The BIM fork – are smart contracts in construction more likely to prosper with or without BIM?

Abstract

This paper examines the question of whether smart contracts implementation in the construction industry necessarily needs to follow on from Building Information Modelling (BIM) in their development. BIM is the cornerstone of the United Kingdom Government's industrial strategy and yet the private sector are not adopting it in the predicted numbers required for a sea change in approach. Smart contracts represent a different yet potentially complimentary approach which may choose to follow the BIM path or forge a new direction using distributed ledger technology. The benefits and drawbacks of both scenarios are examined in the context of a case study before the underlying trends in digitisation are addressed in the debate as to which route is likely to emerge as the preferred option. The hypothesis postulated is that the current debate as framed will, in all likelihood, be swept away as greater inter-operability, granularity and ubiquity of data continue to emerge. The solutions offered by the blockchain will likely form its own framework for both.

Key words: Smart contracts, BIM, Intelligent contracts, Technology, Automated construction process, Construction Law.

Dr Jim Mason, Department of Architecture and Built Environment, University of the West of England, Coldharbour Road, Bristol, BS16 1QY. Jim.mason@uwe.ac.uk

Introduction

Construction contracts are intended to avoid the expense and problems of bespoke contracts (Furst and Ramsey 2016). To quote Professor Peter Hibberd:

"the whole essence of a standard form is to minimise the transaction costs of entering into a contract, by providing benchmark provisions which aid understanding, by allocating risk in a recognisable way and creating the benefits of precedent.(Hibberd 2004)*"*

The situation arrived at, a decade and a half later, is one out of three has been achieved. Benchmark provisions are provided. Alas, this does not aid a detailed understanding and the oft quoted advice endures to "leave the contract in the drawer until you need it and then hope for the best." Risk may be allocated in a recognisable way but this is uniformly amended for the benefit of the paying party. Precedent is only a benefit inasmuch as it brings clarity. More often than not, it arms lawyers with argument and opportunistic opportunities for wriggle room within contract interpretation.

Smart Contracts

Enter the smart contract – partially automated and beguiling simple. Transaction costs and times are reduced by digitisation, the end user need not trouble themselves with the internal workings and risk allocation comes as standard. This standardisation is a result of the economies of scale involved in smart contracts. The contracts are reduced to simple pay/install transactions and the terms become non-contentious in pursuit of this basic formula. Having agreed the base lines there is no need for bespoke amendments. This can be characterised as thousands of mini-contracts leading to an inch-stone progression towards completion. Each mini-contract is independent of the others and has clear functionality and execution. The extent of the automation may differ but even small steps towards this end offer huge benefits in time, cost and quality (Mason 2017).

The term smart contract was coined in 1994 by Nick Szabo, a cryptographer, who defined it as *'A computerised transaction protocol that executes the terms of a contract. The general objectives of Smart Contract design are to satisfy common contractual conditions (such as payment terms), minimise expectations and minimise the need for trusted intermediaries"*(Szabo 1994). Taken to its natural conclusion a smart contract can be defined as '*Contracts that are fully executable without human intervention,* (Morgan 2014)*'* or *'Self-enforcing, monitoring external inputs from trusted sources in order to settle according to the contracts stipulations.*(Peters and Panayi 2015).

The potential is there to automate the complexity and leave the users with a straightforward transaction based interaction, which is called here "earned value (Marshall 2007)." Party A pays Party B for the service and goods received based on the value generated to Party A. There is no need to refer the transaction to any other wider context or value calculation. This is a back to basics merely transactional approach suitable for common adoption insofar as the threshold for appreciating the functionality is much reduced and Hibberd's goal of understanding is met. The latter will always be found wanting where complexity clouds understanding and judgment.

Smart contracts do not necessarily require that people understand how they work. This idea that the complexity should be automated where possible is replicated in popular Apps such as Uber and Air BnB.(Fox 2018) Where everything is taken care of in the background, the participants are left to interact in the foreground in a mutually understood and convenient fashion. The passenger knows that the driver will receive a fair price and do not need to glance at the meter nervously as we sit in traffic. The host knows that the guests have been pre-vetted and have loyalty points and good reviews. The interaction is bound to be much more easily forthcoming and be pre-programmed to have trust and confidence in each other. This would render redundant the need for precedent as per Hibberd's goals. The focus of the paper now moves away from the promised but future land of smart contracts and considers the more immediate representation of technology in the construction sector –BIM.

