BIM4OSH OBSERVATORY: CENTRAL REPOSITORY TO MONITOR THE STATUS OF BIM IMPLEMENTATION FOR OSH – PURPOSED ARCHITECTURE

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Abstract

Key Technological Developments (KTDs), in recent years, have led to a step change in dealing with Occupational Safety and Health (OSH) risk management. Building Information Modelling (BIM), part of a wider trend of applying digital technology in the Architecture, Engineering, Construction and Operation (AECO) sector, has the potential to optimize the management of risks and costs of accidents at work and occupational diseases. Understanding the way OSH management can be improved using BIM is important as new processes and standards need to be created and existing procedures adapted. Currently there is no centralized sharing mechanism where countries, companies or projects can share lessons learned to help their implementation. Furthermore, there is no formal mechanism to observe and monitor trends and dynamics in the use of BIM for OSH at National, European or industry levels. Digital4OSH is a research group comprised of multidisciplinary academics and industry partners whose aim is to encourage the use of KTDs to improve OSH outcomes. Following a pilot study carried in a complex infrastructure megaproject in UK, this group proposes the development of an Observatory to overcome these gaps. The Observatory would be built on a web-based platform that can be used to obtain statistical longitudinal OSH data and provide information about the progress of national and European implementation of BIM for OSH (through dashboards); to capture, centralize and share (through factsheets) lessons learned from previous projects; to create a repository of technical and scientific information.

Keywords: BIM, Improve Health and Safety Management, Digital technologies to HSW, BIM4OSH Observatory

1 INTRODUCTION

1.1 BIM adoption

The AECO sector has gradually adopted digital innovations, with Building Information Modelling (BIM) at the forefront. BIM, as a set of collaborative methods, processes and standards, along with the enabling information technologies, has become fundamental for responding to a growing need for optimization of processes, procedures and decision making, which runs through the entire life cycle of infrastructure and construction projects. Although governments are working worldwide to tackle delays in BIM adoption and the driving forces for implementing BIM for construction are growing globally, progress has been mixed. National level standardization and policy initiatives vary significantly with some countries advancing their digitalisation processes faster than others. Several countries have already accepted and recognized the value of BIM as a strategic enabler for construction requirements e.g. cost, deadlines, quality, OSH, environment, etc. [1] and are taking important steps to implement BIM policies and initiatives for both their public and private projects. It should be noted that each country has its own unique reality and characteristics (economic, societal, cultural, and political) that are going to require a bespoke approach to BIM. BIM adoption is generally led by complex or large-scale projects and large companies, with SMEs showing limited BIM adoption. In Europe, the European Union Public Procurement Directive 2014/24/UE was published in 2014 and recommends that, from 2018 onwards, electronic platforms would have to be used for public tenders [2]. In some countries BIM methodologies are already quite widespread and several advantages are linked to the use of BIM in the daily routines of companies. According to several studies, USA, UK, Finland, Singapore, Austria, Denmark, Germany, Singapore, South Korea, are leading in BIM adoption. Some countries with limited BIM adoption have already developed their national roadmap and/or are actively working on BIM standardization procedures. However, the adoption of BIM by the AECO industry remains limited, resulting in a gap between policy and practice, which is paradoxical as the industry is in theory the prime beneficiary of digitalisation [3]. According to several authors, a number of factors affect BIM implementation including: social issues e.g. lack of awareness for benefits, lack of demand from the contractors, subcontractors not interested in using BIM: legal and regulatory issues, e.g., it is not mandatory, lack of unified standards and norms; financial barriers, e.g. doubts about ROI, high initial cost; technical e,g., interoperability gaps, scarcity of specialists, absence of contractual requirement for BIM implementation; behavioural e.g. lack of BIM experts, inadequate training. These may all change over time. Although there has been a broad increase in industrial investment and research the area of OSH, BIM does not yet have the prominence in OSH that it has in other specialities, such as structures or MEP [4]. However, it must be said that the literature indicates that the construction industry, especially larger general contractors, are starting to adopt these kinds of technologies for use in OSH management [5]. The analysis of the studies already conducted shows that BIM appears to be a valid instrument for the planning of OSH and its use in the early stages of the project has been linked to an improvement in safety conditions (due to a more effective connection with the productive process and a decrease in the accident rate over the last decade [6]. Additionally the UK NBS Report 2020 [7] confirms that 70% of the respondents think that digitalization will improve construction health and safety. It should be noted that the lack of BIM integration methodologies can create coordination problems which could lead to an increased number of accidents at work [8]. However, there is little information about BIM for OSH implementation worldwide.

