AECROS

ARCHITECTURE, ENGINEERING, CONSTRUCTION, REAL ESTATE: OPERATING SYSTEM

AECROS requires an unusually multi-disciplinary approach, by its nature being neither wholly physical nor entirely digital. The convergence of many disparate technologies and systems engages human faculties to a high degree. Integrating many specialized fields of human endeavour requires a global perspective to create this new industry. From this view it seems the development of AECROS might have parallels to the development of the automotive industry. Similarly, the automation of construction and its support industries will no doubt have far reaching implications. It is hoped that this white paper can illuminate enough details of the coming industry to at least explain a few of its potentials to benefit both early supporters and the world at large. We consider that this is the greatest possible use of technology, to improve the human experience and change the world for the better.

Great thanks go out to all contributors who have made this possible

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*AEC(R): Architecture, Engineering, Construction, (Real Estate) *(M)MBU: Mechanized, Monetized Building- Unit

1. EXECUTIVE SUMMARY

AECROS = Auto Construction

“The way to achieve mass adoption of anything, is to create the most profitable result for the adopter.”

1.1. The New Industry of Auto Construction is Based on a new AECR:Operating System. AECROS- A “Universalis Modus”

The redesign of the fundamental building unit to adapt the building method to robotics and financial technology, is to change the DNA of AEC(R). To utilize software technology to fund, trade, design and build within this paradigm creates a new world industry. For comparison the automotive industry has had similar effects by automating transportation while AECROS automates all aspects of construction both physical and digital.

1.2. To Change Performance, Change the DNA

Manual construction (AEC(R) is slow and inefficient. The keys to changing these multi trillion dollar industries are in a single block. To change the ubiquitous building unit is to change the foundations of the *AEC(R) industries. Change this DNA and the long cascading effects which ensue create previously unknown levels of speed, accuracy and efficiency while positively impacting the human and natural environments (no wood required, no waste). (M)MBU is born of advanced engineering and is the patented key to rapid, cost effective, high grade construction, enabling blockchain and other technological integration at its core, and thus is the beginning of AutoConstruction. A “Universalis Modus” to achieve efficiency in AEC(R) and to unite it with the computing industry from beginning to end. Manual work is inefficient. Computers and other machines are most suitable to accurately handle large volumes of work (both physical and transactional) accurately and efficiently. AutoConstruction enables machines to handle AEC(R) in an efficient manner whereby their capabilities can be used to best advantage. “Machine” referring to machine learning (AI), blockchain smart contracts, machine robotic capabilities of speed, accuracy and endurance in repetition, lift capacity, sensory vision, mathematical and geometrical accuracy for manufacturing and assembly, auto cad design & engineering. blockchain financing of ownership and security contracts throughout the long chain of AEC(R) processes. Machine accuracy and speed are critical to improving AEC(R), reducing time, cost and waste. These are the reasons machines were conceived by mankind. To alleviate human misery and to improve human lives. Since the automation of transportation, the population can now choose either to use an automobile, or to walk. AutoConstruction automates (largely manual) AEC(R) creating a similarly long cascade of inestimable and far reaching benefits. The resulting homes will be more advanced, safe, efficient and eco friendly than have existed to date. Imagine a fine home which is imbedded with an interconnected LoRa network, is heated by data processing, is hurricane and fire proof, and is built in days. Each processing unit is part of a vast network, in turn supplying data wholesale utility which Auto Construction requires to run the industry and to assist occupants to operate the smart buildings it creates.

1.3. Volume of Value

Typical large transaction volumes of AEC(R) increase the importance, velocity and permanence of technological adoption. Auto Construction is focussed on benefits which can be realized through currently existing blockchain efficiencies of security through redundancy, reliability, accuracy, low transaction costs and transparency. Auto Construction utilizes Mechanized Building Units, Blockchain, BIM, IOT, Digital Twin, AR, Cloud, AI to enable machine automation of building contracts, financing, transactions, robotics and home automation to revolutionize AEC(R). AEC(R) does not need financial transactions to take place in 1/100th of a second in order to achieve trillions in transactional value per year. A few million AEC(R) transactions per year will achieve this. A steady exchange of high value transactions dispersed through blockchain to the population at large, (vs large trading volumes mainly in the virtual world) will profoundly impact society and AEC(R) +Finance. Typical AEC(R) transactions create long term involvement of the purchaser. By selling a single building to a single person, the value of each transaction is the largest purchase most people will ever make, while this unique system offers the most rapid and profitable end result for adopters. With every new person living in a “crypto” home, word will spread rapidly about this “New high tech, crypto home industry”. This is a step towards mass adoption of Blockchain, and Auto Construction. Placeholders for Members protect their priority of access to this industry, however large existing demand may be.

“Venire primus, primus serviant.”
Early adopters are “ad primum venire” and whether they be considered pioneers or fools, they will always have the greatest opportunities.

2. AECROS > ARCHITECTURE/ENGINEERING/CONSTRUCTION/REAL ESTATE: OPERATING SYSTEM

Auto Construction: The Automation & Mass Production of Building Construction & Financing Enables and Utilizes IOT, Blockchain, BIM, AR, Robotic On-Site Construction, Real Estate Development Contracting and AI- Integration to Redefine Construction

2.1. Blockchain & Block Supply Chain Integration by MBUs: Example 2.3 Diagram Fig 1

MBUs Monetized/Mechanized building Units-The foundations of Auto Construction: MBUs are a patented building system of self contained pre-finished building units imbedded with LoRA beacons. These “Mechanized Building Units” have the special characteristics needed to allow handling by intelligent robots and economic coupling to blockchain, while creating highly desirable finished buildings in todays market. MBU’s are mass produced and retain various common features which make them particularly suitable for “tokenization”. These units are assembled using robotic cranes to create any type and size of building. This allows for rapid deployment, high quality and interchangeable finishes and fixtures, for example: polished granite and marble, metals, bricks and plasters, with a lower (financing, design, engineering, construction and refurbishment cost) than traditional construction methods. Arguably one of the greatest advantages of these standardized building units is their enabling of the physical building units to be connected to Blockchain, and flow of inventory to be tracked via the IOT, reducing costs along the AEC(R) chain simultaneously.

**AEC(R) =(Architecture, Engineering, Construction, Real Estate/Financing)*

The new financing tools allow purchase, lending and sales of self complete building units on crypto exchanges, while “Gas” tokens (or derivatives of MBUs) pay for shipping, delivery and operation of the robotic cranes for assembly of the building units.

2.2. Integration of technologies assists efficiency in all areas of AECR

Auto Constructors (Robotic Cranes) are automated to require minimal human supervision. Blockchain is also automated and relies upon prewritten contracts to carry out business. Utility of MBU: A home can be financed, designed, engineered and built rapidly, construction proceeds 24/7 in all weather. Tokens or (Monetized)Mechanized Building Units (MBUs,) & M.Gas can be purchased or borrowed one at a time, on exchanges and peer to peer lending platforms to allow rapid approvals, replace mortgages, and allow instant liquidity, at any time or place in the world without lengthy approvals. Land and custom homes can be within reach of anyone who has access to our ecosystem. Homes can be designed simply, or be elaborate and large. Features may include marble and granite exteriors, high levels of insulation, extreme durability and excellent storm and fire resisting qualities. These buildings can be added to and integrated with ordinary construction methods such as wood frame or steel frame construction. Locations can be chosen from developments within or outside the ecosystem, on private lands owned by the builder or public lands authorized by various agencies and companies. Building loans are ordinarily difficult to obtain, and liquidity of the home is often difficult to release. Blockchain solves many of these difficulties and enables rapid liquidity. Fractional ownership can be shared, lent, rented, or sold on worldwide exchanges. Of course properties may also be transacted through traditional real estate channels.

2.3. Digital Twins

BLOCK SUPPLY CHAIN

Mechanized Building Unit

MBU

Physical Building Unit with Endless Interchangeable Finishes, Easily handled by remote and autonomous robotic cranes. Creating Hurricane, Fire and Flood Security, Rapid Assembly. Lower costs and higher physical attainability.

IOT

Digital Twin

BLOCK CHAIN

Monetized Building Unit

MBU

Blockchain Contract, Digital TWIN with Endless Interchangeable Financial, CAD, Engineering, IOT and BIM Possibilities, Creating Immutability, Security, Decentralized and Autonomous Rapid Transactions. Lower costs and higher financial attainability.

Physical Automation

Fiscal Automation

The Physical, Geometrically Coded embodiment of the Block,
Twins the Fiscal, Software Coded embodiment of the Block.

MBU

AutoConstruction

Blockchain Provides an Excellent Use Case for Block Supply Chain.

