Title: Barriers and cost model of implementing Unmanned Aerial System (UAS) services in a decentralised system: Case of the Dominican Republic

Journal: Construction Innovation

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Year: 2022 Volume: - Issue: - Page: -

Purpose – The aim of this paper is to identify the business barriers that influence cost of implementing UAS and its suitability for a decentralised system. Unmanned Aerial System (UAS), or drone, plays a role of data provider to AEC professionals within a decentralised system. However, exist disappointments in the execution and test of the effectiveness of the UAS. The reasons for these fails are not well elaborated in the literature. Hence, the study investigates the barriers and cost analysis of UAS that can be used for a decentralised case in which the UAS data is useful for multiple stakeholders and provide illustration of the interactions within this approach.

Design/methodology/approach – This paper is part of a longitudinal project by utilising a qualitative method of interviewing 24 participants involved in the process of application of drones in the country of the Dominican Republic. The open-ended semi-structured interviews were composed for questions regarding the application of UAS, barriers, and business implications. The data gathered were transcribed and used thematic analysis for its interpretation. Later, conclusions of the barriers of UAS implementation in the organisation were analysed and a cost model was developed to identify a viable scenario.

Findings – The paper provides empirical insights about the barriers and economic considerations faced in the implementation process of UAS. In this research were identified: 16 barriers in the implementation process at the management level, 8 types of cases of business relationships, and 13 business models. Furthermore, recommendations in being accountable for the dimensions and recurrent visits to the projects handled by the portfolio of the organisations were made, to prudently invest in this project management tool for construction.

Practical implications – The paper includes barriers to consider before implementation, business implications, project examples and cost structure developed. Furthermore, the findings are fit theoretically into the context of a decentralised system. It was understood and contemplated that monitoring in open and outdoor spaces are the suitable approach for UAS implementations for decentralised system. The trend of decentralised autonomous organisations for transparency and efficiency of human tasks provides the foundations of human-robot interactions as well as the role of tokenisation of assets into the cyberspace. Therefore, the paper brings managers and technicians the implications for the future-proofing implementation of UAS.

Research Limitations – Blockchain system is supported by UAS data and its tests require skills and resources that were outside of the scope of the main research intend regarding UAS implementation in construction. Word counts limited details in a certain degree. Furthermore, as these technologies are still under development, the assessment of the decentralised system, smart contract, and swarm technology was addressed conceptually and further research are encouraged in this field.

Originality/value – This paper provides an overview of the implications of cost and the suitable scenarios for return of investment in the UAS implementation in the current stage of the technology development. In addition, the paper makes reference to decentralised systems, smart contracts and swarm technology as options in which reality capture technologies are essential for construction projects.

Keywords: Transaction Cost, Barriers, Decentralised System, Business Models, UAS

Article Type: Case of Study

1. Introduction

The cost of workers against technologies has been considered as a barrier towards the advancement in the construction industry. The costs involved in the implementation of new tools are mostly compared against the costs of unqualified labours to assess their job. But unfortunately, in these cases, the contractors or organisations do not understand the cost-benefit analysis embedded in applying technologies as it is only observed the initial cost of investment instead of the long-term use. With the implementation of Building Information Modelling (BIM) (Durdyev, Ashour, Connelly, & Mahdiyar, 2021), Smart Contracts (Hamledari & Fischer, 2021) and Unmanned Aerial Systems (UAS) (Golizadeh, et al., 2019) have been described the patterns related to workflows
changes in the adequation of IT infrastructures and types of data reports (Hwang, Ngo, & Teo, 2022). The organisations that have integrated these patterns and are willing to introduce other technologies such as artificial intelligence and cloud base workstations, are opened to: (i) innovation, (ii) digital workflows, (iii) methodologies involved with lean construction, and (iv) automation processes with robotics. For example, the application of UAS in lean construction is focused on visualisation of the project and how in monthly meetings, workers can engage and align with the strategic vision easier through visual representations (McNamara & Sepasgozar, 2021). What do these organisations observe in contrast to the other ones? It is the productivity gained in a long-term basis perceived as an automation and standardisation of the value chain of the construction projects as the methodologies used from the manufacturing industry.