1.2 Rationale

A review of the literature and earlier research including a recent study based on the £4.2bn Thames Tideway Tunnel (Tideway) super sewer projects' Central Section, being undertaken by a Joint Venture made up of Ferrovial Laing O'Rourke (FLO), identified areas that need to be addressed if the use of BIM for OSH is going to be increased [9]. These may be considered gaps in the knowledge needed by practitioners if the successful take up of BIM in OSH settings is to be improved. The two main knowledge gaps identified justify why the Observatory is needed:

KNOWLEDGE GAP 1) It is difficult to observe and monitor the progress of BIM for OSH implementation and the differences between high maturity and low-maturity stakeholders [9] such as Project Owners, Contractors, Sub-contractors, Trade Unions, etc**.**

KNOWLEDGE GAP 2) there is no organized repository covering the capture, storage and dissemination of lessons learned [10].

To address these gaps, the development of a specific Observatory was proposed. In order to take the research forward, a number of research questions were formulated, related to the knowledge gaps, to provide the basis for the ongoing research project.

KNOWLEDGE GAP 1 ► Research Question 1: What is the current state of BIM adoption for OSH in each country and how can this be measured?

KNOWLEDGE GAP 2 ► Research Question 2: How can lessons learned (identifying good practices, enablers and barriers) be retrieved, stored, disseminated and replicated from completed projects and then be transferred, through an easy-to-use interface, to other projects to assist OSH practitioners and wider stakeholders to understand how BIM can be used to improve OSH outcomes?

The timing of this research is of the essence as accidents at work are still prevalent and BIM maturity is still poor in some countries. The results will be of interest to those involved in a variety of infrastructure projects, rehabilitation, housing, etc and also regulatory bodies, project owners, designers, safety coordinators in the design and the construction phases, contractors, health and safety technicians, consultants, suppliers, facilities managers, software providers, on a day-to-day basis or more occasionally.

In order to address these questions, Digital4OSH - an interdisciplinary (OSH, Engineering, New technology) R&D academic-industry team (involving ISLA, Loughborough University, University of Minho, Xispoli Engineering, BIMMS Management) proposes the creation of an BIM4OSH Observatory. So, the objectives of the platform will be to identify the particular actions that projects can take to influence the use of digital technologies to improve OSH outcomes by including OSH information in digital data sets; to identify the difficulties and the obstacles for the above; to identify the lessons learned from existing approaches to improve OSH outcomes using digitalization in industry practice; to create barometers that can help to identify dynamics and trends; to create online outputs to be shared with industry - to identify fields of development and improvement which can be the subject of future research. The aim is to apply it namely in projects like Tideway, HS2, new railways in Portugal, etc.

2 BASIS OF THE PROPOSED OBSERVATORY

2.1 Overview

Observatories can be defined as instruments for observing, noticing or perceiving that are employed to acquire qualitative or quantitative data from primary sources. The data can then be used proactively by investigators [11], to characterize a phenomenon through several hypotheses that can be used to predict logical, observable consequences of the hypothesis that have not yet been investigated. Observatories, due to their longitudinal nature provide more accurate and valid outputs than instantaneous snapshots in time. They have several advantages for project stakeholders including: establishing levels of BIM adoption that could be used as indicators of success for BIM programmes [12]; identifys market conditions and policy developments; monitors trends and dynamics; enables, through rich and multiple data, a good understanding of context and description and interpretation of patterns of change; avoids the pitfalls associated with the infrequent collection of cross-sectional snap-shots with findings being extrapolated backwards and forwards over time and outside of the timeframe the data was collected [13]; stimulates debate and reflection among stakeholders; enables a comparative assessment and benchmarking; provide strong political messages [11]; allow actions to be developed and the alignment of good practices; can be powerful motivators for change [14]; enable better decision-making. Important trials of observing real-world dynamics and trends are currently being made by several observatories that have been established in Europe:

European Construction Sector Observatory (ECSO) - set up in 2015 to regularly analyse and carry out comparative assessments of the construction sector in all 27 EU countries and the UK towards these objectives. It has published the report “Building Information Modelling in the EU construction sector” that examines the implementation of BIM in the EU, analyses drivers, opportunities and challenges and provides recommendations for EU political activity aimed at supporting and promoting BIM adoption [3]. The study does not include all 28 EU countries but analyses a representative sample: Denmark for northern Europe; France for Western Europe; Poland for Eastern Europe. ECSO also recently launched a newsletter focused on OSH to provide up-to-date information and the latest news of Europe's construction sector.

