Les environnements de données communs (EDC/CDE) comme outils d'intégration de l'information dans les grands projets de construction

par

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COMMON DATA ENVIRONMENTS (CDE) EN TANT QU'OUTIL D'INTÉGRATION DE L'INFORMATION DANS LES GRANDS PROJETS DE CONSTRUCTION INDUSTRIELLE ET CIVILE

Charle BEAUCHAMP

RÉSUMÉ

L'industrie de la construction est un secteur fragmenté et complexe qui nécessite la participation de nombreuses parties prenantes, ce qui rend la réalisation des projets difficile. Ainsi, le succès des projets de construction repose en grande partie sur une collaboration efficace, y compris la communication et la gestion de l'information. De nos jours, les technologies de l'information sont utilisées pour faciliter les communications, et les environnements de données communs (CDE), définis comme les espaces centraux pour collecter, distribuer et contrôler toutes les informations tout au long du cycle de vie du projet, sont considérés par beaucoup comme la solution ultime pour la gestion des informations des projets. Le concept de CDE basé sur la modélisation des informations du bâtiment (BIM) étant relativement nouveau, seules quelques études se sont concentrées sur le développement d'une bonne compréhension de ce qu'est un CDE et de la manière dont il devrait être structuré. Cependant, il n'y a pratiquement aucune recherche basée sur le point de vue des praticiens de la construction. La recherche présentée dans cet article explore la perception des praticiens impliqués dans les grands projets de construction industrielle dans un effort pour fournir une bonne compréhension de leurs pratiques et attentes concernant l'utilisation du CDE. Les résultats montrent que si la moitié des personnes dans ce domaine savent ce qu'est le CDE, toutes utilisent déjà des systèmes de gestion de l'information dans leurs projets. Les types de structures, matériels et logiciels sont discutés, et il est clair que le succès de l'intégration dépend non seulement de la technologie, mais aussi de la discipline et de l'engagement de tous les participants tout au long du cycle de vie de tout artefact construit.

Mots-clés: environnement de données commun, collaboration, travail collaboratif assisté par ordinateur, projets de construction, gestion de projet

COMMON DATA ENVIRONMENTS (CDE) AS A TOOL FOR INFORMATION INTEGRATION IN LARGE INDUSTRIAL AND CIVIL CONSTRUCTION PROJECTS

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ABSTRACT

The construction industry is a fragmented and complex sector that requires the participation of many stakeholders, making the projects' completion challenging. Thus, the success of construction projects relies in large part on the effective collaboration, including communication and management of information. Nowadays, information technology is utilized to facilitate communications, and common data environments (CDE), defined as the central spaces to collect, distribute and control all the information throughout the project lifecycle, are considered by many as the ultimate solution to project information management. As the concept of Building Information Modeling (BIM) - based CDE is relatively new, only a few studies have focused on developing a good understanding of what a CDE is and how it should be structured. However, there is virtually no research based on the perspective of construction practitioners. The research presented in this article explores the perception of practitioners involved in large industrial construction projects in an effort to provide a good understanding of their practices and expectations regarding the use of CDE. The results show that while half of the people in this field may know what CDE is, all of them already use information management systems in their projects. The types of structures, hardware and software are discussed, and it is clear that the success of the integration depends not only on the technology, but also on the discipline and commitment of all the participants throughout the lifecycle of any built artefact.

Keywords: common data environment, collaboration, computer-supported collaborative work, construction projects, project management

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LISTE DES ABRÉVIATIONS, SIGLES ET ACRONYMES

AIDC	Automatic Identification and Data Capture devices
BCA	Building and Construction Authority
BIM	Building Information Modeling
BSI	British Standards Institution
CAD	Computer Aided Design
CDE	Common Data Environments
CSCW	Computer Supported Collaborative Work
DB	Design Build
DBB	Design Bid Build
DMU	Digital Mock-Up
EPC	Engineering Procurement Construction
EPCM	Engineering Procurement Construction Management
FPC	Fixed Price Contracting
GIS	Geographic Information System
IPD	Integrated Project Delivery
ISO	International Organization for Standardization
IT	Information Technology
ITC	Information Technology in Construction
PAS	Public Available Specification
PPP	Public Private Partnerships
VDI	Virtual Desktop Infrastructure

INTRODUCTION

Dans le cadre des grands projets, le nombre d'intervenants est généralement assez important. L'interaction entre ces derniers est complexe et souvent défaillante. Plusieurs systèmes de communication sont utilisés et souvent peu compatibles ne favorisant pas la traçabilité et la fluidité de l'information. Quand une situation se produit, il est pratiquement impossible de reconstituer entièrement et directement les évènements recherchés (William East, Nisbet, & Liebich, 2013). De plus, à la fermeture du projet, on se retrouve avec plusieurs systèmes de communication et d'identification qu'il faut convertir en un seul et unique système pour les futurs utilisateurs. Le manque de partage de l'information dans un projet rend difficiles les tâches de gestion et de coordination. Ces manques augmentent les possibilités d'erreur, les reprises des travaux, le dédoublement des tâches et les conflits entre les parties prenantes. Le tout engendre des délais et des coûts supplémentaires (Dzudie, 2013).