Investing in parametric information for BIM, setting up smart contracts with blockchain, and adding capture realities technologies promote strategies of risk mitigation for spiritual entities with prefabrications and assembling of buildings and infrastructures; reduction of inconsistencies between built and design; and the certainty that financial wellbeing of contractors is out of reach from disputes (Hamledari & Fischer, 2021). However, the ideal context of this type of decentralised approach has many barriers that should be explored in particular from each part of the technology’s perspectives. Therefore, the aim of this paper is to identify the business barriers that influence cost of a UAS implementation suitable for a decentralised system.

2. Conceptual Decentralised Autonomous System Approach for Construction Projects

Each emerging technologies play a specific role within the project life cycle. These technologies manifested within physical and cyberspace have participated in the project life cycle from conception to demolition obtaining efficiency in the early stages of the project, in contrast to remake or invest in unnecessary costly arrangements in the construction and completion stages later. Furthermore, the advancement in applying technologies influences the long-term financial status of the organisation by the elicitation of ideas that previously did not have the structure to perform. The elicitation of an automated, digital, and physical construction for project managers combined with emerging technologies, as in Figure 1 seems to be a path for transparency, security, and efficiency in projects (Tezel, Papadonikolaki, Yitmen, & Bolpagni, 2021). When the autonomous systems that monitor the project are able to identify and assess the progress utilising a strong unsupervised machine learning of the point clouds for accurate generative models and object identifications, the conceptual approach of decentralised system of smart contract would be started to wonder about ownership of these tools and data shareability within the system (Xiong, et al., 2022). However, despite the investigations made towards smart contracts with blockchain, BIM, cloud computing and artificial intelligence, the literature is lacking of explanations on whether or not investing in hyper-automation of payment systems in construction could deal with: the scalability project to project, cryptocurrencies fluctuations and value, the human interactions within the system and when/where specific tools may be useful for saving costs (Hunhevicz, Motie, & Hall, 2022).

![Figure 1](image1.png)

**Figure 1.** The decentralised system with the emerging technologies adoption.

The Figure describes the multiple stakeholders participating in a construction project. The interaction between stakeholders is observed with the lines and emerging technology symbols.

Utilising Figure 1 to describe a context that represents an app or a decentralised autonomous organisation (DAO) that exemplifies stakeholder interactions allows to fulfil the gap in how the business implications of each emerging technologies could seem. Writing under a blockchain system and managing them in a cloud environment, the contract clauses and the details of the sentences accomplished (a point cloud of X or the amount of tags recognised by drones), located in time and space the functions of emerging technologies. But, depending on who, what or how the data and transactions are input and output, the interactions between physical and cyber entities could be disrupted by several inevitable risks. Hence, the system may require interventions of external stakeholders in cases of risks of disputes, alterations of designs from the client-side, global economic inflations, and renegotiation of the contracts by unforeseen situations such as pandemics or solar storms. Nevertheless, strategies of BIM, Lean Construction, Agile, and others should govern the design of the smart contract system to avoid disruption from a management perspective by fomenting collaborative mindsets and regime of the spirit of trust. However, the elicitation of adopting the fundamental structure of emerging technologies in construction is a challenging task from different positions due to the unique contexts in which the technologies are matured enough for successful applications. In terms of limitations on its application, in general, regulators are pursuing best practices and cases of the adoption of these technologies to comprehend the range of course of actions that may be faced (Xu, Chong, & Chi, 2021). However, proactively, doing research is a path to provide an understanding of the complexities involved in acting upon technologies and resilience driven societies. As mentioned before, blockchain, smart contracts, cryptocurrencies, cloud computing and others play a role in feeding and assisting project management tasks. In addition, the richness of data capturing tools relies on when/where/which is applicable for specific types of projects. In the case of UAS, they are extremely useful for large and tall projects such as bridges, buildings, and cities design in which rapid surveys, progress reports, and generation of blueprints are required but challenges and suitable business models are difficult to assess. Furthermore, how would be assessed UAS services in a decentralised system? What might be the suitable business model for construction projects?
3. Unmanned Aerial Systems