BIM

Most clients will automatically favour the simpler option when given a choice. Construction clients are no different. Smart contracts offer this. Regrettably, Building Information Modelling (BIM) does not. BIM is a process for creating a managing information on a construction project across the project lifecycle (NBS 2016). The model becomes the digital description of every aspect of the built asset. BIM represents a major breakthrough in the construction sector, which is renowned for its Luddite tendencies. Construction regularly comes out at the bottom of industry comparisons as having stagnating productivity and being the least digitised (McKinsey 2018). However, BIM is complex for clients to understand and for their advisors to deliver. Three letter acronyms and initialisations proliferate and the number of people who understand firstly the contract and secondly the BIM procedures are limited to the experts. The BIM client is often unwilling to commit the time and cost needed to make the decisions required at the front end. The fanfare of BIM technology brought with it all the pomp and promise of a technology saviour that would transform the industry. BIM has struggled to make out its business case of generating savings for clients. The benefits are there, however, their intangibility and assurances that a longer term view must be taken can act as a dampener on adoption. Put simply, BIM has become mired in its own detail. However, pockets of good practice and full engagement with the BIM mission exist and should grow. The number of professionals skilled in the art of BIM adoption will no doubt soon outnumber those that properly understand the complexity of established building contracts.

This situation can be resolved once the birthing pangs have passed. The hard work and dedication of those pursuing BIM nirvana deserve praise. Neither should one fall into the trap of casting around for the next big idea before properly examining the potential of the current (Hibberd and Newman 1999). Nevertheless, the complexity of BIM is of concern given the limited attention span of funders, clients and their short-term focus on cost savings and predilection for risk dumping.

Notwithstanding the above, BIM continues to receive a good press in the construction industry and unwavering support by the UK Government (Department of Business 2013). The Farmer Report has BIM as a key deliverable of change within the construction industry. Some practices report that it is becoming business as usual (Waterhouse 2018). The same author records however that ownership of the Model has been an issue in dispute. BIM is reportedly making headway and the legal groundwork is being put into place to facilitate level 3 take up (Mosey 2016). However, it is worrying that, in 2018, BIM level 3 is described as "yet-to-be-defined" (NBS 2018). This has to be of concern to the BIM supporters if there is to be any chance of a smooth and sure progression through the BIM levels. These are (B1M 2018):

- Level 0 the use of computer aided design (CAD)
- Level 1 the use of CAD to generate non-federated 3D models
- Level 2 the use of BIM models with federation between different parties in the project team
- Level 3 the use of a wholly integrated project information model hosted and fully developed in a common data environment

Alongside the BIM levels are the dimensions if time, cost, energy and operations. These dimensions have the potential to add depth to the BIM coverage and would be important building blocks in the process towards smart contracts and automation.

The Contracts in Use survey 2018 (NBS 2018) collected data from 360 respondents in the United Kingdom. Seventy two percent were consultants; sixteen percent were contractors and twelve percent clients. Forty percent of the respondents claimed to have referred to BIM in their contracts in the past 12 months. However, continuing uncertainty about the status of BIM was apparent even amongst this sophisticated audience. In answer to the question "in my organisation we recognise BIM as contractually binding in the same way as specifications or drawings", only 57% said that they agreed

with the statement. This confusion is unhelpful to the cause of BIM adoption. What, though, is the alternative for smart contracts? The answer is blockchain/distributed ledger technology

Blockchain/Distributed Ledger

The inch-stone approach only works where there is sufficient data generated around the execution and completion of the smart contract and the transactions are recorded. This is where the internet of things and the blockchain comes in. This technology, described as the fourth industrial revolution (Kemp 2016), provides certainty marked by complete consensus, provenance, finality and immutability (Nakamoto 2008). A blockchain is a ledger, or a database of transactions recorded by a network of computers (Peters and Panayi 2015). Often referred to as distributed ledger technology, transactions are grouped in blocks and the chain forms the history of these transactions.