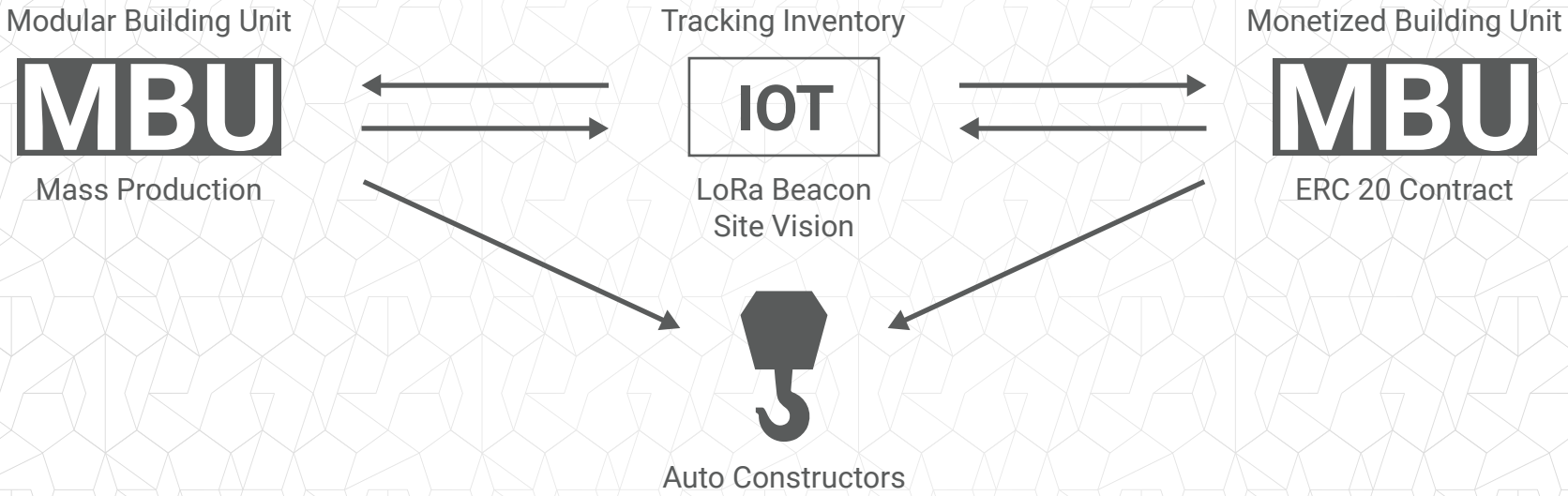
3. BACKGROUND

To this point in history, nearly every conceivable commodity in the human existence has been affected in some way or other by automation. It can be argued that mass production has already become a standard in the production efforts of nearly every commodity. Even with the traditionally manual nature of construction and financing to date, many attempts have been made to automate tools, transportation and production of the many components required to complete a building. Further efforts have been made towards standardizing of the fiscal side of real estate, with limited success. What has not been effectively achieved has been the consistent and flexible production of customized structures using machines to conduct the heavy work of structural building, and allowing factories to mass produce a self complete and universal building unit. While some inroads have been made, no single effort has resulted in a mechanized building industry.

3.1. The Breakthrough:

Mechanized Building Units represent the most basic element in the systemization of an industry that has remained slow to change for hundreds of years. In the effort to create an efficient construction industry, mechanization and automation represent the ultimate in time, cost savings and quality control. Automation of the financial and construction management systems is one of the largest remaining frontiers in the human endeavour to create efficiency in every industry. Mechanization represents the largest technological leap forward in this industry in 1000s of years while the automation of the fiscal/digital aspects allow unique financial and building information management capabilities (BIM). Homes can be financed, bought and sold in minutes, built in days, and can be configured to any desired size and shape. Finance is the overarching factor in building design and quality, with AECROS self completed building units, design engineering is made simpler while more creative license is allowed by the (correct) standardization of units. MBU's enable rapid cost analysis, designs, financing, production, assembly, and affordable, rapid, high quality automated completion.

3.2. Diagram: AECROS The operating System Includes Physical System, Digital System and Robotics to Create Integration Standardized Unit- Mass Production - IOT- Monetized Unit- Auto Constructors



4. MARKET SIZE

**Market Size: The worldwide construction market in 2017 exceeded $7.15 trillion annually and is steadily increasing, expected to reach $10 trillion annually in the next 10 years. (source: compass international.net) While the world market for real estate is estimated over 300 Trillion.(source: Forbes magazine)*

**Not specifically including Architecture and Engineering, BIM and Software Markets*

CRYPTO MARKET
CAP ESTIMATE 1-200B

200 BILLION →

Real Estate Market roughly 30X size shown here.

5.0. MBU (ORIGINAL) ABSTRACT

Mega Block, Monetized and Mechanized (MBU) Block, Mega Universal Building System, Hurricane Homes, includes a self complete building unit for construction, engineering, and financial standardization, tokenization/securitization and mass production of these self complete or nearly complete building units (MBUs) for construction of and/or financing of any building or structure utilizing a system of standardized blocks, levelling tracks, interconnecting conduit grids, vacuum fittings, common cranes, robotic smart cranes, humans, while enabling single units or whole buildings financing and calculations through any blockchain financial technologies and/or utilizing various other elements incorporated into the system for example interconnecting conduit grids, insulation, structural reinforcement and/or levelling foundation tracks and/or self levelling foundation tracks and/or other engineered components as they may arise in this new industry, to complete the structure to a commonly acceptable or high level of quality and finish such as may be desirable in the marketplace for buildings and structures. This may create dozens of new industries and enable the future development of many more. At this present time we may not be capable of imagining all of the possibilities that this new system will open to us in the future.

SHORT BACKGROUND OF THE INVENTION

The present state of the art in construction and its financial, management and engineering components include many materials, forms, panels, boards, blocks, systems and and various materials to create a building. The financial side is riddled with delays and inefficiencies, as is the planning, design, construction and demolition. Since the typical industry processes are complicated and labour intensive they require (for example) many cuts and much waste of valuable resources both in manufacturing and “onsite”. Design is complicated and leads to many errors due to varied materials and mixed results depending upon team execution of these various stages. Since the construction results are characteristically unreliable and inconsistent, buildings might have poor energy ratings, poor air movement and or thermal characteristics, poor positioning, and furthermore offer relatively poor resistance to fires, hurricanes, floods, earthquakes and disasters. Maintenance and other considerations are also costly in time, materials, economics and the environment.

THE UNIVERSAL BUILDING SYSTEM/ AUTO CONSTRUCTION OS IS DESIGNED TO CHANGE THE STATE OF THIS ART AND AFFECT MANY OTHERS.

MBUs proven engineering and other consistent characteristics are incorporated into the initial building design software, causing the designer/engineer/architect/owner to work within specific preset design parameters(height, width, and length of units) which predicts and simplifies mathematical computations (for example) of floor areas and ceiling heights, wall lengths, door and window placements to units of two feet or four feet, while the geometry of these units allows for endless variations in design to suit specific building requirements. Since components such as windows, door assemblies and other features fit into the 2 foot/ 4 foot specification they are more easily are mass produced at high quality and with many quality design features enabled by block geometry. Thicker than average walls allow high R values, thicker doors, steel protective shutters, thicker window casements, enhanced seismic performance and excellent opportunities for services and structural placements using the interconnected conduit grid inside walls, floors ceilings and roof allowing locations as desired. Engineering and design are greatly simplified and utilization/integration of BIM (building information modelling) and Finite Element modelling (component based engineering)are greatly enhanced, thus simplifying and streamlining the materials manufacturing, design, engineering and building process from start to finish. The resulting building design performance, engineering predictability and costing is (in theory) nearly perfect and instantaneous while projects may proceed at a rapid pace, without waste. The consistent geometry of the MBU creates efficiencies in all aspects of the construction process from financing, to manufacturing, planning, design, engineering, through shipping logistics (IOT) and carries through to physical construction, robotics mechanization of the physical process, and finally BIM management and smart home or building characteristics enabled by standard “smart” block configurations and superior computerized planning allowed by standardization, and finally to deconstruction and re-use in completely new customizable building configurations/designs as the most ideal environmentally efficient building method.