L'arrivée des ordinateurs et des technologies de l'information fut des éléments marquants dans le traitement des informations. De plus, la technologie qui ne cesse d'évoluée rend cette tâche de plus en plus facile et accessible. Dans ce contexte, les environnements de données communs (Common Data Environment—CDE) sont de plus en plus évoqués et sont considérés comme ayant le potentiel d'intégrer toute l'information du projet autour d'une plateforme collaborative. Les fonctionnalités de travail collaboratif assisté par ordinateur, associées aux possibilités offertes par la maquette numérique (building information model—BIM), permettraient à ces environnements d'intégrer, de gérer et de diffuser l'information durant tout le cycle de vie d'un projet de manière transparente, structurée, vérifiable et disponible depuis une seule source.

Si les environnements de données communs semblent être la solution du futur pour l'intégration et un meilleur partage de l'information au sein des projets de construction, ils sont encore assez peu connus et adoptés par l'industrie. De plus, peu de littérature a été consacrée à ce que devraient être les CDE, en lien avec les pratiques et les besoins réels de l'industrie. Le but de ce mémoire est donc de mieux comprendre ces besoins, de les confronter avec les capacités des CDE actuelles à les gérer, de manière à intégrer le monde actuel de la construction dans le monde technologique d'aujourd'hui. Il s'agit notamment de répondre aux questions suivantes :

- Que devrait être un CDE ?
- Quelles informations sont vraiment nécessaires ?
- Comment doit-il être structuré ?
- Comment et qui doit y avoir accès ?

La situation voulue est de centraliser les communications et l'information dans un système unique en entrant l'information qu'une seule fois, tout en gardant son contenu original et rendant sa traçabilité accessible pour tout le cycle de vie d'un projet.

Dans un premier temps, pour répondre aux questions précédentes, une revue de littérature sera faite pour comprendre les CDE en commençant par bien comprendre le travail collaboratif, les structures des projets et le travail coopératif assisté par ordinateur (Computer-Supported Cooperative Work—CSCW). Une fois ces notions assimiler, nous établirons une définition des CDE, incluant leurs exigences et leur organisation. Nous ferons un survol des différentes directives et manuels existants sur les CDE pour finir avec les défis et obstacles à surmonter pour appliquer ces derniers.

Ensuite, un sondage parmi les praticiens du milieu sera distribué afin de recueillir l'information sur les pratiques et compréhensions de la gestion de l'information dans les grands projets civil et industriel. Les données recueillies seront utiles afin de donner un regard réel et actuel de la situation d'aujourd'hui face à la gestion de ces informations. La combinaison de la revue de littérature avec les données recueillies durant le sondage permettra de bien répondre à nos questions précédemment posées et donner des recommandations sur les CDE.

Le présent mémoire est présenté autour d'un article soumis pour publication en langue anglaise qui se retrouve dans sa totalité et intégrité au chapitre 3. Un sommaire de la revue de littérature ainsi que de la méthodologie de recherche sera présenté avant ce chapitre pour être ensuite complété d'un résumé des résultats, discussions et recommandations. Le but de faire ce mémoire avec un article était de présenter les résultats à une audience plus vaste et rendre plus accessibles ces derniers.

CHAPITRE 1

REVUE DE LITTÉRATURE

1.1 Travail de collaboration dans la construction

Avant de parler de collaboration, il est important de bien comprendre la structure des projets. Pour commencer, regardons la définition de la structure traditionnelle d'un projet de construction. (Ruparathna & Hewage, 2015) examinent la méthode d'approvisionnement pour définir la structure traditionnelle et la définie comme la contractualisation à prix fixe (Fix Price Constracting—FPC). Cette méthode d'approvisionnement traditionnelle est fragmentée et rend la collaboration difficile, car chacun cherche à se protéger contre d'éventuels problèmes juridiques. C'est une structure tripartite. Les professionnels font la conception, l'entrepreneur exécute les travaux et le client / propriétaire propose les contrats et reçoit le projet final à la fin. Pour surmonter la fragmentation et la complexité de l'exécution du projet, il sera important d'assurer la collaboration entre toutes les parties prenantes.

(Kalay, 2001), a défini le travail collaboratif comme « l'accord entre les spécialistes pour partager leurs capacités dans un processus particulier, pour atteindre les objectifs plus larges du projet dans son ensemble, tels que définis par un client, une communauté ou la société en général. » En parallèle, on peut définir la communication comme l'échange de connaissances pour atteindre un objectif commun, dans notre cas la réalisation réussie d'un projet. Il est important de séparer les connaissances, les informations et les données. Pour que cette structure fonctionne efficacement, une bonne collaboration et une bonne communication entre chaque participant sont essentielles. Le travail collaboratif est essentiel dans la construction et la gestion de l'information en est la clé.