The Blockchain appears to be a much more stable and trusted platform which has gained the interest of the global corporations. The analogy here is of a driverless tube train that stops in the station at exactly the designated place. The doors open and the transactions either get on or get off. The doors close and the train moves onto the next station. This is the logic of the Blockchain. It is a huge string of data which can be added to. The cross verification of the process by multiple reference points prevents the abuse of the system.

Taken to the construction context, it is easy to see how the interim payment for component parts of a build could use blockchain technology. Each component is individually chipped and once big data sensors attest to its successful installation and function then the payment will be made at the next block chain station. Human intervention here is not strictly required. The simpler the construction or engineering component being undertaken the better in the first instance. Laying rails or achieving

electrification of a line could be relatively simply ascertained. More complex build items may present more of a challenge but not an insurmountable one.

One argument seen is that the binary nature of the blockchain exchange is inadequate for financial instruments and security payments. The funds can be released upon electronic execution of the bond or warranty documentation. The argument is that in more variable arrangements the computer will not be able to cope.

In September 2015 the World Economic Forum listed Bitcoin and the Blockchain as one of its Technology tipping points, expecting that 10% of the world's gross domestic product (GDP) will be stored on blockchain technology by 2027. Estimates for the first taxation will be collected by the government via a blockchain was given a 73.1% expectation of occurring by 2025.

The choice which emerges for smart contracts are whether to follow the BIM path or a pure blockchain route. There are merits and demerits to each approach. The most compelling argument on the BIM side is that is makes sense to use what we already have in the construction sector. Blockchain may well work in the financial industry but it is fanciful to assume its adoption in the construction sector. The counter-argument is that simplicity and role rationalisation is bound to be dominant in the near future and blockchain holds all the answers. These two approaches are now considered through the prism of a case study of what they might look like.

Case Study

The University of the West of England (UWE) is an early adopter of BIM technology and a firm believer in the benefits it can bring. Its recent multi-million pound developments have set regional benchmarks in the BIM approach thanks to the contributions and enthusiasm of the project participants. The Faculty of Business and Law opened in 2017 and was constructed with BIM and the learning was available to the students and region alike in the dissemination of results and the open access to the model itself. The Engineering Building (due to open in 2020) will take BIM on to the further advances

in terms of managing the built asset and returning some of the saving promised by BIM in the medium to long term. Plans are afoot for a complete digital campus featuring both existing and other new developments.

The Faculty of Environment and Technology offers a Masters course in BIM which has proved popular with students from around the globe. The course is not merely classroom based and features one module in particular, BIM in Business, where the students become BIM ambassadors and change managers by bringing BIM to local businesses. One such placement has recently generated a PhD opening to further explore the potential of this technology.

The focus on this case study is not one of the recent of current projects using BIM. Instead, the example selected features term maintenance of student accommodation. This example has been chosen because of several advantages offered and existing synergies with a smart contract approach.

Inch-stone nature

Each one of the maintenance tasks logged and actioned is, in effect, a mini-contract. Smart contracts backed by the blockchain or other distributed ledger is absolutely comfortable with the volume of contracts generated. The enormity of a data set has never over-faced Information Technology (IT) and represents one of the major benefits of a technological enhanced approach. Each transaction can be logged on the system and the transparency and validity relied upon.

Non-critical nature

Maintenance contracts are not time/cost critical or cumulative in the same way as a standard building contract. Whilst targets are set for closing off job requests there is no “bigger picture” and delay on a

single item will not have the same consequences as delaying a critical path item on a building programme. In short, it is less risky to attempt to use smart contracts in this context.

Simplicity of coding the smart contract

A popular misconception in the area of smart contracts are that they are too difficult to code. This is not the case. The Accord Project have created a language called Ergo which most computer programmers can pick up easily. The issue is not “can it be coded?” but whether the coded contract which is indistinguishable from a computer programme, can be embed satisfactorily in the mainframe of other systems whether they be tangible or intangible.