**(definition of “self complete” means: that once a building unit is made and positioned, very little or no additional work is required for its completion and integration into present buildings, methods, engineering and design requirements).*

Super Block Building System, Hurricane homes, Mega Universal Building System: A system of self complete building units and the infrastructure to monetize them and support their mass production and mechanized use. Super Block, Mega enables a new “green” state of the art in three industries: the new industry of mechanized construction, and two relatively new industries, construction related financial technology (Tokenization and Securitization), and the green building industry. This invention will spawn many new industries. At its smallest detail we save paper in ordinary construction related valuations, financial transactions and documentation of contracts, time for design and engineering using the Finite Element and simplifying BIM models, and at its furthest reaching we prevent deaths due to fires and disasters, while saving trees, wasted time and materials (landfills), while buildings resist destruction, decay and fire. Mechanized (and/or Monetized) Building Units and the system supporting them form a basic fundamental role in enabling mechanized building construction, mass production of buildings, and financially integrated transactions with Blockchain and other modern financial technologies. The MBU forms the basis for this future industry and changes the present state of the art. This technology is environmentally efficient and green (manufacturing from recycled materials and re useable buildings) and throughout the process of construction (building de-construction and transport for reuse) to enable the most environmentally green buildings to date. This establishes a new state of the art in green building technology, and also assists future progress in this area at an increased pace.

The invention provides a system based upon a *“self complete” building unit. Monetized and Mechanized Building Unit, (MBU) and the many components and systems (forming a new industry) to support its monetization and use. The “MBU” has standard configurations ideally suited not only to construction and mass production, but also enabling a new practicality to “securitize” the “monetized building unit” value, and/or attach smart contracts to building construction units prior to building planning and construction. Financing of single units now becomes possible, as does reverse financing of a home or building as single self complete and/or pre-determined value building units.

to be continued

Little to no waste is generated in its manufacture or assembly, and little energy is required to heat the resulting structure."Mechanized Building Units or MBUs", are suitable for rapid construction by ordinary cranes, manual labour and construction by our more advanced mechanized (robotic) means. While the "super cranes" hold valuable capabilities in many industries as well as construction, the MBUs hold intrinsic and unique qualities to segment the construction process into self completed and valuable building units allowing for complete surface finishes, utilities, insulation, structural integrity and allowance for seismic and other qualities within. The compartmentalization of the building and design process into smaller self completed "MBUs" or Mechanized Building Units, allows for handling of the heavy components for the construction of buildings of any size and configuration by "smart" cranes and ordinary cranes, and in rare cases even manual labour, to place these MBUs or blocks in position and thus to complete a construction to a high level of quality both in structural engineering (finite Element) and finish. Further the intrinsic quality of separateness of units and geometry and specific materials allows for a value to be ascribed to a single MBU, "unit" or "block".

Monetary Securitization and/or tokenization then becomes feasible, relatively simple, and very practical. The financing and further trading of these units as a commodity allows them to be funded, traded, purchased, borrowed, sold and in any way financially transacted when coupled with blockchain technology and "fin tech" including IOT (internet of things). This allows for pre-financed or at least premade inventory to be readily available for rapid deployment, and for rapid assembly of a building without the lengthy financing process ascribed to traditional funding and construction of real estate.

It could be said that the MBUs are a mirror of BlockChain, software programming with many similarities, Programming "blocks" as are created in modern blockchain, and as such they form "self complete" singular code components (blocks) interacting with a larger system (blockchain) and in our case single MBUs form larger aggregates creating structural buildings. In several embodiments, these units can be both assembled into complete buildings, and disassembled later for reconstruction at a new location and in a new configuration or building design, thus saving time, environmental and economic costs associated with building demolitions and reconstruction. This will prove valuable to many major construction related industries and offers humanitarian value such as rescue housing, physical rescue by super cranes in hazardous environments such as forest fires and floods, and offers many options for disaster relief. Both the new robotic drone cranes, and the system MBUs and components will prove valuable to many industries.

The simple cost based individual valuation model of each MBU enables it to be accurately valued and its factory finished construction as a standard unit allows inclusion of many kinds of electronics and/or RFID/LoRA types of identifiers to allow it to be attached to a smart contract, and/or to include location miners or sentinels, which are valuable components of the new IOT (internet of things). This provides valuable location data to the IOT industry, (thus potentially enabling revenues for the building owner) and also enables strong worldwide inventory control, while the financial tech capability offers unprecedented mobility of financial transactions. Enabling robotics through MBUs and their support systems also allows a new state of the art scope to support the burgeoning robotics industry. This is enabled by the consistent geometry, weight and other characteristics of the MBUs and system. Cranes may be custom designed to handle these units with ease and accuracy, while financing and manufacturing are all predictable and efficient.

Auto Constructions universal Building system (Operating System) and its various embodiments form a construction and building system (auto construction industry) comprising of standardized, selfcomplete building units, or "blocks",and/or "Mechanized/Monetized building units"(MBUs), and/or foundation and structure levelling tracks, containing all or nearly all of the construction elements required by state fo the art building design and engineering, and to be completely or almost completely finished on all exterior surfaces, and containing passages (interconnecting conduit grids) within wall units, floor units, roof units, and thereby within walls, floors and roofs, and spaces within the wall, floor, roof, system for concrete, and/ or internal scaffolding and/or other reinforcements suck as rebar, steel beams or any other sort, while containing within and/or on the exteriors of these units the required characteristics and materials such that these units meet modern engineering specifications within the completed structures, (such as various forms of insulation, and/or geometric based interlocks, and/or IOT sentinels and/or beacons of any sort to enable tracking and /or IOT, while being finished on external surfaces (inside and outside of the building, (external to the blocks) (for example stone or metallic or plaster finishes or others) or semi finished (for example maybe requiring paint or any other form of finish) on the exterior surfaces of the building units, and with face dimensions of width equal to and/or greater than the height and with a length exactly two times the width. One example of many having faces (outer finished or semi finished surfaces) that measure twice the length as the width and height (example width and height being equal), which will allow corners to be achieved with finishes intact and conduit interlocking grid alignment to be completed accurately) and/or may enable standardized costing of materials, and/or engineering evaluation (finite Element Modelling) of the units and/or completed buildings, this standardized unit build and cost thus enabling a unique and formerly unknown practicality of IOT integration and/or blockchain tokenization and/or smart contracts to utilize these uniquely standardized, self complete, easily valued units for Securitization and/or tokenization/and/or monetization of the building incrementally and/or prior to construction and/or manufacturing,(a former impracticality in prior art) either as a single mechanized building unit (MBU), or as any system grouping of these "smart" building units to predetermine the value, design and engineering characteristics of the building both prior to design and/or building, and during and/or after construction, and/or to furthermore enable rapid design and engineering of same, to near perfect accuracy, and the system and/or including a foundation levelling track system and/or self levelling system, an integral interlock system geometry within the block design, and/ or may have smart contracts and/or location beacons "built in" and the system comprising of further endless variations of units which may contain MBU windows, MBU doors, and any other MBU feature required by the buildings final purpose, a very long list of these variants is indeed possible as anyone can imagine who understands this art.

6.0 SMART CONTRACTS AND THEIR ADVANTAGES IN AEC(R)

AECR is extremely contract intensive. The present system is inefficient. Until now, escrow has been the most common method of storing and distributing money for AECR. A smart contract can be embedded with key milestones (replacing subjects and clauses) which must be satisfied to release payment to a contractor. This reduces the need for costly legal counsel and other middlemen, reducing the chance of unnecessary disputes over payment, ensuring agreed-upon work is completed to release funds, while also creating confidence that these funds will indeed be released at the appropriate stages. Anyone familiar with the construction financing process will see how this greatly improves the present situation to the benefit of all parties. Since the blockchain creates a viewable list of the contract terms checklist (clauses and subjects, schedules and deadlines, code approvals, materials and building inspections etc), the payment process becomes much more transparent. This is very valuable in the case of construction projects involving multiple parties with numerous supply and execution contracts having deadlines and payments required to meet tight schedules. With smart contracts, every stakeholder can view the project terms and gain a clear view of the project's completion status in real time. One continuous line of data improves back-end workflows and reduces friction on the contract side, streamlining both payments and project delivery. We can already see the legal profession advancing in this direction, "boilerplate" contracts are an example of this. In architecture, engineering, construction and real estate, speed is a key factor.

7.0 ENABLING SMART CRANES WITH STANDARDIZED MBUS

Smart Cranes or "Auto Constructors" are not yet in use for many reasons. They have not been sufficiently enabled to carry the workload of construction in a manner which satisfies the needs of market demand. This can be traced to economic factors and other practical considerations that (until now) have limited their effective use and profitability in construction and other sectors. This is largely due to the lack of an efficient mechanism for the full capabilities of fully mechanized cranes to be utilized. Neither cranes nor robots are capable of the myriad skillsets and tasks required to complete buildings using the present materials and method of construction. MBUs or "Mechanized Building Units" are designed to solve this issue, thus creating a powerful use case for mechanized, robotic smart cranes to be built and put into use. It may be considered that these Auto Constructors, as they come into effective use in the building industry, will also find demand in other industries. They may not have been considered for other fields such as search and rescue due to a lack of financial incentives. The robotic smart crane is in essence a "drone" and comes with all the usual advantages realized with drone use. These include characteristics and capabilities that were previously unavailable in a large conventional land vehicle. A few advantages: Unprecedented levels of human safety, remote operations, more accurate control and longer scope of operations in regard to weather, time, and geographical locale. Some use cases for these cranes include: forest fire fighting, disaster relief, flood/storm damage reparations and rescues. Shelters may be created in hostile environments such as arctic regions or desert regions where temperatures are typically restrictive to human operators and workers. Since these units can traverse rough terrain and water, they can be useful in many situations where neither an automotive vehicle, boat or plane may be used effectively.