Unmanned Aerial Systems (UAS), or drones, are devices with multiple sensors capable of being piloted autonomously, manually, or semi-autonomously to achieve vision beyond the capabilities of humans. The knowledge of operating the UAS relies on spiritual or artificial cognition according to the technical capabilities in place (span of battery life, gravitational power, levitation span, and cloud computing). In construction projects, the current UAS in the market normally hover and operate manually to take images and photographs of projects and, in some organisations where the connection with digital strategies is known, it immediately becomes a specialised and versatile instrument for surveying. 3D reconstructions of the physical geometries of infrastructures and buildings, inspections and documenting evidences for contractual processes (Zhou, Irizarry, & Lu, 2018; Ham, Han, Lin, & Golparvar-Fard, 2016). These virtues refer to the potential of transforming operational processes in construction in all phases of the project as well as in the internal workflows of the organisation as a tool for feeding the cyberspace (Gomes, Lopez-Vega, & Facin, 2021).

4. Application of UAS in the Construction Industry

The majority of the elements of the cities such as bridges, roads, tunnels, aqueducts, buildings and more, have been conceived, built, and monitored without digital strategies. Public and private entities have decided to change the approach of designing, building, and maintaining these assets by adopting digital workflows for reducing risks and costs in routine works. For example: Buildings projects use the UAS for safety inspections around skyscrapers, monitoring progress, reconstructing the sites, visualising, surveying, documenting progress reports, and other solutions. Infrastructure projects commonly receive the visit of a UAS for their inspections in facility management by identifying cracks with pictures, reconstructing the geometry for refurbishment, and quantifying the damages after a disaster. On a larger scale of infrastructures and buildings, in other words, cities, the UAS applications are commonly for monitoring the city growth, traffic flow, disaster risk reduction, quantification of risks and waste management. Table 1 is identified the projects and tasks that the UAS is utilised normally. In terms of business cases, skyscrapers show feasibility in the application of UAS by their dimensions. In infrastructure projects the most notable case is related to bridge inspections. The task of bridge inspection is costly, risky, and specialised that investigations with the UAS allow researchers to understand the principles of UAS photogrammetry as well as national technical manual upgrades (Morgenthal, et al., 2019). In cities, rural and small towns without large buildings but with prominent walkable distances present viability of the UAS applications. The cities involved in natural risk have influenced the application of UAS. Furthermore, the tasks related to cities are still under development by the regulatory boundaries on operating in congested areas that affect safety and privacy issues.

Table 1. Literature related to UAS and construction projects

Each of these cases present examples of workflows supporting the ability to carry out tasks efficiently. The UAS tasks are also mixed with other emerging technologies such as artificial intelligence for point cloud classifications as well as other systems such as robot dogs. Inside of a decentralised system as in Figure 1, the role of UAS is to reduce cost, risk, produce records of the projects by reconstructing it into the cyberspace the geometry and descriptions for visualisation and interaction with stakeholders in virtual reality in the blockchain system. Various stakeholders are required for their work the UAS data and integrate them into the system. In addition, some photogrammetry techniques, sensors and payloads are essential for specific tasks that between them, one UAS can be more useful than another. Therefore, to feed the system with geometry and energy levels that can align with the BIM model, an independent interaction of outsourcing organisations of UAS could produce these tasks. Furthermore, data preservation and ownership are topics that arise concerns and business cases (Vanderhorst H. R., Suresh, Renukappa, & Heesom, 2021). The discussion of converting data or models into non-fungible tokens may tend, to data holders, to consider different methods of monetising digital assets. Furthermore, within the system, the barrier of interoperability, that appears in the process of delivering the data, should be addressed by optimising the operations in regards the stakeholder in hold or position. Therefore, the integration of the BIM will serve as an intersection point for the stakeholders in the system. Moreover, there is other software that is integrated into the system such as Geographic Information System (GIS) that could support the monitoring of feeding and transactions where critical positions in the physical project located.