Transnational OSH e-observatory - set up to collect and enhance relevant information for about the issue of OSH in the context of posting abroad to provide services.

European Risk Observatory – set up in by OSHA to identify trends in new and emerging risks in occupational safety and health, to improve the timeliness and effectiveness of preventive measures.

Based on the review of existing observatory platforms the proposed Observatory will have four main components:

1) A Collaborative Platform – an online collaborative platform that hosts collection of information about BIM4OSH practices and enables the sharing of experiences.

2) A Barometer – a statistical data collection instrument (barometer) for measuring longitudinal implementation of BIM4OSH that will monitor trends in different countries and companies.

3) Lessons Learnt – a repository populated with real lessons learned from projects using BIM approaches that have already been validated and that can serve as anchor points for knowledge transfer to less mature stakeholders.

4) A Library – a source of information repository that includes theses, papers, legislative and normative documents, etc.

2.2 Collaborative platform

This section covers the first of the key components of the proposed observatory. It outlines the requirements for an online collaborative platform which will enable multiple stakeholders from different organisations to access, populate and retrieve information from a structured database. This will be a web-based collaborative platform that will act as a repository of information about results obtained.

A centralised database, supported on a collaborative web platform, is a system where multiple users can access and share information stored in a single secure central location. Such a platform allows different authorised users to access the database and make changes or updates, with access control and editing permissions set by the system administrator. It is designed to avoid duplication of information and make it easier to coordinate and manage the system. The collaborative web platform allows collaboration and information sharing between different users and works as a broker which allows users to feed it with data input but also consume information that others have stored.

The advantages of a centralised database on a collaborative web platform include easy access and collaboration between different users on a single point of centralised control; reduced data duplication

errors (avoiding redundancy); improved security and a considerable performance; dependence on single point of failure; and the possibility of real-time data analysis.
The collaborative platform incorporates scalability and evolution mechanisms in order to represent a constant dynamic of filling needs that the volubility of the markets transforms. Artificial Intelligence and machine learning exercise a fundamental component in the value proposition that the observatory offers to consecutively improve efficiency in collaboration and increase knowledge. Also the individual and collective (corporate) personalisation both at the interface and content level is one of the characteristics of this platform, as well as the integration with third party platforms in order to obtain and complement the information provided.
It is important to ensure that the platform and database are secure and protected from unauthorised access or privacy breaches. Some of the main security issues include: unauthorised access (it is necessary to prevent that only legitimated users access the levels of information that is relevant and been made available to each profile – mechanisms such as authentication and authorisation should be strongly enabled); protection against attacks (the web platform must be protected against cyber-attacks such as phishing attacks, malware, ransomware, among others – some important security measures should cover hardware actives such as firewalls, but also software such as antivirus, data encryption, among others); data backup and recovery (routine procedures for safeguarding information preventing of data loss or corruption and aim for permanent availability of information in case of problems, activating mechanisms for redundant access to information); monitoring and auditing (it is important to monitor the database in real time and log all activities carried out by users, so that any suspicious or unauthorised activity can be detected); data privacy (it is equally important to classify information of whether to make it public or private but, in addition, it is important to have mechanisms that ensure data confidentiality and that only authorised users have access to that information).
It is important to keep in mind that security should be a priority in all phases of the web platform building project, from planning to implementation and ongoing maintenance phases.
The platform will be built using software development methodologies based on Sommerville's [15]: 1) detailed definition of the objectives; 2) definition of the engineering requirements (functional and non-functional); 3) definition of the web architecture; 4) system modelling definition; 5) data model development; 6) agile software development; 7) system development and implementation; 8) testing and validation; 9) production and maintenance.