The Mechanized Building Units open the economic doorway to the development and deployment of Auto Constructors. MBUs pave the way to rapid and accurate building which satisfies current market demand. Financial incentives for rapid construction exist in the construction market at large. Autonomous and robotic construction now becomes both practical and economical. Auto Construction becomes a new standard of construction.

8.0 FUTURE PROOFING

A typical constructed building incorporates many surfaces and internal features. For this structure to maximize its utility and value in the future it is crucial to enable easy service access, removable panels, and easily replaceable features. With Auto Construction these upgrades may be integrated at any time in the future, with a minimum of damage to existing structures. This saves both time and money while providing the "ultimate" in renovations capability. For example: To change locations of a plumbing fixture such as a shower, the base unit can be easily removed, the plumbing can be disconnected, and a new location chosen anywhere within the structure. In the old location, a single panel is replaced, bringing the surface back to as new condition and eliminating former access holes to the services. In the new location, a panel is removed, and the fixture is connected. The entire operation can be completed in a few hours. This timeframe can enable entire kitchens, bathrooms and other features to be removed, replaced, repositioned and may completely change the internal service layout of the building. This is all accomplished with a tiny fraction of the waste and inconvenience usually generated by such a procedure. In existing building designs new styles and materials can be added when the older surface begins to appear "dated" or out of style.

9.0 PROOF OF WORK

For contractor submissions, proof of work completes a portion of a smart contract and completion may trigger payment automatically. This automation streamlines the payment process. Since payments are made automatically upon verification of a task's completion, there is no longer a need for someone to "sign off" to release payment, which removes middlemen and speeds up payment times. Contracts may incentivize contractors who complete jobs early, which again is all managed automatically using smart blockchain-based contracts. A typical construction project involves huge quantities of data from multiple sources, some of which is subject to unethical manipulation. Storing data in a unified ledger system protects data and creates immutability, reducing
or eliminating data corruption. Faster "progress" payments mean shorter construction schedules and faster completion times.

10. FINITE ELEMENT ANALYSIS (FEA): SIMPLIFIED & STREAMLINED WITH MBU

Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use FEA to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.
It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behaviour, thermal transport, wave propagation, etc. Most of these processes are described using Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical techniques have been developed over the last few decades and one of the prominent ones today is Finite Element Analysis. Differential equations can describe physical phenomena encountered in engineering mechanics. These partial differential equations (PDEs) are complicated equations that need to be solved in order to compute relevant quantities of a structure (like stresses (strains, etc.) in order to estimate a certain behaviour of the investigated component under a given load. It is important to know that FEA only gives an approximate solution of the problem and is a numerical approach to get the real result of these partial differential equations. Simplified, FEA is a numerical method used for the prediction of how a part or assembly behaves under given conditions. It is used as the basis for modern simulation software and helps engineers to find weak spots, areas of tension, etc. in their designs.
Preprocessing is a process that must be performed before doing the actual simulation. During this process engineers will amongst other things clean the CAD model and create the mesh. A mesh is a cluster of small cells representing an object. For Finite Element Analysis, engineers will usually create a mesh of the actual model that they want to simulate. Since the time and difficulty of work is determined by set up and preprocessing times, it becomes obvious that having these processes completed at the beginning of auto construction will greatly accelerate engineering of each project undertaken. FEA is important to determining physical characteristics of a given design. Once this process is completed for a new system component, mass production proceeds with predictable system characteristics in the final build. engineering time is greatly reduced without compromising integrity. Once these results are stored on the blockchain, specifications become secure for accurate reproduction in the future. Building speed, cost, accuracy, safety, quality and built designs will benefit.

11. UNIFIED LEDGER SYSTEM OFFERS AN IMPROVEMENT ON PRESENT DAY BIM.

Each supplier and subcontractor involved in a construction project using a blockchain-based smart contract may receive its own smart contract. All would be available for viewing at any time as individual “blocks”. New blocks are added to the chain as new information becomes available and new contracts are created. BIM: 6D Building Information Modeling refers to the intelligent linking of individual 3D CAD components or “assemblies” with all aspects of project life-cycle management information. The model is used for construction process and then delivered to the owner when a construction project is complete. The “As-Built” BIM model is populated with relevant building component information such as product data and details, maintenance/operation manuals, cut sheet specifications, photos, warranty data, web links to product online sources, manufacturer information and contacts, etc. This database is (presently) made accessible to the users/ owners through a customized proprietary web-based environment. This is intended to aid facilities managers in the operation and maintenance of the facility. This BIM process creates proof of concept for applying Unified Ledger technology.

12. MONETARY DELAYS

It is quite obvious that Blockchain technology has wide-ranging implications for the construction and real estate development industries. How we handle contracts, payments and collaboration are all critical components of the AECR industry. Many are already aware how blockchain creates an encrypted ledger system for money to be exchanged for goods and services outside the traditional monetary system. The ledger stores and records all transactions, keeping all such transactions available and transparent to be referenced as required. Use Case: What many people may not yet be aware of is how valuable this is to the worlds construction industry. Increased efficiency is particularly important in building contracts where ordering, work scheduling and payments are intertwined and can cause real time delays in progress of both the purchasing, materials supply, construction and occupation or sale of the property in question.
Monetary delays often have a cascading effect. The building industry today accepts these costs as the “cost of doing business”.

Eliminating these costs and time delays are very important factors in providing efficient, timely and cost effective construction projects, and ultimately affecting the final cost of housing and other important buildings such as public works and even disaster relief projects. Immediate and efficient funding is a necessity if these projects are to benefit the people who need them most. In fact this is only one example of many, as the entire BIM chain of operations will be greatly enhanced in speed, accuracy and cost reductions. This affects the Architecture, Engineering, Construction and Real Estate industries, expanding into the financial sector of construction development and construction equipment financing.

Supporting Study follows next:
Jun WANG et al. The outlook of blockchain technology for construction engineering management aka; (Building information management or BIM)

13. THE OUTLOOK OF BLOCKCHAIN TECHNOLOGY FOR CONSTRUCTION ENGINEERING MANAGEMENT

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14. ABSTRACT

Current construction engineering management suffers numerous challenges in terms of the trust, information sharing, and process automation. Blockchain which is a decentralized transaction and data management technology, has attracted increasing interests from both academic and industrial aspects since 2008. However, most of the existing research and practices are focused on the blockchain itself (i.e. technical challenges and limitations) or its applications in the finance service sector (i.e. Bitcoin). This paper aims to investigate the potential of applying blockchain technology in the construction sector. Three types of blockchain-enabled applications are proposed to improve the current processes of contract management, supply chain management, and equipment leasing, respectively. Challenges of blockchain implementation are also discussed in this paper.

15. INTRODUCTION

Trust relations in the construction industry concern people from organizations such as clients, contractors, subcontractors, and suppliers (Lau and Rowlinson, 2010). Previous studies have shown that mutual trust helps to smooth the construction process, allows flexibility for facing uncertainty, increases efficiency and sustains long- term relationships. In practice, formal contractual rules are always developed to legitimise behaviours and strategies at odds (Kadefors, 2004). However, current contractual relationships are mainly based on confrontational situations that reflect the level of trust (or mistrust) in the contract documents, which can be the driver to increase the total cost of a specific project (Zaghloul and Hartman, 2003). Today international contracting becomes common and the complexity of the construction projects is increasing (Lau and Rowlinson, 2010). These projects require not only advanced construction technology transfer but also a shared project information environment with fair data exchange. Conventional contracting methods and information exchange technologies are far from the industry needs.

Blockchain technology which started with the popular crypto currency Bitcoin allows digital information to be distributed without being copied or altered. In the conventional construction industry, data is stored at a central database which can be accessed from various places. The security problem is the main concern because the transaction data could be altered by a hacker. The blockchain technology is different, which can be treated as a database that is shared on a peer-to-peer network. Transactions are grouped together in blocks in a certain time and then added to a permanent chain. These blocks cannot be altered once they are added to the chain, which makes the chain of transactions publicly verifiable and totally un-hackable (Taylor, 2017).