Il serait donc avantageux de se tourner vers d'autres structures qui amélioreront la productivité et la collaboration et réduiront la fragmentation. (Hosseini, Haddadi, Andersen, Olsson et Laedre, 2017) parlent de contrats de base transactionnels dans lesquels chaque phase d'un projet a ses propres contrats (structure traditionnelle), par opposition à une base relationnelle où toutes les phases peuvent être regroupées sous un contrat, ce qui facilite la collaboration. Dans cette deuxième catégorie, on retrouve la livraison de projet intégrée (Integrated Project Delivery—IPD). « Le IPD peut être défini comme une méthode de réalisation de projet qui se distingue par un accord contractuel entre un minimum de propriétaires, de constructeurs et de professionnels de la conception qui aligne les intérêts commerciaux de toutes les parties » (Cohen, 2010). Pour obtenir le meilleur niveau de collaboration, il semble utile de se concentrer sur le type IPD, dans lequel le partenariat améliore la communication et facilite le partage d'informations.

De nombreuses méthodes et approches informatiques ont été développées pour faciliter la collaboration. Ainsi, la croissance exponentielle de la puissance des nouveaux ordinateurs et l'étendue des réseaux de communication rendent la collaboration plus simple et plus rapide. Il y a une tendance à trouver ou à créer des outils plus courants, tenant compte de multiples aspects du travail collaboratif. « Les plates-formes de collaboration sont utilisées, non seulement, pour améliorer l'efficacité de la collaboration synchrone et asynchrone, mais aussi pour la gestion et le partage d'informations structurées et non structurées » (Ma, Zhang et Li, 2018). Il est important que les plateformes de collaboration puissent intégrer tous les systèmes informatiques nécessaires à l'exécution d'un projet. Ces plateformes offrent la possibilité de coordonner les ressources et les informations d'un projet tout au long de son cycle de vie. « Une plate-forme technologique collaborative parfaite peut atteindre l'objectif ultime de réduction des coûts, d'accélération des progrès, d'assurance qualité et de contrôle des risques » (Guo, 2019).

1.2 Environnement de données commun (CDE)

Le CSCW, le BIM et tous les systèmes de traitement de l'information peuvent être regroupés sous un cadre plus large appelé Environnement de Données Commun (CDE). Pour (Preidel et al., 2018), « Le CDE représente un espace central de collecte, de gestion, d'évaluation et de partage d'informations. » Le CDE est l'endroit où tous les participants peuvent récupérer et soumettre les données d'un projet. La tâche principale est de fournir une plate-forme d'échange d'informations dans un environnement contrôlé. L'utilisation structurée d'un CDE exige une discipline stricte de la part de tous les membres d'une équipe de conception en ce qui concerne leur adhésion aux approches et procédures convenues, par rapport à la « liberté » relative associée aux approches plus traditionnelles.

Le travail collaboratif et la gestion de l'information reposent sur la nécessité d'être centralisé. LE CDE nécessite donc une configuration technique qui permet aux informations d'être accessibles à tout moment et par toute personne autorisée. L'accès et la structure doivent être établis au début d'un projet et doivent être mis à jour en permanence. Pour assurer la cohérence des informations, il sera important de mettre en place une gestion appropriée du bien et des droits d'accès à ces informations. Enfin, l'échange d'informations devrait avoir lieu exclusivement via le CDE, qui servira d'archive centrale pendant toute la durée du projet et au-delà (Preidel et al., 2018).

Diverses directives et manuels ont été mis à disposition pour normaliser la structure et les pratiques autour du CDE. On y retrouve, sans s'y limiter, le Guide BIM de Singapour (BCA-Singapore, 2013), la norme allemande (VDI-2552-Blatt-5, 2017), la spécification britannique disponible au public (PAS-1192-2, 2014) et (PAS-1192-3, 2014) et celle de l'organisation internationale de normalisation (ISO/DIS-19650-1, 2017). L'adoption d'ISO 19650 présente plusieurs avantages. Parmi les principaux, nous pouvons inclure la clarté des informations requises par les clients du projet, ainsi que les méthodes et processus qui seront utilisés tout au long du cycle de vie d'un actif. L'utilisation de l'ISO 19650 régulera également la quantité d'informations nécessaires pour être efficaces et efficientes dans le transfert entre les parties concernées. Il aide également à définir comment un CDE doit être coordonné et partagé avec d'autres personnes et organisations. Les méthodes et procédures utilisées sont importantes pour établir les règles au sein du CDE (UK-BIM-Alliance, 2019). Enfin (Radl et Kaiser, 2019), ont suggéré que les gouvernements lancent des initiatives pour normaliser cet environnement.

1.3 Défis et obstacles

L’un des défis majeurs liés à l’utilisation d’un CDE est de savoir comment rendre les informations stockées accessibles à toutes les parties afin que les informations puissent être interrogées et récupérées rapidement (Preidel et al., 2018). Si nous regardons du côté de la technologie (Samuelson, 2002) mentionne que la non-compatibilité des logiciels et leur demande continue de mise à niveau représentent des obstacles. Les autres défis qui deviennent de plus en plus importants avec l’utilisation croissante d’Internet sont les menaces de cybersécurité et les vitesses de connexion (Khan et al., 2016). Le facteur humain a aussi été étudié, car il pose d’autres défis : intérêt / engagement insuffisant de la direction, attitude générale selon laquelle « les anciennes façons de faire ont bien fonctionné tout au long des années et les changements ne sont pas nécessaires », le niveau de formation plus élevé requis par le personnel, les préférences pour le travail manuel en raison du manque de connaissance, coordination avec les différentes normes, et les gestionnaires qui n’ont pas le temps pour la compréhension des Technologies de l’information (TI) en raison de leur lourde charge de travail (Samuelson, 2002).