The other water cooler opinion is that contracts cannot cope with legal wriggle room words such as reasonable and satisfactory. The benefit of a maintenance contract task is that the contract will be simple and straightforward. The contract will come into being: “If X generates a work order then Y agrees to do it in return for the fee agreed.” The performance of the contract will be acknowledged, say, for instance by a student representative approved installation at the time of execution. The payment will be transferrered – the university pays the installer directly.

Shortcomings in Existing Payment Arrangements

It is at main contractor level that the nervousness around the future of building contracts is felt. They are often identified as the middle man who sits on the money of the third parties involved. The latter are often depicted as the hard done to and victims of extended payment terms in a market place where insolvency often stalks the weaker, less resilient members. There is truth in this picture but the main contractors should take comfort from knowing that the clients need them. The client’s core business is not the management of subcontractors and ensuring that the latter deliver on the promise.

Main contractors are best placed to manage the supply community and will retain their usefulness here. The whole essence of the project bank account was to remove the non-transparent element of the main contractor's profit whilst ring-fencing their ability to claim a decent price for a decent job. The short-term vision of the client focusing on the lowest tender price has been the root cause of the main contractors keeping this other income generating source from their view.

In the new smart contract arrangement the client can contract directly with the sub-contractors but will still need the intermediary of the main contractor to ensure performance. A system of cross-indemnities similar to the American mechanic's lien arrangement may operate here.

Shortcomings in Existing Inspection Arrangements

Maintenance contracts routinely feature elements of technology enabled solutions. Maintenance operatives regularly use their smart phones or ipads to take pictures of their work and upload them to the main contractor. Inspections follow in a small percentage of cases and the results of the inspections are extrapolated over the whole package of works. If a fault was found in the 5% of work examined then a similar percentage deduction on quality will be made across the board. This game of "catch me if you can" is no different to time-honoured customs checks where the officers might cut open one bag of grain to examine whether the cargo is as per the bill of lading. Something more scientific is possible as we approach the third decade of the 21st century. The client should be able to pay for exactly the service received at the point at which it is received.

How a smart contract approach could work with a BIM model

The student accommodation block could have a BIM model which is a real-time record of its construction and operation. The “moving parts” of the building, say for example, the heating and ventilation system and automatic doors, have their own sensors which feed information on their performance to the BIM dashboard. Such technology exists and is in current usage. A works request is either generated by a third party or by the model itself picking up on a low reading. The variable terms of the smart contract are automatically generated and automated execution follows. The contract is recorded on the ledger as is performance when the operative logs completion of the task. The payment (also logged on the ledger) follows directly to the installer within minutes of completion being logged. The BIM model is updated with the working part now no longer listed as work to be completed. The main contractor stood ready to source an alternative operative and to facilitate the performance of the task.

How a smart contract approach could work without a BIM model

This version of the case study involves the installation of Heating Ventilation and Air Conditioning (HVAC) equipment. This equipment is valuable enough to have sensors embedded within it. This allows the earned value approach to be the main driver in the execution. The malfunction or defect in the component equates to a reduction in the value of the unit. Less value if being derived, whether this is represented in student dis-satisfaction with the temperature in the bedrooms or against some performance target. The correction of the issue will re-instate the value of the asset and the smart contract execution and performance will be recorded as per the earlier example. The difference is that the approach is stigmergic rather than the hub and spoke approach. This is expressed in Figure One.