16. TRUST IS THE KEY FEATURE OF BLOCKCHAIN TECHNOLOGY.

If the construction business or activities are executed on a blockchain system, participants involved don’t need to have an established trust relationship if they trust the blockchain itself. In addition, blockchain technology takes care of the information exchange by making every participant of the project a custodian of all the information flowing through the project lifecycle. Unlike Internet information exchange where information is passed from point to point, in Blockchain, the same information is passed across to the whole system. Therefore, no persons including the sender have more information than others.
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A construction project is a network of hundreds of processes, participants, products, and materials. Money transaction and/or data exchange are frequently performed along with project progressing. There are a significant number of disputes and litigations occurring during construction. Although things like payment terms and data confidentiality are outlined in a contract or an agreement, disputes often arise over the stipulations of the agreed protocols (Taylor, 2017).
Current research of the Blockchain technology is limited to the digital currency (i.e. Bitcoin system) though the technology is applicable in other industries (Yli-Huumo et al., 2016). The purpose of this paper is to introduce the concept of Blockchain technology and investigate its potential applications in the construction sector to avoid these disputes. Three types of blockchain-enabled applications are proposed and demonstrated in this paper including blockchain-enabled contract management, blockchain-enabled supply chain management, and block- chain-enabled equipment leasing. Challenges of block- chain implementation are also discussed at the end of this paper.
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17. CHALLENGES IN CONSTRUCTION ENGINEERING MANAGEMENT

The first challenge faced by the construction corporations is the trust issue. Traditional construction engineering management involves trust issues in almost every aspect of daily activities. For example, (Johnston et al., 2004) found that in the buy-supplier relationship of construction engineering management, supplier's level of trust is related to some inter-organizational cooperative behaviours, such as shared planning and flexibility. To manage project relationships, especially in a cross-disciplinary environment, a higher level of trust is expected to enhance project performance (Kadefors, 2004). Similarly, (Wong and Cheung, 2005) argued that the establishment of trust is the most critical factor that facilitates partnering success, which means that management should direct their effectors to enhance a systematic and effective trust system between various partners.

However, there seems to be a problem of building such a systematic and effective trust system in traditional construction engineering management. Traditional construction engineering management uses lump-sum contract and lowest bidder will normally be appointed. If the lump- sum contract is used, many aspects of the building design will not be measured accurately in verifiable terms, which may affect the completion of the project (Kadefors, 2004). In addition, as (Kadefors, 2004) pointed out, the constant change of requirements will also impede the establishment of a trust system. The level of trust that is required for successful completion of the project is also very difficult to be determined. For example, according to (Wicks et al., 1999), it is expected that the extrinsic and economic incentives of other people's work will normally be overestimated and the intrinsic and non-monetary incentives, such as social recognition, will be underestimated. From a rational point of view, participants in construction engineering management tend to emphasize their own economic self-interest. As such, building a systematic and effective trust system may be difficult. It may be beneficial to investigate project success in an environment where no trust is required in single entities.

18. SUPPLY CHAIN ISSUE IS THE SECOND MAIN CHALLENGE.

Many studies in the construction engineering management discipline have focused on improving supply chain management performance between manufacturers, distributors, contractors and customers (Simatupang and Sridharan, 2005). According to (Kopczak and Johnson, 2003), the ultimate goal of supply chain management is to achieve seamless and agile supply chain to meet customers' needs at lowest cost. However, because of the conflicting interest of various participants in the supply chain, this ultimate goal is very difficult to achieve.
There are a variety of reasons leading to ineffective and inefficient supply chain performance in construction engineering management. However, it is argued that the transparency and traceability of products should be highlighted as the basis for further improvement (Abeyratne and Monfared, 2016). At the moment, it is very difficult for end-users to track the origination of the products, their delivery, storage as well as distribution. This problem is amplified in a complex project where second-tier suppliers and subcontractors are involved. In a complex project, transparency in the supply chain requires that the information of every product in the supply chain be documented in a centralized system so as to understand the effects and consequences of an isolated decision on the overall supply chain performance (Abevratne and Monfared, 2016). It requires accurate data collection, input, storage and analysis between various participants in the supply chain. At this moment, there are very limited studies which focus on visualizing the transparency of supply chain (e.g. see Bonanni, 2011). However, it should be noted that these studies rely upon an established trust system between various participants. In addition, the company that owns the centralized supply chain performance system will gain significant power by obtaining such valuable data, which may potentially damage other companies. It seems that there is a need for a decentralized system in managing supply chain data, which can help improve supply chain management performance without building a trust system between participants.

19. INFORMATION SHARING

The other important aspect of supply chain management is related to information sharing, including information sharing support technology (such as the software used to record supply chain data), information content and information quality (Zhou and Jr. Benton, 2007). As stated earlier, there are many studies which focus on using advanced IT applications for supply chain management. However, such applications require a centralized company to record and manage the data, which other participants may not be willing to provide. Information quality refers to the degree to which the shared information can be trusted and used to meet the needs of the supply chain (Petersen, 1999). It can be measured by accuracy, frequency, credibility and availability (McCormack, 1998). However, it should be noted that traditional construction engineering management practices may not be sufficient to help achieve such information quality. For example, it is necessary to have an established mechanism to identify false information and providing false information should be penalized.

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20. ASSET MANAGEMENT

The third one is related to asset management, which is of critical importance in construction engineering management, especially for sectors where much attentions are directed toward operation and maintenance. As such, many studies have focused on asset management in construction engineering management. Similarly, asset management in construction engineering management shares some of the aforementioned challenges, such as sharing data between different parties, as well as reducing the needs of duplicative data. In addition, it is recommended that such data should be collected by a distributed ledger, which is defined as geographically spread digital data across multiple sites (Shah et al., 2016). It can help reduce the risk of a single entity owning the whole asset data.

In addition, current asset management practices are that each company constructs their own asset management platform using their own internal database. Such practice has created some challenges around interoperability, especially when multiple asset management platforms are involved. The interoperability issue, which can be solved by creating assorted API solution, of an industry-wide or even cross-industry collaborations will be too complicated. In addition, the company who owns the API solution or the cross-industry asset management platform may intentionally reduce its interoperability with other platforms in order to gain a strong economic advantage (Mattila et al., 2016). While this may be good for the API owner, it may damage the overall productivity of the whole industry.

Other than interoperability issues, traditional asset management practices which rely on data input into a centrally controlled platform are not appealing to all participants. Providing data to a platform which is owned by other companies leads to the reluctance of participants. Although this problem can be addressed by using a trusted agent who is not a direct participant of the project (e.g. using the asset management platform provided by individual software developers), it should be noted that the direct participants of the project will lose value in terms of control of the platform (e.g. if the individual software developers decide to stop updating the platform). As such,

21. BLOCKCHAIN TECHNOLOGY

Blockchain, mostly known as the technology running the Bitcoin cryptocurrency (Nakamoto, 2008), is a public- permissioned-distributed ledger system maintaining the integrity of transaction data (Yli-Huumo et al., 2016). According to the Allens (2016), the distributed ledger can be public or private. A public ledger has no central owner which can be accessed and maintained by any member of the public. Identical copies of the ledger are distributed to everyone in the network. A private ledger is one with limited or pre-selected participants that are authorised to transact and interact while subject to some form of external control.
The blockchain information exchange is disintermediated and every individual in the ecosystem has access to the same information as the other participants. The essential feature of blockchain is the maintainability of the data and information without any organizations or governmental administration in control. Swan (2015) classified the blockchain technology into three categories: Blockchain 1.0, 2.0 and 3.0. Each of them is explained in detail as follows.

Blockchain 1.0 is for the decentralisation of money and payments. Bitcoin is a typical application in this category. The core functionality of blockchain 1.0 is that any transactions can be sourced and completed directly between two individuals over the Internet. Unlike fiat currencies for which governments can print more money, the money supply of Bitcoin grows at a predetermined rate. The new currency is being issued at a regular and known pace, with about 13.5 million units currently outstanding, growing to a capped amount of 21 million units in 2040.

Blockchain 2.0 is for the decentralisation of markets more generally, and contemplates the transfer of many other kinds of assets beyond currency using the block- chain, by the creation of a unit of value whenever it is transferred or divided. Blockchain 2.0 can include Bitcoin 2.0 and its protocols, smart contracts, smart property, Decentralised Applications (Dapps), Decentralised Autonomous Organizations (DAOs), and Decentralised Autonomous Corporations (DACs). All financial transactions could be reinvented on the blockchain, including stock, private equity, crowdfunding instruments, bonds, mutual funds, annuities, pensions, and all manner of derivatives. Public records (i.e. property ownership certificates, business licenses, and vehicle registrations), digital identities (i.e. identity cards, passports and driver licenses), and private records (i.e. loans, signatures and escrows) can be migrated to the blockchain and stored. Attestation can be executed via the blockchain for proof of insurance, proof of ownership, and notarised documents. Physical assets such as houses and cars, and intangible assets such as patents and copyrights, can also be encoded, protected, and transferred via the blockchain.