2.3 Barometer

Past research has called for the status of BIM adoption to be further explored particularly in OSH settings: e.g.
- If nothing is done on a European scale to tackle the barriers, then it might become difficult for BIM late comers to adopt BIM and work at the same standard as the BIM early adopters [16];
- Industry surveys of adoption levels could be used as indicators of success for the BIM programme [12];
- It is encouraged that measurements of pilot projects are used to demonstrate improvements [12];
- Notwithstanding the much-touted benefits of BIM as a means of increasing productivity, there are currently few metrics that measure such improvements [17];
- when BIM is introduced or specified at a project, organisational or national level, there is often a lack of clarity and common understanding of where to start, what to do [12];
- little guidance is available for organizations wishing to generate new or enhance their existing BIM deliverables [17];
- it is recommended to establish and participate in a common set of metrics (KPIs) to measure and monitor the uptake and effects of BIM in practice [12];
- Could produce measurements and reports of pilot projects and industry adoption levels to encourage the long term industry wide transition to digital method [12];
- There is no universal independent means or organized statistics / compiled information that ease the observation and monitoring of implementation, trends and dynamics of BIM for OSH implementation [10].

Most of the research into OSH interventions in construction projects has been cross-sectional rather than longitudinal studies [18]. Menard (1991) described the difference between cross-sectional and longitudinal studies as: 1) cross sectional has data collected once for each item over a narrow space of time; 2) longitudinal has data is collected over one or more time periods, the subjects or cases are the same or comparable from one period to the next and the analysis allows trends to be identified and monitored over time [13].

In the UK the National Building Specification (NBS) organisation conducts annual surveys of Architecture, Engineering and Construction (AEC) professionals concerning their views on BIM implementation. Surveys have also been carried out in other countries but at varying points in time making comparison of results difficult.

The development of a barometer that continually monitors the progress of BIM4OSH adoption will provide a longitudinal approach. It will enable users to: 1) observe BIM for OSH adoption and uses worldwide; 2) monitor what are the acceptance levels, trends and dynamics in each particular country through periodic statistical assessment. This type of instrument has several advantages including: the creation of quantitative and statistical metrics to measure BIM for OSH in order to assist improvements to be planned, realised and sustained; the progress of development of BIM4OSH implementation can be monitored; benchmarking is enabled between countries; it improves decision-making in BIM and OSH implementation; BIM technology suppliers can identify which countries they should prioritise; it promotes the importance of having national and European indicators. The barometer will be created using longitudinal data obtained through regular data collection and periodical statistical assessment (allowing comparisons over time). Two sets of indicators will be used: I1 – Level of use and implementation; I2 – Level of acceptance. The data collection instrument will be an on-line survey which has the capability of reaching a high number of respondents. The survey will have three major sections: the first for obtaining general information; the second to identify actual BIM uses for OSH (these questions were chosen based on main uses of BIM for OSH identified in previous research); and the third section covers levels of acceptance and BIM potential for improving OSH. Responses will be sought from several different types of stakeholders e.g. Project Client, designers, contractors, suppliers, subcontractors and with various roles both digital and non-digital plus a minimum of 2 years of experience in the field of construction. The measurements obtained will have the potential to structure and present information in a systemic way providing accurate measurement and observation of improvements from BIM for OSH adoption. The panel of respondents for the questionnaire and follow-up interviews will be developed by the research team and partners to assess their availability and affinity to the subject under study. The sampling technique to be used will have the objective of creating a random sample subject to the minimum experience level of two years. The questionnaire will be anonymous multiple-choice using a Likert scale to get a holistic view of respondents' opinions and will use the freeonlinesurveys.com platform which is compatible with the Digital4OSH teams' IT security requirements.

In terms of data analysis and to provide granularity, indicators will be used to establish measurements at: 1) Country or company levels; and 2) Global level. The advantages of this approach is that it takes into account different political and technical frameworks; promotes knowledge sharing; and evaluates the potential for successful use and acceptance levels of BIM for OSH. Using a global approach enables the creation of knowledge about global BIM for OSH framework, the ability to make comparisons between countries or companies, and promotes improvement and knowledge exchange. Stakeholders can benefit from benchmarking their progress and this can act as a motivator for less developed countries; it enables to a more deeper and global data interpretation and analysis for upgrading global strategies. Interpretation of results and discussion will take in account different realities, frameworks, legislation, and standardisation. Outputs will be in form of simple and objective dashboards (Fig. 1), available on the platform based on the two indicators that reveal, longitudinally, individual or global realities.