4.2 Details of the UAS Workflow within a Decentralised System

BIM and GIS are cyber tools for the analysis of the construction projects. GIS is used for land and population studies, while BIM provides the parametric informations of the designs that can simulate the construction, operation, and maintenance process of infrastructures and buildings. However, the gap between digital designs and physical as-built plans is still a problem within the field of construction. A few approaches have been used to close that gap (Hamledari & Fischer, 2021) propose a workflow of feeding the BIM model with recurrent 3D reconstruction of the site using a Web3 interface for the visualisation of the process and program the cash flow interactions with the Ethereum system inside the smart contract clauses. However, decentralising the different stages of payment leads to new customer relationships and may not be favourable in some cases. Malfunctions,
quality issues, and the approach of reconstructing the site influence the scope of the work, and the amount of transactions within the smart contract. Furthermore, a proof of concept designed by (Hunchevitz, Motie, & Hall, 2022), focused on digital twin interactions discussing the challenges of legal issues, resistance to migrate the technical systems, maintenance of the digital twin, and the development of new business relations. Another study by (Xiong, et al., 2022) evaluated the blockchain system with smart camera nodes. A UAS and normal cameras were used for feeding the system with data related to the recognition of safety elements in workers. However, the system requires improvement in the tasks of surveillance. The internet of things in multiple devices is the foundation of the decentralised system approach. But the limitations of costs for data capturing, identification of tasks for suitable decentralisation, and accurate site reconstruction influence the decision in investing in technologies, for this case UAS as a data capturing tool.

5. Barriers and Business Implications of the UAS implementation

(Golizadeh, et al., 2019) developed a framework in which the barriers observed and managed are described in general sense for construction projects. Furthermore, the barriers enlisted in the framework related to organisations are: the acquisition, setup, operating, maintenance cost, management, and owner support. They are typical concerns in managerial positions inside of the adoption of technologies in construction industries (Moshood, Nawanir, Sorooshian, Mahmud, & Adeleke, 2020; Arabshahi, et al., 2021). But, these studies do not elaborate in details of the barriers in business terms for construction and UAS. The lack of literature could be inferred by the complexity in matching UAS, price, training, and effectiveness of the tasks. It is an exhausting exercise that provokes asseverations of outsourcing and, latter, integrating the UAS service, as appreciated in the social-technical framework by (Vanderhorst H. R., Suresh, Renukappa, & Heesom, 2021). Despite the effectiveness of the UAS of almost 70% of the time in the data collection tasks contrasting the traditional method of walking and developing the topographic surface (Vanderhorst H. R., Heesom, Suresh, Renukappa, & Burnham, 2020), the resistance of taking the route of integrating a digital workflow could be based on cost-benefit analysis. The initial investment of UAS can vary according to the land space and details required in the organisation. In 2016 (Irizarry & Costa, 2016) estimated the associated costs of UAS on construction sites, but additional costs of regulatory compliment and wages for the spiritual pilot were unavailable to determine at that moment. Nowadays, commercial manufacturers of UAS were tabulated in Table 2 providing an update of the estimated prices with the regulatory boundaries in force for 2021 in Europe. Additionally, the boundaries and subsequent details of the items to take into consideration similar to (Duque, Seo, & Wacker, 2018) as in Table 3 were plotted.