Pour comprendre le CDE, il est important de prendre en considération non seulement la technologie, mais aussi et surtout le facteur humain qui le conduira. Nous avons couvert la partie théorique du CDE et à partir de cette position de connaissance, nous avons décidé de mener un sondage pour étudier l’interaction des parties prenantes avec la technologie comme principal vecteur pour définir le CDE. Ce sondage présente les technologies que les gens utilisent, comment ils les utilisent et pourquoi ?

CHAPITRE 2

DÉMARCHE DE TRAVAIL ET ORGANISATION DU DOCUMENT

2.1 Construction de l'enquête

Pour la recherche sur les technologies de l'information dans la construction (ITC), Bjôrk (1999) a noté que les chercheurs s'intéressent généralement au développement d'outils qui changent la réalité plutôt qu'à l'étude de la réalité telle qu'elle est, sans l'influencer. Sur la base de cette déclaration et de nos questions de recherche, une méthodologie a été mise en place à l'aide d'un sondage en ligne. L'objectif était de recueillir des informations et des commentaires sur le CDE auprès d'un groupe ciblé dans les grands projets de construction civile et industrielle. L'idée était d'obtenir des informations sur la situation actuelle de la gestion de l'information et comment elle est utilisée, ainsi que de voir si le CDE est un sujet connu dans l'industrie de la construction. L'approche de l'enquête en ligne a été choisie pour acquérir ces informations. C'est probablement la plus efficace, car elle est facile à utiliser et une gamme d'échantillons peut être facilement atteinte avec un faible investissement en temps et en argent. Le sondage en ligne est le moyen le plus simple et le plus rapide de collecter des informations auprès des entreprises en termes de partage et de gestion d'informations sans perturber indûment le temps d'un personnel hautement qualifié (Murray & Fisher, 2002). Il était donc important d'être aussi complet que possible, tout en restant aussi bref en termes de durée afin de minimiser l'investissement en temps de tout candidat qui souhaiterait répondre. Le sondage est composé des six parties suivantes :

1. Description du participant et de l'entreprise pour laquelle il travaille,
2. Description du projet sur lequel le participant se réfère pour le sondage,
3. L'aspect collaboration : qui travaille avec qui, comment et à quel titre ?
4. Les technologies de l'information et de transfert,
5. BIM —Modélisation / gestion des informations du bâtiment,
6. Performance, améliorations et attentes des participants.

La totalité du sondage est fournie à l'annexe I dans sa version imprimable.

2.2 Distribution du sondage et collecte de données

La méthode de sondage en ligne a été choisie pour recueillir les informations nécessaires pour les raisons mentionnées ci-dessus. Il a été décidé de cibler un groupe spécifique de candidats au lieu de le diffuser ouvertement dans son ensemble. Nous avons choisi cette approche sélective pour avoir les réponses les plus fiables et les plus précises. Cent candidats ont été sélectionnés conformément à des critères spécifiques. Ces candidats étaient tous impliqués directement dans un projet de construction, avaient un poste de direction et avaient une expérience significative dans leur domaine. L'anonymat était de vigueur et la fourniture des coordonnées des participants était sur une base volontaire. Parmi les cent candidats potentiels invités, quarante-trois ont répondu, trente-deux complètement, cinq partiellement et six qui ont refusé de répondre aux questions. Les autres n'ont pas accusé réception de l'enquête. On retrouve dans le tableau-A II-I (annexe II) la liste des réponses reçues.

Pour gérer le sondage, une plateforme en ligne (Limesurvey) a été utilisée. Cette dernière permet d'utiliser plusieurs types de questions (vrai ou faux, choix multiple et même avec des questions à développement). Les résultats du sondage ont été compilés par catégories et les réponses ont été présentées avec des tableaux et des graphiques pour montrer la répartition des données. Ces derniers sont présentés dans la section 4 de l'article présenté dans le chapitre 3 de ce mémoire.

2.3 L'analyse des données

Si la plateforme Limesurvey est capable de trier les données collectées et de générer des graphiques, il restait encore à revoir certains résultats avant de les utiliser. Pour ce faire, ils ont été exportés vers Excel, à partir duquel de nouveaux tableaux et graphiques ont été créés pour être ensuite utilisés dans l'article. Certains résultats ont dû être combinés et résumés. Deux cas ont nécessité cette intervention. La première à la question 4.8 Quel logiciel utilisez-vous sur le projet ? Et la deuxième à la question 5.1 Comment les conceptions du projet sont-elles créées (quel format) ? Le tableau-A III-I (annexe III) fait le résumé des logiciels énoncés par les répondants et les fonctionnalités les plus utilisées par ces derniers.

Le tableau 2.1 combine les différents logiciels de conception et le type de formats utilisé. Le but de cette intervention était de catégoriser sous quelle dénomination les répondants avait classé leur réponse. Comme vous le verrez dans la discussion, plusieurs d'entre eux ont mélangé les notions de modèle numérique et dessin 3D.

