technology tied to BIM can be used to relieve a number of concerns BIM participants typically have, such as ownership of intellectual property, liability, project oversight, data access, and traceability. In addition, in the same way that companies in the health care system are using blockchain technology to capture information across multiple systems that lack interoperability, blockchain technology can be used in construction as the repository of data collected from the multiple software applications used by project participants.

Smart contracts can be used to tie specific processes to a BIM model to improve efficiency in supply chain transactions; to confirm key process events, like permitting and inspections; to facilitate financial transactions; to track weather conditions in real time; to confirm change orders; and to provide notice. The result is a clear record of the process of a project as well as the as-built condition of the structure.

The Facility as a DAO

No description of smart contracts and blockchain technology would be complete without a discussion of distributed autonomous organizations (DAOs). A DAO is an organization represented by rules encoded into a computer program that is transparent and self-executing. Decisions are made and actions are taken by the DAO electronically by written computer code or through the vote of its members. One example of a real-world DAO project is the company DigixDAO (DGD). Founded in Singapore in December 2014, DGD specializes in the tokenization of a physical asset, namely gold. In the context of the built environment, buildings and other structures can be created as DAOs. A building, for example, could collect data from IoT-enabled sensors to manage the building by automatically adjusting heating and lighting, schedule condition-based maintenance, make payments for the same, and bill for and collect rents without the necessity for human intercession.

Assessing the Risks and Benefits of Blockchain and Smart Contract Technologies

Risks Associated with Blockchain Technology

New technologies always create potential for new risks, but the bottom line is that companies need to embrace new technologies to succeed. In a perfect world, the use of new technology enables the delivery of a sustainable design for a structure of higher quality (building or infrastructure) in a shorter period, at a lower cost, and with fewer injuries and less waste. In the real world, there is always concern about the potential risks: (1) new technologies create uncertainty, (2) new technologies have the potential to blur traditional lines of responsibility and shift risks, and (3) the use of some technologies may create new risks for which there is no insurance coverage.

What new risks might blockchain pose? Blockchain technology can be employed in many ways and in many industries. As a result, blockchain technology overlays specific areas of law, and the application of law to blockchain in any given area will reflect the relevant body of law. There are, however, some overarching legal questions related to blockchain. One of the risks of blockchain technology is uncertainty about the regulatory framework. In the United States, blockchain regulation is still in the early stages. At the federal level, legislation has been introduced to deal with inconsistencies in the use and enforcement of blockchain technology. There have been several recent developments on the international front, including the creation in 2018 of the European Blockchain Partnership. April 2019 saw the creation of the International Association for Trusted Blockchain Applications (INATBA). It brings together suppliers and users of distributed ledger technologies with representatives of governmental organizations and standard-setting bodies from all over the world to promote the collaborative development of the technology. The regulatory framework for blockchain development remains in flux.

Other issues of concern to companies include privacy laws, and cybersecurity risk. The cybersecurity risks associated with blockchain are similar to those for cloud-based applications. There are risks of unauthorized access, compromised encryption, hacking attempts, and open doors created by third-party vendors. Arguably, the use of a blockchain platform reduces those risks. Securities law relating to cryptocurrency is an evolving area. This will influence other applications of blockchain to the extent they employ cryptocurrency for financial transactions. Finally, issues raised for construction lawyers include jurisdictional and choice of laws issues, discovery issues and evidentiary issues.

The Legal Issues Raised by Smart Contracts

Because smart contracts are built in a blockchain platform, the legal issues concerning blockchain apply to smart contracts, and more. In practice, smart contracts do not eliminate the need for a written contract that specifies the terms of the agreement between the parties. Smart contracts add a step to the process. They are written by programmers who are tasked with translating previously agreed-upon terms into executable code. The programmer may be a third-party programmer who is not otherwise involved in the transaction. There is potential for a disconnect between the written words and the smart contract code, and if something goes awry in a transaction, technical experts would be required to explain how the computer code accurately captured the intent of the parties. Other concerns have been raised about the security of smart contracts, given that the complexity of the current programming languages makes it very hard to program smart contracts securely.

David Black, a Fintech expert at Oak HC/FT, argues that smart contracts are not smart and that they are not contracts. His contrarian view of the utility of smart contracts is worth a read.[29] From his perspective, the creation of the computer code creates greater opportunity for mistakes, and once embedded in the blockchain, mistakes can become immutable. He questions whether smart contracts will be as seamless as they are intended to be and argues that there are faster and more efficient ways of performing many of the tasks written into smart contracts.

Perhaps the best way to think of smart contract technology is as a useful tool for automating and recording specific contractual processes rather than as embodying a complete contractual agreement. For example, when payment is to be made in a supply chain agreement is a contractual provision, but the verification of a delivery and release of payment may be facilitated through a smart contract process. Some standard contractual terms, for example, a term requiring a standard of “reasonability,” cannot (yet) be reduced to the logic of computer coding.

Conclusion: Adapt or Die

The major obstacles to the effective use of any new data-sharing technology in construction are the complexity of the contracts and the lack of standardization in processes.[30] The story of Flux Factory highlights these problems. In 2015, Flux Factory, a startup out of Google X, created a suite of tools employing AI and a data-sharing platform that supported the incorporation of topography, zoning requirements, building codes, and meteorological and other site-specific information into BIM. Flux took its suite of tools offline in March 2018. CEO Jamie Roche explained that “until the industry is ready to revolutionize its processes, relationships, and contracts, it may be too soon to offer an end-to-end data sharing solution.”[31]

Despite the fact that there is significant value to be captured by everyone involved in the design and construction process by employing the full value of new technologies, especially those that increase collaboration and improve communication, stubborn structural problems in the industry slow the adoption of new technologies. If the industry is unable to shift its relationships to become more collaborative and remains unable to realize the value to be gained from new collaborative technologies, it is in danger of being disrupted by innovators in the same way the transportation industry has been disrupted by Uber or the hospitality industry has been disrupted by Airbnb.

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[26]. *Id.*

[27]. For a thorough review of smart contracts platforms, see Katya Kovalenko, *Investing in Smart Contract Platforms*, P2P CAPITAL: NOMICS BLOG (Nov. 12, 2019), https://blog.nomics.com/essays/investing-in-smart-contract-platforms/.

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[30]. Intelliwave, which is working to provide a blockchain application to the industry, makes the following assessments about obstacles to adopting new technologies: (1) "[I]ndustry standards in construction are almost non-existent from an Information Systems (IS) standpoint" and (2) the problem remains that there is "still the age old challenge of getting all stakeholders to buy in on a single methodology." *See How SiteSense® Uses Blockchain*, *supra* note 21.

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