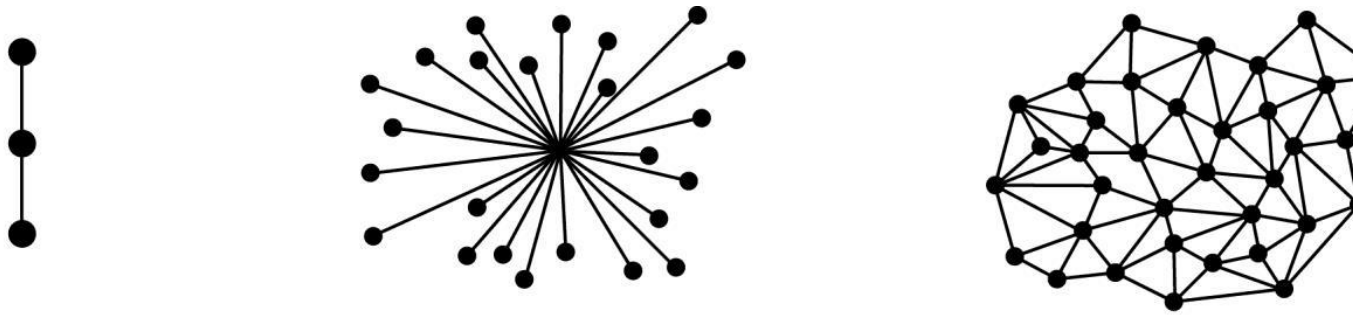

Figure One – Contractual relationships in the construction industry.

Discussion

The case for smart contracts to use BIM as part of their fulfilment is compelling. BIM provides the yardstick against which the smart contract can align. The execution and completion of each smart contract task can be referred to the model and actual compared to planned. The value extracted from each completed contract is therefore measurable and demonstrable. This inch-stone approach amounts to each mini-contract contributing towards the fulfilment of the project. The essence of the model is hub and spoke. Smart contracts could be viewed as the logical extension of the BIM levels. At this level, the BIM model is not simply the digital description of every aspect of the built asset but also of its execution and performance. The question is therefore – will smart contracts follow this route to BIM fulfilment?

The alternative is for smart contracts to avoid BIM and to progress on the purely transactional earned value route. Here the completion of each task is an end in itself, whether or not it is referred to the wider completion of the BIM model. The analogy is to termites completing their pre-destined task. Each termite knows not what the others do and yet the mound is built. The mound is built on the inch-

294 stone, as opposed to mile-stone, principle using a distributed or stigmeric approach (Mcnamara 2017).
295 The different approaches are shown in Figure One.
296
297 The benefit of the hub and spoke model of BIM is that there is a control centre. Actual overlays
298 planned and the dashboard of completion demonstrates progress against pre-decided metrics. A
299 project manager retains control and payment is released against earned value. The providers of
300 standard form contracts in the United Kingdom stand at a crossroads of accepting this type of multi-
301 party contracts as the way forward (Ho 2016) For the most part, construction contracts remain
302 resolutely linear with the accompanying poor practices in terms of payment abuse and unfair risk
303 allocation.
304
305 The hub becomes redundant when the data takes over. A stigmeric approach is infinitely preferable
306 from a management point of view given that it facilitates delegation. This is not to say that abdication
307 of all responsibility is desirable or possible.
308
309 It is open to conjecture as to quite how soon the construction industry will reach sufficient maturity
310 to embed a data led inch-stone approach. The availability of powerful handheld computers in
311 everyone's pocket in the form of smart phones is an obvious starting point. These terminals permit
312 the upload in real time to a programme which continuously overwrites planned with actual to
313 demonstrate value. The embedding of censors in devices is already in wide usage and is set to pass
314 25 billion by 2020 (Gartner 2018). Whether this means censors in every brick space or capping stone
315 remains to be seen. Already heating and ventilation units have multiple sensors recording
316 performance and maintenance issues. The earned value model offers a different sort of control and
317 overview, which will be automated to a degree previously unseen. The project manager can observe
318 the termites without needing to run the diagnostics checks on performance and completion in the
319 same way.

A popular view is that the construction industry requires a disruptive influence in order to force it down the route of digitisation and engagement with the cutting edge of technologies in other sectors (Threlfall 2014) . This is not necessarily the case given the platform offered by BIM. Smart contracts are a complimentary technology and ought to explore both paths presented by the fork in the road. Smart contracts might be what BIM needs to succeed. Equally, smart contracts can be at the forefront of the disruptive intervention apparently required.

Conclusion

The instigators of BIM cannot have foreseen an alternative route to automate and digitise the industry as is now available through distributed ledger technology. The smart contract movement is a newer, fresher concept, which can decide whether to support existing technologies or write its own narrative. It will doubtless soon be superceded as the celebrated cause of the day. The benefit of compatibility, both with antecedent and later technologies is a hallmark of permanence and resilience. This could serve smart contracts well in the construction sector.