Tableau 2.1 Synthèse question 5.1

	2D	**3D**	**DMU**
	(11)	(17)	(2)
Aconex		1	
Autocad	10	3	
Autocad civil	1	1	
BIM360 Glue		1	
Revit		6	1
Smart Plant		1	
Tekla		1	
Autres		3	1
	11	17	2

L'analyse des données et la discussion sur les résultats sont présentées dans les sections 4 et 5 de l'article original présenté dans le chapitre 3.

CHAPITRE 3

COMMON DATA ENVIRONMENTS (CDE) AS A TOOL FOR INFORMATION INTEGRATION IN LARGE INDUSTRIAL AND CIVIL CONSTRUCTION PROJECTS

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3.1 Abstract

The construction industry is a fragmented and complex sector that requires the participation of many stakeholders, making the projects' completion challenging. Thus, the success of construction projects relies in large part on the effective collaboration, including communication and management of information. Nowadays, information technology is utilized to facilitate communications, and common data environments (CDE), defined as the central spaces to collect, distribute and control all the information throughout the project lifecycle, are considered by many as the ultimate solution to project information management. As the concept of Building Information Modeling (BIM) - based CDE is relatively new, only a few studies have focused on developing a good understanding of what a CDE is and how it should be structured. However, there is virtually no research based on the perspective of construction practitioners. The research presented in this article explores the perception of practitioners involved in large industrial construction projects in an effort to provide a good understanding of their practices and expectations regarding the use of CDE. The results show that while half of the people in this field may know what CDE is, all of them already use information management systems in their projects. The types of structures, hardware and software are discussed, and it is clear that the success of the integration depends not only on the technology, but also on the discipline and commitment of all the participants throughout the lifecycle of any built artefact.

Keywords: common data environment, collaboration, computer-supported collaborative work, construction projects, project management

3.2 Introduction

For large industrial construction projects, the number of stakeholders is usually quite extensive. The interaction between them is complex and often faulty (Guo, 2019). Several different information systems are being used, and these are often not very compatible and interoperable, which does not foster the traceability and fluidity of information. When a problem occurs, it is very difficult to quickly and completely reconstruct the desired events (William East et al., 2013). In addition, at the end of a project, there are several information systems that must be converted into a single system to be handed over to the client. Poor communication and the lack of information sharing in a project make management and coordination tasks problematic (Dzudie, 2013). These shortcomings increase the possibilities of error, the duplication of tasks and the conflicts between stakeholders, and delay in the resumption of work after stoppages. All of this leads to longer delays and additional costs (Dzudie, 2013).

Managing the various types of information in large construction projects is a recurring problem. To simplify this task is to minimize the manipulation of information and thereby minimize the risk of omission, modification and interpretation. The desired situation would be to integrate communications and information into a single system by entering information only once, while retaining its original content and making it easily traceable. To achieve this goal, new technological approaches such as Building Information Modelling (BIM) are increasingly being adopted (Staub-French et al., 2011). In general, these cover the geometrical part of project information, with the option to extend it for scheduling, costing and other dimensions (Sacks, Eastman, Lee, & Teicholz, 2018). However, there are still many other elements that are necessary for project execution and beyond, such as administration, contracts, management and operational information. Common Data Environments (CDE) are being more and more referred to and are perceived as offering the potential to integrate all project information, including the three-dimensional digital mock-up (BIM) and the other previously mentioned activities. The Computer-Supported Collaborative Work (CSCW) features, combined with the capabilities of the BIM, would enable these environments to effectively integrate, manage and disseminate information throughout the entire project lifecycle in a transparent, structured, verifiable and available way (Penichet, Marinb, Galluda, Lozanoa, & Tesoriero, 2007).

However, given the peculiarities of the construction industry, the concept of CDE should be carefully studied in order to ensure a good alignment with industry practices. While CDEs seem to be the solution of the future for integration and better information sharing within construction projects, they are still relatively unknown and have not yet been adopted by the construction industry (Radl & Kaiser, 2019). In addition, there has been little literature on what CDEs should be in relation to actual industry practices and needs. The purpose of this article is to better understand these needs, to mesh them with the capacities of the current CDEs to manage them, and to verify the concept of having one central space to manage information, documents and communication during a building project and even after.

The research presented in this article explored the literature on current CDE definitions and document management systems, and then conducted a survey within the construction industry. The aim of the survey was to gain insight into the current situation for managing information in large construction projects and the perceptions practitioners have about CDE. Specifically, it should help to answer the research questions regarding Common Data Environments: What should a CDE be? What sort of information is really needed? How should it be structured? And who is best placed to use it to effectively manage the information and communication systems in today's large construction projects? The results will not only serve to better understand the industry needs, but also to guide and motivate the construction industry in the use of BIM-based information-management technologies. On the practical side, it will give direction on how to put in place effective communication and information management that should lead to a reduction of misunderstandings and disputes, with the associated cost and time saving. At the scientific level, it will add more knowledge to the current understanding of CDEs. It will also help to effectively integrate new technologies and bridge the gap between old and new generations of practitioners.

This paper is organized as follows: After this introduction, a literature review on the subject is followed by the methodology of the research, where a survey was used to gather the required information. Then the analysis and discussion of the results were presented, in line with the research questions.