<table>
<thead>
<tr>
<th>Table 2. UAS Prices, Weight, and technical details</th>
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<tr>
<td>Table 3. Estimation of UAS initial Investment for construction organisation</td>
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<tr>
<td>The costs presented are intended to be a guide to explain the statement that the UAS is a specialised service that it is cost-effective for organisations willing to adopt it. Furthermore, there are cases in which open-source software are available for reducing the initial cost of investment. Each model of UAS may not present significant different for photography works in terms of price of initial investment, with a lower prices UAS is address similar tasks as the expensive ones. The item that presents weight in the initial investment is the cost focalised in the UAS and software to convert the data into useful output for the organisation. Nevertheless, issues with interoperability could be encountered in the implementation as well as processing power. In terms of business, the business models to exploit the initial investment have the alternative of delivering knowledge to other organisations on how to improve their workflows or address seldom tasks as shown by (Vanderhorst, Heesom, Suresh, Renukappa, &amp; Burnham, 2020; Opfer &amp; Shields, 2014). Finally, few studies of this nature have been carried out to provide insight and knowledge of the number of projects required to obtain benefits from the UAS, understanding that the training requirements to qualify the personnel and the process of change management towards new digital workflows should align with BIM. Furthermore, as other technologies emerge such as blockchain, the lack of literature in cost analysis and barriers makes challenging the adjustment of UAS in the decentralised systems and the suitable tasks for it. Therefore, an exploration of the barriers and implications is required. Consequently, the following is developed to explain the barriers and cost implications UAS.</td>
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5. Research Methodology

As a part of a longitudinal study in the developing country of the Dominican Republic, different aspects were taken into consideration. The first study did not provide sufficient details of the UAS operation for a generalisation of the case. Therefore, a second study was executed to expand the scope. In other words, after refining an exploratory case of study with 2 interviews and 24 surveys and adding 2 more interviews and 6 surveys (total of 4 interviews and 30 surveys); a 24 semi-structure interviews were carried out. This paper is reported the qualitative approach of the investigation as this approach provides detailed explanation of the barriers and business implications. As the richness of the UAS implementation is merely describing the context in which it is applied, the semi-structured questions were designed to extract knowledge of cases, barriers and business implications.
The participants had between 0-20+ years of experience in piloting, regulating, and managing projects. For that reason, the questions were redated as below for guidance and further clarifications were sought:

- What are the applications of UAS in the Dominican Republic?
- What are the key barriers faced implementing drones in the Dominican Republic?
- What is the current entrepreneurial environment of drones business services in the Dominican Republic Construction Industry?

Later, the iPhone 8 recordings during the face-to-face interviews were transcribed and analysed in Nvivo2020. In the data analysis, the data was arranged in cases and each of the participants reported their recurrent barriers of implementation. Therefore, the identification of the thematic codes related to social barriers and business implications were assessed to produce comprehensive business models for the implementation of UAS digital workflows that may be suitable for a decentralised context in infrastructure, buildings and cities. Furthermore, the concept of smart cities underlies and promotes transparency and safety in cities (Tezel, Papadonikolaki, Yitmen, & Bolpagni, 2021; Vanderhorst H. D., Suresh, Renukappa, & Heesom, 2021). The contexts and prices were tabulated and analysed to understand the variables that provide the business unit of UAS services. Then, the variables were organised and segmented between exogenous and endogenous. After this approach, the path analysis was carried out for modelling the business interactions in a graphically.

Table 4. Research Methodology map

5. Results

5.1 Cases of UAS implementation in Construction Industry of the Dominican Republic

During the phase of themes identification, similar ideas were clustered. The projects and cases were collocated to establish differences between the studies and understand the similarities between them. As presented in Tables 5 and 6 the PhD research contains comparable projects and cases rather than the master. The digital workflow embedded in the implementation has significantly enhanced the productivity rates of workers despite the IT provisions required before the integration. The workflows own different data management approaches, but the production of the process remains the same for all the tasks in implementing the UAS. Changes in techniques of UAS photogrammetry for BIM, project specifications for reconstruction of GIS and formats were prominent during the transition. Furthermore, in terms of decentralisation of tasks, after reviewing the cases and task presented, it is understood and contemplated that monitoring in open and outdoor spaces are the suitable approach for UAS implementations. Analysing the consideration of UAS implementation in the conceptual decentralised case, it seems to be an aspect to approach in the construction industry as automation of the process is pursued by contractors. However, focusing on a managerial perspective, there are various barriers to overcome to understand the business implications of UAS within the decentralised system. Therefore, the general barriers of the UAS implementation were discussed with the participants in the following section.