Future gazing is an imprecise and difficult art. This author has sought to draw together some strands in an effort to predict future development. Whether or not such fashionable debates prove entirely academic (Stringer 1994) remains to be seen. The challenge remains for policy makers and lawyers to recognise the demand for a new contractual response and to deliver this in the most expeditious and efficient manner possible.

References

B1M, *BIM for Beginners,* B1M (2018), https://www.theb1m.com/BIM-For-Beginners

Department for Business, Innovation & Skills, *Construction 2025: Strategy,* GOV.UK (2013), https://www.gov.uk/government/publications/construction-2025-strategy

Fox Sarah, *If Banking can do it, why not construction?* NBS (2018), https://www.thenbs.com/knowledge/national-construction-contracts-and-law-report-2018.

Furst Steven & Ramsey Ramsey, *Keating on Building Contracts,* (10th Edition, Sweet & Maxwell, 2016).

Gartner, *Gartner Identifies the Top 10 Strategic Technology Trends for 2018* GARTNER (2018), https://www.gartner.com/en/newsroom/press-releases/2017-10-04-gartner-identifies-the-top-10-strategic-technology-trends-for-2018

Hibberd Peter, *The Place of Standard Forms of Building Contract in the 21st Century,* Society of Construction Law Paper 120 (2004).

Hibberd Peter & Newman Paul, *ADR and Adjudication in Construction Disputes* (Blackwell Publishing, 1999).

Ho Francis, *Interview with Richard Saxon,* BUILDING (2016), http://www.building.co.uk/interview-richard-saxon/5083020.article.

Kemp Richard,(2016) *The Fourth Industrial Revolutions: Blockchain and Smart Contracts'* THE LAWYER (2016). https://www.thelawyer.com/issues/6-june-2016/the-fourth-industrial-revolution-blockchain-andsmart-contracts

Mckinsey Global Institute, *Rapid Advances in Automation Mean a lot of Workers Won't Have the Right Skills* RECODE (2018), https://www.recode.net/2018/5/23/17382198/mckinseys-report-predicts-workplace-skills-people-economy-needs-workforce-automation-ai-jobs-lost

Mcnamara Alan, *Is the First Step to Implementing Intelligent Contracts in the Construction Industry Through BIM integration?* MSc International Construction Law Dissertation University of the West of England (2017).

Marshall Robert. *The Contribution of Earned Value Management to Project Success of Contracted Efforts*. Journal of Contract Management, 2007, pp. 21-331.

Mason Jim, *Intelligent Contracts and the Construction Industry*. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 9 (3) (2017).

Morgan Pamela, *Bitcoin South: Innovating Legal Systems through Blockchain Technology,* BRAVE NEW COIN (2014), http://bravenewcoin.com/news/pamela-morgan-at-bitcoin-south-innovating-legalsystems-through-blockchain-technology/

Mosey David, (2016) *Enabling Building Information Modelling through Procurement and Contracts,* Society of Construction Law Papers, www.scl.org.uk

NBS, *National Construction Contracts and Law Report 2018* NBS, (2018), https://www.thenbs.com/knowledge/national-construction-contracts-and-law-report-2018

NBS *What is Building Information Modelling?* NBS (2016), https://www.thenbs.com/knowledge/what-is-building-information-modelling-bim

Nakamoto Satoshi, *Bitcoin: A Peer-to-Peer Electronic Cash System*, BITCOIN (2008), https://bitcoin.org/bitcoin.pdf.

Peters Gareth & Panayi Efstathios, *Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money,* ARXIV (2015), https://arxiv.org/abs/1511.05740

Szabo Nick, *Smart Contracts,* SMART CONTRACTS (1994), https://szabo.best.vwh.net/smart.contracts.html

Stringer George, *The Future Role of Standard Forms of Contract* in *Proceedings of the Fifth Annual Conference,* Centre of Construction Law (1994)

Threlfall Richard, *Construction's Next Revolution* BUILDING (2014) https://www.building.co.uk/contractors/constructions-next-revolution/5068779.article

Waterhouse Richard, *Introduction to the National Construction Contracts and Law Survey* NBS (2018), https://www.thenbs.com/knowledge/national-construction-contracts-and-law-report-2018