3.3 Related Works

After defining the research issue, a definition of CDE needs to be agreed. Before proceeding, traditional project management structure will be reviewed, follow by a better understanding of collaborative work and the different associated tools in construction projects. Once collaborative work has been presented in an all-around manner, the CDE terminology will be introduced and defined, including its criteria and organization. This section will also explore the known obstacles and challenges associated with CDEs.

3.3.1 Collaboration work in construction

3.3.1.1 Traditional project structure

To define the traditional structure of a construction project, Ruparathna and Hewage (2015) look at the traditional procurement method, defined as Fixed Price Contracting (FPC). It is a three-party structure. This traditional procurement method is fragmented and makes collaboration difficult, as everyone seeks to protect themselves against potential legal issues. Many stakeholders are involved in the execution of a project. Not only are there different phases in a project, there are also many specialties in each phase. Howard et al. (1989) divided the fragmentation into two types, identifying the fragmentation between phases as vertical (planning, design, construction, etc.), while the fragmentation between the specialties inside each phase as horizontal. This separation between the phases and specialties make communication, collaboration and information exchange quite complicated, with an impact on scheduling, accounting, design, construction and management. This fragmentation is more pronounced in the construction industry than in any other manufacturing sector (Howard et al., 1989).

To overcome the fragmentation and complexity of project execution, it will be important to assure collaboration between all stakeholders. Nowadays, labor, equipment and technology are available to almost anyone. The differences in the execution of projects will rely mostly on how they are accomplished. Collaboration thus becomes the key element in project execution performance.

3.3.1.2 Collaboration Work Definition

Kalay, Y. E. (2001), defined collaborative work as “The agreement among specialists to share their abilities in a particular process, to achieve the larger objectives of the project as a whole, as defined by a client, a community, or society at large.”

In parallel, the communication can be defined as the exchange of knowledge to reach a common goal, in our case the successful realization of a project. It is important to separate knowledge, information and data. The exchange of information can also be divided into three different types: inside a project, between projects and between the firms and the industry. Larson and Gray (2011) identified communication as one of the most crucial elements of a project’s success, and W. Turk (2006) found that failure to communicate can sabotage and ultimately collapse a project.

It has been shown that the construction industry is fragmented. To overcome this obstacle, which appears to diminish productivity, it is necessary to look toward better collaboration. Dainty, Moore, and Murray (2005) showed that the construction industry is mostly a service-oriented industry, which means each project will have a general contractor combined with a multitude of subcontractors. For this system to work effectively, good collaboration and communication between every participant are essential. Collaborative work is essential in construction and the managing of information is key.

3.3.1.3 Project structure to facilitate collaborative work

The traditional structure of construction projects and the importance of collaboration have both been elaborated. There are other structures that can improve collaboration and reduce fragmentation. This is especially true when considering that the definition of a construction process should include the whole lifecycle of a civil artefact, from design to operation and maintenance (Björk, 1999).

Hosseini, Haddadi, Andersen, Olsson, and Laedre (2017) talk about transactional base contracts in which each phase of a project has its own contracts, versus a relational base where all phases can be regrouped under one contract, making collaboration easier. They classified contract models into three main categories; the first category is the most well-known, Design-Bid-Build (DBB). This type of contract is qualified as transactional because there are separate agreements between the design, procurement and construction phases. The second category, Design-Build (DB), is considered as transactional relational, since it only involves two groups of players. The last one, called Integrated Project Delivery (IPD), is deemed relational based, as its integrated design and delivery team are in one group. To obtain the best level of collaboration, it seems helpful to focus on the IPD type, in which partnering improves communication and facilitates information sharing.

"IPD can be defined as a method of project delivery distinguished by a contractual arrangement among a minimum of owners, constructors and design professionals that align the business interests of all parties" (Cohen, 2010). The motivation in IPD is linked to the success of the project which is evaluated according to the success of the stakeholders along the following principles: participants are bound as equals, financial risks and rewards shared in terms of project outcomes, liability waivers established between participants, fiscal transparency, open communication, the early involvement of key participants, joint development, collaborative decisions, respect and willingness to collaborate (Cohen, 2010). From a study by (Kent &

Becerik-Gerber, 2010), the most commonly observed benefits with IPD projects are fewer change orders, cost savings, shorter schedules and fewer requests for information.

3.3.1.4 Computer-supported collaborative work (CSCW) in construction

The use of information technology has proven its usefulness in many other fields such as the automobile and aeronautical industries and is now gaining its place in the construction industry. “Information technology (IT) can be defined as the use of electronic machines and programs for the processing, storage, transfer and presentation of information” (Björk, 1999).

Many IT-based methods and approaches have been developed to facilitate collaboration. Thus, the exponential growth in the power of newer computers and the extent of the communication networks are making collaboration simpler and faster. It is now possible to be in one country and to collaborate on a construction project in another one. While this opportunity has been made possible from a technological perspective, it still appears to be complicated from a practical point of view, since cultures and backgrounds can be very different (Kalay, 2001). There is a tendency to find or create more common tools, accounting for multiple aspects of collaborative work. These tools are generally referred to as groupware, while the term CSCW is used for the scientific discipline aiming at designing adapted groupware (Penichet et al., 2007). “Collaboration platforms are used [not only] to improve the efficiency of synchronous and asynchronous collaboration, but also the management and sharing of both structured and unstructured information” (Ma, Zhang, & Li, 2018).