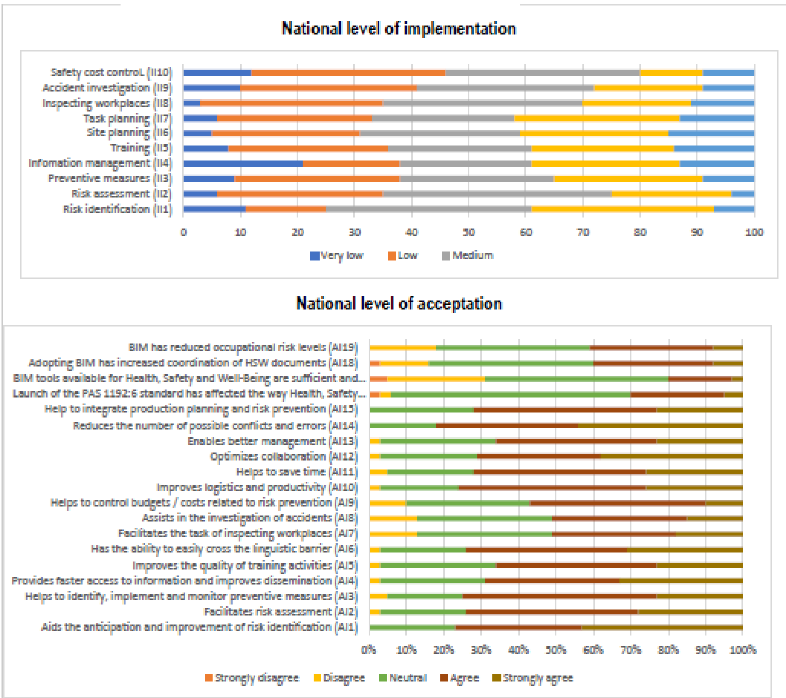

Fig. 1 – Example of national analysis dashboard

Dashboards have several advantages: they are interactive, personalizable and flexible mechanisms; provide at-a-glance views of relevant indicators; enable “rolling up” of information to present a consolidated view across a subject; gauge exactly how well an organization is performing overall and provide a "snapshot" of performance; visual presentation of performance measures; ability to identify and correct negative trends; measure efficiencies/inefficiencies; align strategic goals; saves time compared to running multiple reports; total visibility of all variables instantly; quick identification of data outliers and correlations; available on mobile devices to quickly access metrics; and provide a quick overview for decision-makers. Special attention will be given to the design of dashboards covering simplicity; ease of communication; readable in desktop or mobile formats; clear spatial arrangement. In the examples below dummy data has been used, this means no real data is shown. Dashboards will be gradually archived and upgraded periodically in order to enable to see changes between dates. This will allow the user to verify if implementation had improved in a country since a previous date.

2.4 Lessons learned

Lessons learned in construction projects is typically not carried out in a rigorous structured manner and the lessons tend to be ‘retained in project records and people’s minds which makes them difficult to access and share and this includes the capture and dissemination of OSH lessons [20].

A lesson learned has several characteristics: must be significant having a real or assumed impact on operations; be valid in that is factually and technically correct; and be applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result” [19].

Compiling lessons learned (namely successes, failures, opportunities and threats) from stakeholders with a high level of maturity in the use of BIM in the OSH domain has the following advantages: specifies the reasons for project success and failures to prevent similar errors being repeated; promotes mutual learning and the exchange of best practices between stakeholders; helps to identify, collect, construct and share examples based in methodologies that are already validated which can serve as anchor points; knowledge will be translated easily emphasising it’s value; helps stakeholders to create and implement effective initiatives;

The absence of lessons learned can lead to a knowledge gap that could affect profitability of future projects as the regular collection of lessons learnt in projects, their careful storage in the organizations historical information data base, and their meaningful utilization in subsequent projects are critical elements of project success and organizational competitiveness [21].

However, the literature has shown that lessons learnt interpretation is inconsistent, if carried out at all, creating wasted resource as mistakes and poor delivery are repeated time and again [19]. Reasons for not capturing routinely the lessons learned can include: no defined lessons learned process in place;