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Blockchain 3.0 is for the justice applications beyond currency, economics and markets, particularly in the areas of government, health, science, literacy, culture, and art. The freedom attribute associated with the blockchain becomes more pronounced in Blockchain 3.0, which is fundamentally a new paradigm for organizing activity with less friction and more efficiency. The coordination and acknowledgment of all manner of human interactions, and a higher order of collaboration between human and machine can be significantly facilitated through the blockchain 3.0. Blockchain government is an important application of the blockchain 3.0, which uses the blockchain as a universal, permanent, continuous, consensus-driven, publicly auditable, redundant, record keeping repository to provide decentralised government services.

22. APPLICATIONS OF BLOCKCHAIN IN CONSTRUCTION ENGINEERING MANAGEMENT

4 Potential applications of the blockchain in construction engineering management can be classified into the following three categories:

(1) Notarization-related applications to eliminate the verification time of documents' authenticity. Corporations operating within the construction sector face mounting pressure to meet increased industry and government regulations. Notable resources including time and labor are assigned to preserve the integrity and authenticity of construction documents during storage and retrieval. With the implementation of the blockchain, every document can be stored in a distributed ledger, there is a perfect notarization of each creation, deletion, and updating across the system. The whole blockchain system knows exactly what the source of the information is and the technology enables the authentication. Such type of applications can be used for recording construction quality data including the quality of the raw materials and installation, construction progress information (i.e. daily, weekly and monthly), and resource consuming data such as concrete, scaffold, formwork, steel, and equipment.

(2) Transaction-related applications to facilitate auto- mated procurement and payment. It is easy to perform title transfer for any properties including tangible and intangible whose ownerships are controlled by the blockchain. In the construction sector, there are numbers of disputes that are related to payment, technology transfer, equipment leasing, and house selling. With such applications, significant time and cost can be saved if all of the processes are automated and neutral.

(3) Provenance-related applications to improve transparency and traceability of construction supply chains. Since every transaction is visible in the blockchain ecosystem, it is easy to trace backward of the supply of each product or service with authenticity from a compliance or quality assurance perspective. This is of particular importance in global construction projects. For instance, during operation and maintenance stage, if a serious defect of a product is found, the histories of the total supply chain are always available from the raw material preparation to offsite manufacturing, transportation, site construction, and until the final commissioning. The responsible party of the occurring defect can be quickly identified and confirmed without tedious arguments because all of the records stored in the blockchain system are authentic and non-editable. There are no chances, in theory, to hack into the system and manipulate the records to suit one party.

To demonstrate how to use the blockchain technology to address the three challenges mentioned in Section 2, three types of blockchain-enabled applications are proposed, respectively. For the trust challenge, contract management is selected as an example to show the capabilities of the blockchain. The application of blockchain-enabled contract management developed in this paper belongs to the category of the notarization-related applications. To solve the issues of transparency and traceability in the supply chain management process, a blockchain-enabled supply chain management system is proposed which belongs to the category of the provenance-related applications. In terms of the challenge faced by asset operators, due to the broad area of the asset management, in this paper the authors only choose a small sub-topic of the asset management (i.e. equipment leasing) to illustrate the underlying mechanism of the blockchain. The proposed blockchain-enabled equipment leasing system belongs to the transaction-related applications.

23. BLOCKCHAIN-ENABLED CONTRACT MANAGEMENT

A blockchain-enabled contract, also called smart contract, is an agreement that can execute a part of its function by itself (Swan, 2015). The self-executing component is built based on the blockchain technology and requires the expression of terms in logic statements. Figure 1 illustrates a simple example which is developed based on the Ethereum blockchain platform (Ethereum, 2016). The contract states that if the temperature of the construction site is higher than 40 degree centigrade, then the client pays a certain amount of dollars (allowance) to the construction contractor. With such a smart contract implemented, three significant improvements can be achieved in the current construction sector. Each of them is described in detail in the following paragraphs.

24. FIG. 1 A SMART CONTRACT EXAMPLE:

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SOLIDITY CONTRACT SOURCE CODE

```
pragma solidity ^0.4.2;


contract MyContract {
    /* Constructor */
    address public contractor;
    uint256 public allowance;
    uint256 public temperature;

    mapping (address => uint) public balanceOf;
    event Transfer(address _from, address _to, uint value);


    function token(uint supply) {
        balanceOf[msg.sender] = supply;
    }

    function transfer (address contractor, uint256 allowance) {
        if (temperature < 40) throw;
        if (balanceOf[msg.sender] < allowance) throw;
        if (balanceOf[contractor] + allowance < balanceOf[contractor]) throw;

        balanceOf[msg.sender] -= allowance;
        balanceOf[contractor] += allowance;
        Transfer (msg.sender, contractor, allowance);

    }
}
```

25. 3-WAYS OF ELIMINATING THE PAYMENT AND CASH-FLOW ISSUES.

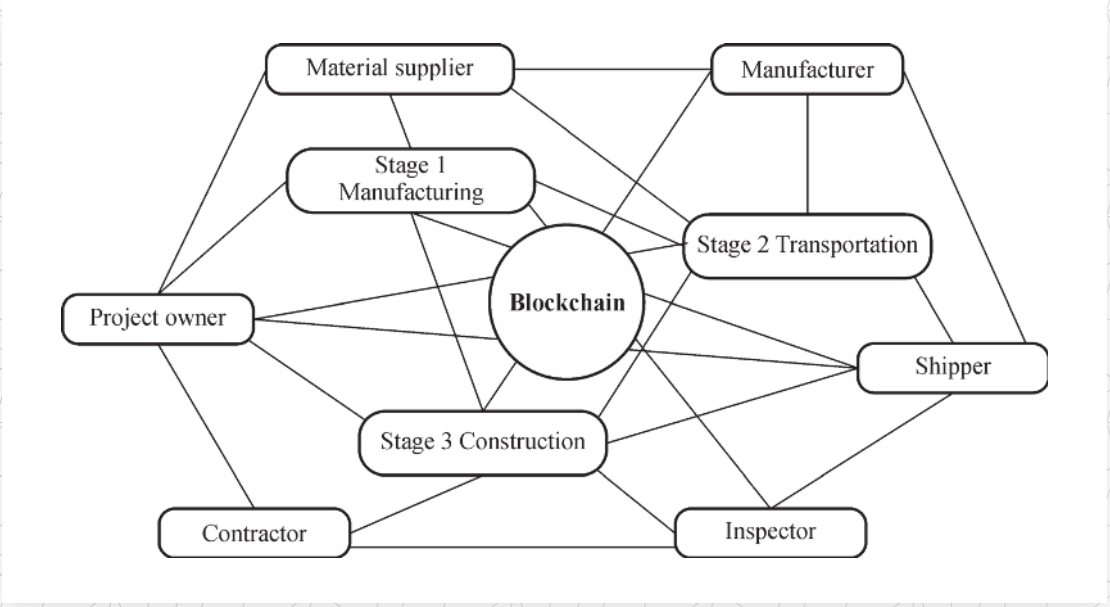
Payments withheld or not paid is a serious problem in the current industry, and has been highlighted as the main cause of business failures and escalating disputes. With a smart contract, the funds or cryptocurrencies can be embedded into the contract against the insolvency of the late payments so as to protect general contractors, subcontractors and suppliers. Moreover, these smart contracts can be interlined with each other to create a web of payments. For instance, when a construction project achieves a payment milestone such as structure completed to building Level 10, the general contractor will get an automated payment through the smart contract with the project client. This event will also automatically activate all the related payments, such as the smart contracts between the general contractor and their subcontractors or suppliers, based on the contract conditions.
The second one is improving the efficiency of the contract administration process. A smart contract is expressed as a software code which is unambiguous and predictable when compared with the traditional contracts. Massive time in terms of contract registration, monitoring and updating can be saved because of the automated process and tamper-proof system.
The third one is reshaping the trusted behaviour from the human trust to coding trust. The cost of building trust among different parties in a construction project is very high because every project is one-off and the project team is always temporary. In the traditional way, construction lawyers play a key role in creating and managing the enforcement of many of business rules through contracts and litigation. To maximize their profits in a real project, corporations rely on in-house lawyers or large firms to help them stay on the right side of the law and execute their contracts appropriately. Blockchain makes it easier for two parties to trust each other without a third-party enforcer. The blockchain-enabled contract can be stored in a non- editable format. Together with the self-executing codes, neither party has the upper hand to tamper or prevent the execution of the contract. With right code and secure code executing across a peer-to-peer network of databases, the “trust” function that a legal team currently plays becomes redundant, which can lead to significant time and cost savings.