It is important that collaboration platforms can integrate all the information processing systems required for the execution of a project. These systems include project management systems, cost control systems, progress control systems, and logistics management systems, just to name a few (Guo, 2019). Working together, these systems can help to implement information management for larger and larger projects with more and more participants in different regions. These platforms offer the ability to coordinate the resources and information of a project in its whole lifecycle. “A perfect collaborative technology platform can achieve the ultimate goal of cost reduction, progress acceleration, quality assurance and risk control” (Guo, 2019).

There is not much literature available to describe such platforms. (Ma & Ma, 2017) conducted a study on the functional requirements of BIM-based collaborative platforms, to support IPD projects. Their study found five main categories of information: BIM models, drawings, documents, comprehensive information and audio-visual information. They also conclude that geometric and non-geometric information need to be regrouped and not treated separately.

Over the last decade, the construction industry has integrated the Building Information Model (BIM) as a tool to manage projects (Boton, Rivest, Ghnaya, & Chouchen, 2020). It is important to differentiate between the model, a structured representation of a building, and the modelling itself, a process that involves communication, especially the sharing and processing of information. According to (Ž. Turk, 2016), the BIM process can result in cost and time savings, increase the accuracy of estimates and help to reduce mistakes, as it vastly reduces the need for alteration and rework due to information loss. According to (Hung-Ming, Kai-Chuan, & Tsung-Hsi, 2016), there are drawbacks if BIM is used as a stand-alone platform. These include computers being overloaded by the size of the software, not being able to use multiple BIM projects at the same time, limited data sharing for multiple users in the same project, complicated statistical analysis, the need to store large files and to purchase costly software. To overcome such drawbacks, new solutions are being developed; one of the most significant makes use of cloud computing to ensure a better access to information and assure its continuity during the entire lifecycle of construction projects (Logothetis, Karachaliou, Valari, & Stylianidis, 2018). There is a current tendency for BIM software to support cloud-based services and offer web services and this type of service has become more and more popular (Hung-Ming et al., 2016). This approach will allow small and medium-sized enterprises to access BIM. Such broader access includes specialty contractors, who will be able to use BIM for cost-effective collaboration technology for communication, coordination and information transfer (Khan, Flanagan, & Lu, 2016).

As for the future direction for BIM or for any platform, (Ž. Turk, 2016) suggest the following three-phase approach: a) Structure: how to make the database better; b) Function: how to use the database better; and c) Behavior: how to change the environment and be changed by it.

As noted by (Kämpf & Haley, 2011), the integration of new technique and processes has increased the complexity of project management. With projects becoming more complex, more information is required, which is exactly where the newer technology will facilitate the planning, organizing, executing, monitoring, and evaluation of these projects. As mentioned by (Neil, 2007) and cited by (Dzudie, 2013), this complexity has justified the proliferation of Project Management Information Systems (PMIS) to foster efficiency in the strategic management of such projects.

CSCW, BIM and all information processing systems can be regrouped under a larger umbrella called the Common Data Environment (CDE).

3.3.2 Common Data Environment (CDE)

3.3.2.1 Definition

For (Preidel, Borrmann, Mattern, Konig, & Schapke, 2018), “The CDE represents a central space for collecting, managing, evaluating and sharing information.” The CDE is where all participants can retrieve and submit a project’s data. These include 3D models and documents which are necessary for the coordination and the execution of a project. The primary task is to provide a platform for information exchange within a controlled environment. The CDE thus serves as the basis for a well-defined way of cooperating among all participating stakeholders. The centralization of data storage within the CDE then reduces the risk of data redundancy and ensures the availability of up-to-date data at any time.

The work conducted by the (UK-BIM-Alliance, 2019) notes the differences between the CDE workflow (i.e. the process) and the solution (the technology). As a process, it will help to make information readily available for those who need it, when they need it. As for the technology, it will refer to the hardware/software required to support the process. The combination of both will define the proper use of a CDE. The advantages of adopting a CDE as a common place to share information, include its ability to reduce the time and cost of producing and coordinating information. Moreover, the ownership of information remains with the originator; while it is shared and reused, only the originator can change it. Data within a CDE is finely granulated and structured to ease its re-use.

The structured use of a CDE requires strict discipline by all members of a design team in terms of their adherence to agreed-upon approaches and procedures, compared to the relative “freedom” associated more traditional approaches. The benefits listed above can only be realized with a commitment to operate in a disciplined and consistent manner throughout the lifetime of a project. Another important aspect of project management concerns the internal communications between the involved parties. By centralizing all information in the CDE, this can also serve as a central communication platform. One significant advantage is that the transmitted information can be directly linked to information from the model, thus significantly increasing the power of expression and avoiding redundant communication paths. Finally, the handover and archiving of project information after construction will be simplified, as all information will be regrouped in one central place (Preidel et al., 2018).