Table 5. Example of the Cases of the Studies related to Master’s Dissertation

Table 6. Example of the Cases of the Studies related to PhD’s Thesis

5.2 Organisational Barriers of UAS implementation in construction

The barriers were arranged in the themes of policy, technical-policies, organisations, and people performance describing their meaning and understanding (Table 7).

Table 7. Thematic organisational Barriers of UAS in the Dominican Republic

The comments that the participants made regarding cost were comparing the high price of the UAS contrasting to free satellite and imaging services. However, the lack of knowledge in terms of cost-benefit analysis make it difficult the comprehension of the UAS implementations within organisations. In the same line of thought, the resistance to change into digital strategies represented a significant barrier to the implementation process. Some managers affirmed that the integration of new technologies could be a waste of resources because there is not skilled worker for this new department of digital data collection and workflows.
In terms of regulations, some barriers related to technology understanding and airspace regulation were commented. It was expressed that regulations in the price of acquisition and innovation incentives could seem as a positive reinforcement for fomenting digital workflows in the Dominican Republic. Nevertheless, the lack of knowledge from academia and the lack of incentives in innovation for implementing technologies were barriers for the technologies spreading it, generally. As a recommendation, the development and publication of the best practices would enhance the industry growth. However, as the data was presenting patterns related to information communication technologies adoption as mentioned by (Moshood, Nawanir, Sorooshian, Mahmud, & Adeleke, 2020; Arabshahi, et al., 2021), the cost significantly influenced the decision of implementing a UAS. Therefore, the following section describes the perspective of business interaction.

5.2 Business Models of UAS implementation in construction

The business models have different scenarios that include or not transactions. The business models involved in the UAS industry are based on the RBG sensor and software. The business model starts with the acquisition of the UAS in or outside of the organisation. Normally, a fearless employee/CEO acquires the UAS for hobby purposes, then, after several flights, the person gets confident to explore the professionalism of the UAS operations. Images and videos of the surroundings are the first tasks in exploration. Later, the application of the UAS is pursuit with or without payment as a part of the learning curve inside the organisation. Software for photogrammetry and reconstruction are used and tested. At the moment that the team is aware of the productivity increment of the UAS (a 2 weeks work converted into 1-3 days work), negotiations begin between pilots and the organisation. Different cases were identified as in table 8.

Table 8. Business Cases and payments

Furthermore, the reasons for transactions can be different according to the level of knowledge, who absorb the risk of the UAS, and workflows that is supported. The first transactions start with the UAS and its selection in which research and consultants are normally required. The topics related to the number of batteries, remote controllers, radio frequencies, cables, reparations, and warranties are involved in UAS acquisition. In addition, as the taxation of the UAS is most of the 50% of the UAS value the price should be taken into consideration in the cost-analysis.

The next step is regarding skills development. The key activity, here, is to develop the fingers agility to perform shoots, videos, and photogrammetry patterns for the tasks desired. Easily, these tasks can be merged with unsupervised machine learning that captures the perspective of the construction project. Experienced pilots in photography, filmmakers and photogrammetry technique for buildings, power stations, towers, and complex geometry can supply this knowledge skills in the 3D reconstruction. Moreover, other reasons for transactions are the knowledge of how to comply with the national regulation, operational insurance, and training. Normally, medium companies require to fulfil risk analysis of operations outside their main offices driving them to evaluate legal implications of their activities. This duty is carried out by the contractor to provide legal support for the operations.

After the pilot complies with the training and regulatory forms, the data collection process with UAS is divided into different stages for business model purposes. The acquisition of images, software licensing and transformation of data into an effective outcome are the stages suitable for business models. For data acquisition, the UAS pilots support each other in the community providing sub-services based on the location, emergencies with the UAS and expertise requirements. For the software licensing and processing the following table map their model.