25.1 Blockchain-enabled supply chain management

The main challenge of the traditional supply chain is the shortage of an open and trustworthy information resource across the supply chain. Customers and buyers have no reliable ways to verify and validate the true value of the products they purchase because of the lack of transparency and traceability. A typical supply chain is a series of bilateral contractual links that are put next to each other to form a supply chain such as: buyer-vendor link for the procurement of materials or equipment, production- distribution link for transportation of the products, and inventorydistribution link for the optimal inventory levels. Every link in the supply chain is a bottleneck for information sharing and trust erosion.
The Blockchain technology has the potential to tackle these challenges through the use of the open permissioned ledger system. Figure 2 shows a blockchain-enabled supply chain for an off-site fabricated instrument from procurement to the end of the final installation.

25.2 Four Potential applications of the blockchain in construction engineering management

Fig. 2 Blockchain-enabled supply chain



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4 Potential applications of the blockchain in construction engineering management

25.3 Blockchain-enabled supply chain management

The system starts with the purchase order developed by the project owner. The manufacturer who fabricates the instrument receives the information and send the raw material requirement to their suppliers. The system then sends a notification to the inspection agency which records the details of the raw materials to be inspected. During the manufacturing process, records related to the quality of cutting and drilling, welding, surface treatment, and assembly are also uploaded to the blockchain system. Once the inspection agency has issued the certificates to approve the delivery, the shippers can arrange to ship the instrument and issue the delivery status in the system, such as alongside ship, on board and ship's arrival. When the instrument is unloaded in a material offloading facility, a notification of quarantine inspection will be sent to the specific department. All of these records are available to the supply chain participants and can enable any audits on quality issues faced in the downstream supply chain. Since the information input to the blockchain system is authenticated, the reliability of the information is significantly higher than the traditional. In addition, the extended supply chain traceability can be also achieved, for instance, each part of the instrument can be traced to the provenance.

Blockchain-enabled equipment leasing

With the increased complexity of the construction projects, there is a large demand of using heavy equipment to help deliver their jobs such as cranes, compressors, excavators, and loaders. Due to the high cost of these heavy equipment including maintenance and repairing cost, most of the construction contractors face financial constraints to purchase. Therefore, instead of making huge investments in buying them, leasing is a lucrative option for both large and small contractors to cut down their expenses on construction projects.
The conventional leasing process is time-consuming and inefficient, which includes lengthy negotiation cycles, insurance quoting procedures, burdensome financing applications, and reams of paper documents which need to be signed and maintained. Figure 3 illustrates an example of a crane leasing which is developed based on the IBM Blockchain Platform (IBM, 2016). For a new crane to be produced, the manufacturer needs to record the crane first in the blockchain system. To begin the process, a prospective construction contractor (i.e. leasee) chooses the crane they want to lease after checking and evaluation according to their requirement. The crane's identity is then registered on the leasing blockchain (i.e. the secure ledger database) to record transactions over broadly-distributed computer networks. After that the construction contractor will choose a lease option for the crane (i.e. short-term, long-term, or finance lease). This is all in turn updated on the Blockchain. They then choose their insurance options in a familiar way, and the Blockchain would again be updated. The customer then links their payment details to pay for the lease and insurance, and crane payments will be covered automatically, for example: operational training, maintenance and repair services. All of the above processes will take a mere matter of minutes. Together with sensing technologies, the operational status can be tracked and recorded in the blockchain such as abnormal breakdown events, daily lifting load and frequency, and electricity consumption.

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26. DISCUSSION

Blockchain technology is no doubt a disruptive innovation that has the potential to revolute current practice of construction engineering management. Compared with conventional methods of performing contract management, supply chain management and equipment leasing, the three proposed blockchain-enabled applications can significantly avoid disputes and litigations due to the immutable data record. Time and cost can be also reduced through process automation. However, there are still lots of challenges when implementing it into real construction projects. Three main types of challenges are discussed as follows.
(1) *Technical challenges: The blockchain technology is still in the early stages of development and faces a number of technical limitations such as throughput (a theoretical current maximum number is 7 transactions per second), latency (each block takes 10 min to process which means at least 10 min needed for your transaction to be confirmed), and size and bandwidth (long time needed to download the entire blockchain). Detailed information can be found in the Swan (2015).
(2) *Construction business-related challenges: Companies in construction sector have gotten accustomed to maintaining their business activities in their own ledger in the last many centuries. It is very hard to change this method to a permissioned distributed ledger. Moreover, most of the companies have incurred heavy investment on building their Enterprise Resource Planning (ERP) systems in the last few decades. The position of blockchain has a conflict with these internal ERP systems, which makes the transformation more difficult. Another significant challenge is the significant initial investment if a private blockchain solution is selected, which means companies involved in a construction project need to develop a full ecosystem to provide the entire value chain of service delivery. Due to the one-off characteristic of the construction projects, the reuse of existing private blockchain solution becomes difficult.
(3) *Human-related challenges: Blockchain is still an emerging technology to most construction people. Lack of awareness and understanding prevents the diffusion of this technology. There are many issues to be resolved before individuals would feel comfortable storing their personal records in a decentralised manner with a pointer and possibly access via the blockchain. In the current blockchain architecture, if a personal secret key is stolen, the implications could be staggering for an individual who would no longer have his identity at all due to the identity theft. The blockchain technology is still quite new to construction corporations. Many firms are still in an exploratory phase due to the numerous technical and regulatory uncertainties.

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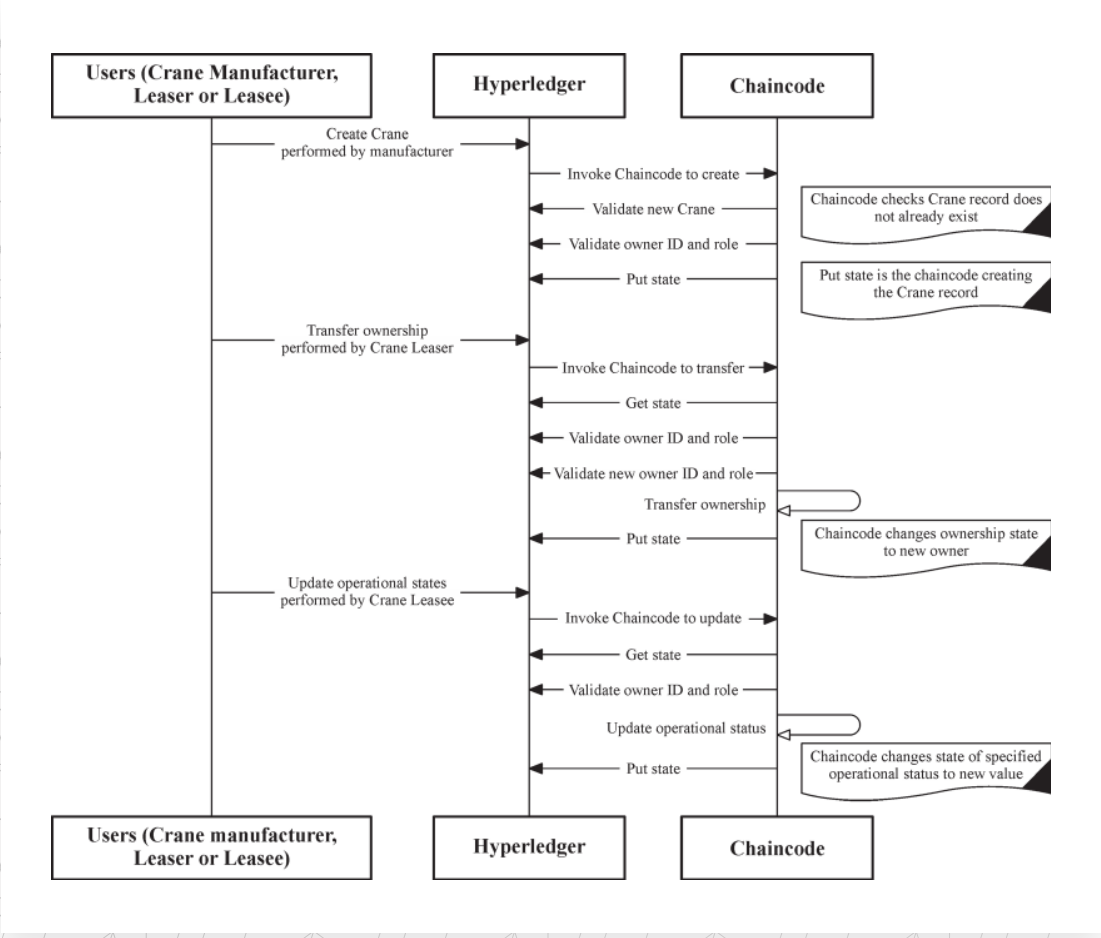
27. AN EXAMPLE OF A BLOCKCHAIN-ENABLED CRANE LEASING



28.