pressure to end projects and begin the next one; knowledge about lessons learned becomes 'buried' in project files which are not easily accessible.
There have been reports that have focused in sharing best practices, lessons learned and recommendations, e.g. EU BIM Task Group [12]. Several researchers identified the lack of material covering lessons learned about BIM in OSH and pointed out the need to develop BIM in the area of OSH using practical cases in order to create a database that could be used by those who are beginning to apply BIM for OSH purposes: further work should be considered which explore in more detail some of the areas identified and establishes the benefits of using digital technologies to improve OSH outcomes“ [10]; there should be a focus on detecting weaknesses and threats, in order to try and find solutions for them“ [22]; „Incomplete technology transition from construction safety research into practice“ [23]; „there is a gap between the theory and realised benefits at the application stage by industry“ [24]; “EU countries need to have a common ground by sharing the best practices, enabling BIM leading countries to pull the late adopters upwards” [16]; “should produce lessons learned reports which identifies areas for improvement” [12].
The proposed lessons learned repository will consist in collection, analysis, contextualization, and storage of lessons learned, best practices, difficulties and barriers, trends and underlying factors information about real-world longitudinal successful case studies based in projects from different stakeholders that have a good level of BIM implementation. This would enable the information collected to be retrieved from construction sites to that would act as novel “living labs” - in order to make theory real and effective. There are several advantages of doing this: it enables the collection, documentation and sharing of good practice based in approaches that are already validated and that can serve as exemplars; the lessons learned document will clearly specify reasons for project success and failures; organisations will be able to learn from past mistakes and the repetition of same mistakes will be reduced; it will facilitate good communications between stakeholders with different levels of BIM OSH implementation maturity; It will enable benchmarking and replication of knowledge in the form of a BIM4OSH 'Book of Knowledge'. Lessons learned will be focused on: prevention in design phase; Common Data Environment; document/contractual management; hazards and risk identification, mitigation, and control; training; on-site monitoring and implementation; emergency planning; accident investigations, skills and competences.
The process for retrieving lessons learned will be based on semi-structured interviews with stakeholder focus groups and direct observation on site. Collecting both quantitative and qualitative data will help understand the links between quantitative variables. It will also provide a form of triangulation allowing for a better accuracy of interpretation of results [25] compared to the use of just one method [26]. It will also provide a more complete analysis of the topics and assist in the identification of possible paradoxes and contradictions [30]. Direct observation will take the form of site visits will allow, using direct vision and hearing, a neutral, direct and face-to-face observation of the phenomenon (behaviours and attitudes) under study, without interfering or changing the reality. Individual and focus group (construction, OSH and BIM managers) interviews will be designed to uncover everyone's thoughts about BIM implementation for OSH and to understand advantages, disadvantages and barriers to this approach creating, this way, the “lessons learned”. This information can be used not only to reveal and understand the “what” and the “how” but also to give more emphasis on exploring the “why” [31]. Interviews are divided in three parts: an initial part with global question (participant information; use and experience with BIM tools on OSH), a second part for exploring previous experiences with BIM for OSH, and a third part related to earlier survey findings in order to understand each point of view about the results obtained.
Outputs will be available in website in form of “Lessons Learned Factsheets” covering the project details, timescale, operational area covered, BIM4OSH focus, task description, challenge, solution, methodology, benefit analysis – current state/futures state, benefits measurement/targets, benefits realised, critical dependencies, risks/issues/mitigating actions [27], as illustrated in Fig. 2.

Country	United Kingdom	**Date BIM became mandatory**	2012				
Project name	**Thames Tideway Tunnel**	**Period**	2017 - 2023				
Project Summary	Sewer tunnel 25km long and 7.2m internal diameter located beneath the central section of the River Thames that will connect 34 combined sewer overflows discharging into the river during exceptional rainfall.						
Project budget	746.000.000eur						
Years using BIM	**12**	**Years using BIM for OSH**	**4**				
Operational area	Training	**3D**	**X**	**4D**		**5D**	
Construction site	Albert shaft construction located in the Central Section of the project being delivered by the FLO (Ferrovial Laing O'Rourke JV)						
Task description	Concrete pour of internal walls and vortex generator while simultaneously pouring 3m secondary lining sections of the shaft using jump form several meters high.						
Challenge	The construction sequence complex in terms of the many activities that were occurring in the shaft concurrently at different levels and also making users aware of these. Risks.						
Solution	Creation of a3D model of the Albert shaft construction sequence, including all permanent and temporary works which can be exported in a format that would allow users to visualize it using a VR headset. A headset could then be brought to site so that the site team and operatives would be able to visualize the spatial constraints at each phase of the construction sequence.nd They could then highlight risks and propose solutions/improvements to the sequence based on their experience of using the VR headset.						
Methodology	The site teams outlined the proposed construction sequence to the digital engineering team so that an accurate 3D model can be created. The 3D model was then shown back to the site team to ensure all high-risk areas are captured within the model and the key areas highlighted that need to be reached within the eventual virtual model. The 3D model was then exported into the 'Unity'software, , in order to create the virtual model. which coild then be viewed using avirtual reality headset. Each member of the site team would take turns using the virtual reality headset to get a notion of not only the spatial constraints that each phase contained but also the magnitude of the works ahead. Then each site member could highlighte concerns and highlighted potential problems or risks that they could see within the virtual model.						
Benefit Analysis	**Current state** Poor engagement in construction planning Lack of accuracy in task planning Not all risks captured Information not always captured	**Future State (Areas for improvement/benefit)** More accurate plans Improved identification of risks Better retention and access to information					
Measurement method & target range	Actual time to complete task(s) vs programmed time (days) – 5 to 10% saving Actual cost to complete task(s) vs original budget (£) – 3 - 5% saving						
Benefits realisation – key influencing factors	**Critical Dependencies/Barriers** Use of VR is critical Lack of buy-in – management & operatives Time & budget constraints	**Risks/issues and mitigating actions** Time needed to develop 3D model Budget Availability of suitable facilities for VR sessions Training in use of VR					