Table 9. Business Models

Some comments related to identify a reasonable price for specialised services with UAS services prices were mentioned. Some public organisations with UAS implemented share their personnel and equipment to another organisation without cost. But the lack of experience and adequate UAS for specific tasks moved the public organisations to the practice bids without a cost of reference. The solution of arranging bids was used to understand the range of prices between UAS organisations and operators. However, different ranges of prices without an accurate frame of reference make arduous selections. Standardisation of prices or guidance of minimum wage expanded the idea. Prices between £200-£500 were inferred as fair enough for qualified professionals, operations with DJI models and up to 1 hour of image capturing.
Furthermore, the reconstruction services or full surveying process is around £750 with 1 battery and open space projects were mentioned. But normally, survey works are compared against traditional survey to adjust a fair price in terms of purpose (legal or design). For legal purposes, UAS surveys are still not accepted for direct submissions. Some additional checks should be carried out in previous litigation entitlement submissions. For design purposes, any degree of accuracy limits the outcomes of the UAS.

6. Discussion

The progress of the longitudinal study provides a vision of how the next trend of UAS will be interacting with humans (Figure 2). The tasks of monitoring with UAS seems to be useful for decentralised approach. But, when the tasks require a complex reconstruction, images, and videos of the construction site, a combination of technologies should be explored. For stakeholders into the decentralised system, autonomous single or swarm of UAS could be a solution from the perspective of a contractor. The data entry for the system may be used for monitoring purposes at managerial level for payments and legal obligations. However, as the smart contracts may not depend on other data capturing technologies as a consequence of the barriers in their implementation, a deeper perspective of them were assessed. The four aspects of the business barriers identified (policy, technical-policy, organisational and people) provided an overview of the UAS implications. The policy and technical-policies limit the UAS implementations in terms of risks, number of UAS and permissions for commercial operations. Then, the most relevant organisational barrier in terms of implementation of digitalisation process and decentralised autonomous systems was the cost as the barriers of personnel may restrict the sustainability of the process inside the organisation (Golizadeh, et al., 2019; Arabshahi, et al., 2021). The organisational barriers of business models provoke delays in the implementation of UAS. The setting up process of UAS units have various key resources to take into consideration in different adoption scenarios. As the UAS implementation have a learning curve, pilots are opened to negotiate with their customers to identify the value exchange. The relationships are based on the UAS ownership and skills as the 2 key components for data acquisition. Nevertheless, the main implication within the UAS is the capability of risk absorption. Who hold knowledge in creating, fixing, and repairing a commercial UAS or have a sufficient financial support to face the UAS incidents, have competitive advantage in the market.

In this Figure is presented the findings and interaction towards a decentralised system according to the data obtain from study A, B and the decentralised approach.

The business models suitable for UAS are around the acquisition of images, software licensing, and production of useful outcomes. The spiritual pilots are the main resource for producing the outcomes until AI systems and the autonomy of the UAS can significantly change the scenario. As a single UAS operations requires a minimal programming skill based on the multiple solutions in the app store, UAS services could seem almost effortless to operate (Ham, Han, Lin, & Golparvar-Fard, 2016). But, when multiple UAS with swarm technology is involved, the conversation of business is around algorithms for detections of entities (walls, people, cars, land, risk conditions, cracks, etc). A Swarm or a single UAS with a strong AI or multitasking software for data recognition would allow the decentralised system to autonomously provide updates of buildings, infrastructures, and cities status for construction professionals. In addition, as the data ownership is an element for commercialisation, the data captured and processed could supply real-time information of people mobility trends, wildlife conservation, and identification of potential business points for malls, stores, etc. The aspect of sub-contract a UAS service should contemplate the location, urgency or time scale of the work, and expertise. Nevertheless, the UAS in some public organisations have the barriers of identifying reasonable prices for specialised services. Therefore, bids were implied by the participants with the aim to have an idea of the range of price between UAS organisations. However, the practice of bids without a cost reference could undermine the UAS service value. Standardisation of price or guidance of minimum wage should be integrated into the range of prices as is developed in Figure 3.