Construction corporations that want to assess the viability of the blockchain technology for specific applications, such as supply chain management, should consider a number of factors, such as anticipated time and cost reduction in goods delivery, current supply chain management costs, and blockchain deployment cost. The next step is to clearly identify risks and challenges. Only then should a corporation begin developing a detailed blockchain roadmap, determining user scenarios and creating an implementation schedule. In the meantime, construction corporations should consider which uses would benefit most in the near term, explore the technology closely, and engage with one another in test cases to create blockchain-enabled distributed ledgers (Accenture, 2015).

In terms of blockchain integration with other innovative technologies, such as Building Information Modelling (BIM), there are few pieces of evidence from both academia and industry sectors. BIM has been widely used in current construction industry to improve collaboration, data exchange, information flow, and project delivery (Chong et al., 2016; Shou et al., 2015; Wang et al., 2015a; Wang et al., 2015b; Wang et al., 2016). The blockchain technology can provide a useful tool for managing and recording changes to the BIM model throughout the design and construction phases by using smart contracts to negotiate editing privileges and storing an immutable public record of all modifications to the model (Lohry and Bodell, 2015). Moreover, blockchain combined with the database properties of a BIM model can provide a vital, visible and permanent chain of "evidence of trust" which in turn can lead to a new value proposition for the construction industry and the clients its serves (Mathews, 2017).

29. CONCLUSIONS

This paper has shown the potentials of how to apply the blockchain technology to improve current construction industry. Through the investigation of the technology itself and considering the challenges faced by construction corporations, three types of blockchain applications are discussed which are: Notarization-related applications to eliminate the verification time of construction documents' authenticity, Transaction-related applications to facilitate automated procurement and payment, and Provenance- related applications to improve transparency and traceability of construction supply chains. This paper also demonstrates three blockchain-enabled user scenarios including contract management, supply chain management, and equipment leasing.

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31. THE PROCESS

Quantum computing AI uses point clouds created by flying Drones and IOT LoRa beacons located within machines and building blocks (on site and in transit), uplinked by satellites to BIM cloud and fed into the Design Architecture, Building Software and Blockchain Financial System. Data points create Augmented Reality (and phase space) populating the Building Information Management Cloud for AI assisted human interaction through the AR/BIM/Phase Space environment. The human assisted by AI completes a desired design and the system makes a query to the Fintech financing application which sends its qualification parameters to the BIM enabled System to show allowable budget, costs and contracts and interacts with BIM to show project approvals and scheduling to the prospective building owner. This enables the human to adjust their decision making and adjust building design parameters to fit their own physical and economic requirements. Upon design completion the AR allows the human (wearing goggles or accessing a computer or smart device) to walk through the actual building site, or virtual representation of it, while seeing the virtual building features in real time and space. The final inspection and approval then allows the building scheduling to begin.
Upon acceptance by all parties, the component requirements are sent to the manufacturing network to adjust inventory.
Simultaneously the required building components are shipped to the building location from nearest existing inventory.
Earth Moving Machines and crew are dispatched to site to begin site preparations and interact with AR and BIM throughout the building process. The system creates the required scheduling and robotic cranes dispatch to building site to arrive with inventory. IOT and LoRa beacons provide real-time tracking data to the logistics portion of the BIM system.
Robotic cranes utilize Autopilot, Phase Space, Drone Mapping, Infrared sensors, Remote operator software, IOT and BIM to erect the buildings.
Upon completion of assembly building trades complete ancillaries and finishing of building and property. Final inspection for occupancy is issued and upon receipt the real estate agency receives property listing and 3D walk through or in the case of pre-sold buildings the occupants take possession.
This will be the first “Drag and Drop” building application and method in the construction industry, (“Drag and Drop” applying to both the virtual design and the physical site.)
IOT beacons within blocks create a smart network between building units and also a network between buildings.

The Future:
The greater the project demand fulfilled, the more efficiently the system operates, both from the perspective of technological and data processing capabilities but also by increasing economies of scale, streamlined manufacturing and transport logistics. Robotic systems and Blockchains continuing development and improved AI machine learning will also enhance system efficiencies. The more “exercise” this system gets, the more efficient it becomes both economically and through enhanced speed in both the digital and physical world. This is in direct opposition to the traditional construction method and AEC industry, where greater volumes more often result in reduced profit margins and decreasing efficiencies as the workload increases. Streamlining and integrating these new technologies are the goals of the coming autoconstruction industry.
Automation of the architectural design and costing , engineering, property financing and physical building construction processes is a new and largely untapped frontier. Robotics, mass production and blockchain technology will soon change the face of AEC, real estate development and financing, while in turn the 300 Trillion dollar AEC and Real Estate industries will impact the blockchain, robotics and manufacturing industries, creating increased demand for autoconstruction related technologies.

32. TEAM

Nikolaus G	Specialist Of Horizontal Geometries
Milos R	Chief Perfectionist and Climber
Marko G	Climber of Catalog Mountain
Christine R	Keeper Of Records and Chief of Excitement !
Ivan G	Assayer of Details
Bohdan R	Architect of Wonders
Muhamed	Master of Motion
Tracy M	Phase Space Robotics
Stuart Moir	Legal And Strategy
Don M.	Legal
Jean D	Trades Expert
AI	Techtronics Manipulations
Aleks	Engineer of Machinations
Savanna S	Admin
Nenad N	Chief Picturist (and AI)
Ishkan I	Hardware Philsophist
Sadham M	Configurations in Qatar
Mohammed	Oracle (of Tamil)
Tim W	First Light Automation
Rocky P	Fabrications Chief Dude
Tanks-A-Lot	Supplier of Fascine Layers
Web Security	Down with DDoS !
John H	Inspector of Inspectors
Manufacturers	Seriously too long to list (but we love you).
Ankur S	Warning- Graphic Content
Aleksandar G	Mechanical engineer
Aleksandar M	Mechanical engineer
Nenad S	Graphic designer, 3D animator
Ahamed I	Graphic designer
Faazil Imam M	Specialist in finance and accounting
Marco & Milos	Amazing Engineers (Embedded Planet)
Alex N	TRUE NORTH LABOUR
ALEX S	Founder at Bitcoin Embassy Georgia
HRANT P	Graphic & UI/UX designer
Govind J	Full stack developer
LOUISE L	JING SOURCING
SUNNY Q	Sales Manager: EJET SOLUTIONS LTD
Muhammad H	Chief Technical Officer
Nisar A	Database & Blockchain
Muhammad A	Blockchain dApps Dev
Abdul M	Sr. Blockchain Spec
Waqar K	Blockchain Specialist
Ali G	Android Blockchain specialist
Usama I	Backend Specialist (ICO expert)
Muhammad N	Blockchain developer (Node.js)
Muhammad U	Cryptocurrency Exchange Specialist
Usman R	Legal Editorial
Abul H	Python & JAVA Specialist
Farrukh S	Website Designer
Shiza A	QA tester
Embedded Planet.	Eyes and Ears
XYO	Brain for the Eyes and Ears
D-WAVE	Quantum Hopefuls :))
Stephan B	Cranes & heavy equipment monster!
Marcus	Bountyful Planner
Alex N	Chief Officer of Abundance
Ryan H	Ya man nobody forgot u...:)
International Advisory	Greatly Appreciated
Paul M	Un-Real Estates
Ute T	Administrator of Business
Remy R	Director of Planning
Jasson T.	Construction All-Trades
Chief Scient-istic Team.	X__REDACTED__
Sean G	Global Trade Specialist
Pham K	Engineer
Bohdan	Architect
Shubham	Architect
Olivera	Architect
Nick M	Engineer
Gopal P	Engineer
Andrei	CAD
Erwin	Architect
Sean	Sourcing: MG TRADING
Paul	Engineer: Cimtech
Stephan B	Cranes & heavy equipment monster!

AECROS = AUTO CONSTRUCTION

Hundreds of years experience in many fields. Too much actually.

Blockchain Coding, Creative Problem Solving, Designs, Legal and Banking Stuff, Robotics, Artificial Intelligence, Systems Architecture,Geometrical Mathematics and Specifications.

Ethics all around, and if WE can't do this? Noone can!! Mechanical Engineering, Civil Engineering Software architecture, Building Architecture, Building Inspections, Determination and Grit. Many more titles abound. As design freezes are achieved, engineering walls are overcome, and we approach the Golden BOM, we would like to thank all contributors, in every way, for their massive and fantastic efforts. Nobody here really needs a title.

We are all one, and we are changing the world.