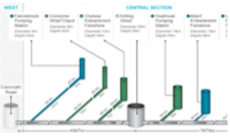


Figure 2 – Example of realisation card

3 DISCUSSION

The results of the Observatory will have a wide potential audience of end users who will be able to exploit the outcomes, both in terms of their professional roles and nationallyl and European-wide, as they will be of interest of stakeholders with diversified public and private project roles (e.g. project owners, designers, safety coordinators in the design and the construction phases, builders, health and safety technicians, inspectors, consultants, suppliers, O&M managers, software and hardware providers). The research will aid their need to create or use technical documents, on a day-to-day basis e.g. specifications, manuals and health and safety plans. The results will also be of interest to researchers, professors and students of the fields of BIM and OSH as they will provide a structured information base for the development of new academic projects. It will also benefit standardization bodies and add value to existing R&D programs including: Healthy Workplaces Campaigns of the "European Health and Safety Agency at Work" – EU-OSHA campaign 2023-2025 covering digitalization for OSH purposes; Longitudinal Tideway Tracer (University of Loughborough / Thames Tideway / IOSH – 2014/2017); European Risk Observatory - based at the European Agency for Safety and Health at Work (EU-OSHA); European construction sector observatory (ECSO), Working Conditions Portuguese Observatory.

4 CONCLUSIONS

The proposed approach is intended to enable a significant raising of the bar in terms of BIM4OSH adoption, bridge the gap between stakeholders of differing maturity, and will have a significant, credible, long-lasting impact and positive influence in scientific, technological and socio-economic areas both in the short and long term.

In scientific terms, BIM4OSH will enable stakeholders to: 1) understand gradual implementation of BIM for OSH enabling organizations to assess their BIM for OSH implementation level against others reducing the gap between involved stakeholders; 2) provide a centralized database of information about lessons learned from previous projects namely in terms of such important areas as prevention through design, risk assessment, etc. The research will have a technological impact as it will provide new approaches and tools for a longstanding problem; project performance will be increased and optimized

with reduced delivery times and costs through the provision of easy-to-use tools. The socio-economic impact will be to increase the competitiveness of academic and industry partners and increase the impact of research outcomes which will consolidate and enhance the research team's reputation for the improvement of OSH outcomes using BIM; improve stakeholders satisfaction regarding implementing OSH; and, last but not least, the most important impact: the reduction of accidents at work and occupational diseases through maximising the prevention opportunities offered by digital technologies and creation of safer and healthier workplaces for all in the digital new era.
Users of BIM4OSH Observatory will have specific benefits of participating including: improving their network capacity; the opportunity to provide training; align their strategies through validated approaches; understand the dynamics and trends in each country and in Europe; join Digital4OSH in funding opportunities.
Some challenges include particular characteristics of stakeholders and their organisations, reluctance to share knowledge; project time pressures. These can be studied and solutions to mitigate their effects developed.
The wider research team will build on existing relationships with other countries that have indicated their interest in participating in research based on the BIM4OSH Observatory.
At the end of the project, new routes for further research will be open, namely replicating the Observatory in order to improve the take up of other KTD for OSH uses e.g. Digital Twin., AR/VR, IoT, Drones, Robotics. Artificial Intelligence will also certainly have a place in further research on this theme.

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