The variables that influence the costs or Business Unit (Bu) triggered in the UAS implementation were segmented into 4 categories: Minimum Wage (Mn), Reconstruction Skills (Rs), Location risk factor (Lr) and cost analysis against traditional method (Ctm). As the participants inferred that the Mn should be between £200-500 the factors that influence the cost are related to the UAS and permissions for operations. This may include images and short video packages, and orthomosaics with acceptable accuracy. Furthermore, the number is also derived from a standard case of a non-congested scenario. UAS less than 2kg are used for this purpose (Irizarry & Costa, 2016). Then, this variable would also increase by the number of UAS involved in the operations (n). In sophisticated cases in which recurrent infrastructures, urban sites, and buildings are monitored, the factors of skills in reconstructing, location risks, and contrast between the actual traditional method support the business case of implementing UAS for construction. Vegetation of the site, LiDAR technology, Ground control points, Internet connexion, aircraft fails, Airport proximity, inaccessibility of locations, and several details of accuracy influence
the range of prices from £750-15,500. Therefore, the initial investment presented in Table 3 can be returned with 20-50 works in 5 years as more than an hour may take in capturing data and reconstructing larger projects.

7. Contribution and Limitations

The contribution of this paper was to provide the steps into the cost implementation process of UAS up to reach the case of decentralised systems with smart contracts. As the accuracy of data capturing and management are the fundamental elements of a digital workflows, the barriers and business implications of implementing UAS were essential to present as they are the key elements of sustainability and scalability of technology in the sector. With this paper the industry, academics and policy makers can understand the trends and business expansion that integrating reality capture technologies trigger. Transparency and safety in public and private contracts promote the spirit of trust between contractors and project sponsors as well as disseminate the best practices in academia. Blockchain system is supported by UAS data and its tests require skills and resources that were outside of the scope of the main research intend regarding UAS implementation in construction. Word counts limited details in a certain degree. Furthermore, as these technologies are still under development, the assessment of the decentralised system, smart contract, and swarm technology was addressed conceptually and further research are encouraged in this field.

8. Conclusion

The implementation of technologies in construction organisations from the project management perspective is relevant. One of the tools to observe is the decentralised smart contract with AI and the tools embedded to execute this kind of approach. The tool of UAS was explored by the versatility and easiness of its use and the cost-benefit analysis involved on it. Furthermore, the UAS are part of the technolgies that support and ground the fundamentals of the feeding decentralised systems. The prominent barriers for UAS implementation explored were from management perspective leading to the business implications that could be suitable for decentralised system approaches. The UAS has a high initial investment in contrast with other technologies that provoke delays in the decision of implementing. Therefore, the implementation is normally made by the owner of the UAS, who shares its interest in testing and appraising the UAS for work purposes at multiple tasks. The implementation of UAS is consolidated when the benefits in the workflows are perceived in cost terms and business expansion (new digital workflow department, virtual reality experiences for metaverse, etc), in addition to the new behavioural business and policies contexts as the decentralised approach in social aspects are established. However, the case showed that the implementation of the UAS reflects the integration of BIM and probably GIS workflows in monitoring tasks making suitable the decentralised systems, and the epistemology of the UAS capabilities prudently fomenting trust in investing in transitioning into digital workflows. Nevertheless, different business models could satisfy the UAS services market, by monthly fees for an independent entity with a single or swarm of UAS in or out a decentralised system. Furthermore, the model of costs developed will support the business aspect of the UAS by giving the key value propositions of the data acquisition and risk reduction for this sector with minimum prices of £200-500 operating with a UAS less than 2kg. In the near future, There would be more advanced systems such as swarm AI autonomous operations that may change these approaches and business implications. Meanwhile, the UAS operations inside the organisations seem to be a productive, cost-effective, and appropriate decision, but risks, maintenance, and contexts or cases should be identified for its sustainability. Furthermore, other contexts in which the UAS could serve as a part or support another workflow of a different emerging technology should be analysed in further works. The role of UAS in the experiences of the metaverse and physical transport of humans should be exemplified how these applications may influence the designs of cities and societies in the near future.

Conflicts of Interest: The authors declare no conflict of interest.

References