3.3.2.2 Requirements and Organization

Now that the definition of the CDE is known, it is important to establish the requirements to create a CDE. In other words, what are the needs, the structure, the resources and the technology required to implement and to use such a platform. According to (Preidel et al., 2018), there are three main aspects to consider:

1. Adequacy, meaning that the objectives are proportional to the projects and capability of the contractor,

2. Neutrality in the use of procedures and measures that are independent of any particular software or customs programs,
3. Applicability to those procedures and actions can be applied to any size project or application field.

Collaborative work and information management are based on the need to be centralized and it requires a technical setup that allows information to be accessible anytime and by anyone with the right authorization. The access and the structure need to be established at the beginning of a project and should be updated on an ongoing basis. As mentioned earlier, this will depend on the size and type of a project as well as the technological level of the participants. To ensure the consistency of the information, it will be important to implement appropriate management of the property and access rights to this information. Finally, the information exchange should take place exclusively via the CDE, which will serve as a central archive for the duration of the project and beyond (Preidel et al., 2018).

As mentioned in the (PAS-1192-2, 2014), it is important to apply the Lean principles as much as possible. This means trying to avoid duplicity and overproducing of information, the need to search and wait for information and items, in other words, to maintain a high level of coordination. To be truly Lean, it is also being important that participants understand the future use of information. "This is achieved by "beginning with the end in mind" and identifying the downstream uses of information, to ensure that information can be used and reused throughout the project and life of the asset."(PAS-1192-2, 2014)

Before creating or developing any structure, an overview of the current options is presented.

3.3.2.3 Existing guidelines and manuals

The methods and procedures used are important to establish the rules inside the CDE (UK-BIM-Alliance, 2019). Various guidelines and manuals have been made available to standardize the structure and practices around CDE, including the Singapore BIM Guide (BCA-Singapore, 2013), German standard (VDI-2552-Blatt-5, 2017), British Publicly Available Specification (PAS-1192-2, 2014) and (PAS-1192-3, 2014) and International Standardization Organization (BCA-Singapore, 2013).

Those guidelines provide the best practice for the development, organization and management of production information for the construction industry and provide templates for common naming conventions and approaches to collaborative working in construction throughout the lifecycle (procurement, design, construction, delivery, operation and maintenance) of buildings and civil engineering projects.

In addition of those guidelines, the International Standardization Organization (ISO) recently issued a series of standards (ISO/DIS-19650-1, 2017) that cover the management principles and requirements of all the basic information (geometric and non-geometric information including construction record, meeting, contracts, etc.) in the sectors of the built environment throughout the lifecycle of assets (design, construction, refurbishment, operation and decommissioning).

Finally Radl and Kaiser (2019) suggested that governments should launch initiatives to standardize this environment.

3.3.3 Challenges and obstacles

It is widely recognized that the implementation of BIM-based projects and the related collaborative process are becoming a part of the construction industry (Logothetis et al., 2018), but there are still challenges. One of them, according to (Preidel et al., 2018), will be to manage information throughout the whole lifecycle of a project. As mentioned previously by (Howard et al., 1989), one of a main characteristic of the construction industry, and one that makes it less productive than the others is fragmentation. Starting from this perspective, one of the major challenges related to the use of a CDE is how to make the stored information accessible to all parties so that the information can be queried and retrieved quickly (Preidel et al., 2018).

On the technology side (Samuelson, 2002) brought some obstacles as software non-compatibility and their continual demand for upgrading. Other challenges that are becoming more and more important with the increasing use of the Internet are cyber security threats and connection speeds (Khan et al., 2016). Also, the human factor has been investigated, as it poses other challenges: difficulty in measuring profits, in assessing if the investment cost is too high, insufficient interest/commitment from management, the general attitude that "old ways of doing things have worked well throughout the years and changes are unnecessary," the higher level of training required by staff, preferences for working manually because of lack it can avoid standards/coordination problems, and decision makers that have no time for IT efforts because of their heavy work load (Samuelson, 2002). Also, according to (Boton, 2009), some less developed countries may want to migrate to BIM but they lack the required organizational and material resources.

To understand the CDE, it is important to take in consideration, not only the technology but also and mostly the human factor that will drive it. The theoretical part of the CDE has been covered and from this position of knowledge, a survey was conducted to investigate the human interaction with technology as the main vector to define CDE. This subject featured what technologies people are using, how they use them and why? This survey is part of the research methodology which is elaborated in the next section.

3.4 Research methodology

For the information technology in construction (ITC) research, Bjôrk (1999) noted that researchers are usually concerned with the development of tools which change reality rather than studying reality as it is, without influencing it.

Based on the previous statement and the research questions, a research methodology has been put in place using an online survey. The main purpose the survey is to collect information from large industrial construction project about the current situation of information management, and the practitioners' perception of CDEs. A literature review was conducted at the beginning, then elaborated in the previous section, that covers mostly the theoretical definition of CDE and its main component. This section explains how the survey was constructed and gather the desired data, including the selection of participants. The analysis and discussion of the data collected are presented in the section 4.

3.4.1 Construction of the Survey

The goal was to collect information and comments about CDE from a targeted group in large civil and industrial construction projects. The idea was to get information about the current situation of information management and how it is utilized, as well as to see if the CDE is a known subject in the construction industry. The online survey approach was chosen to acquire this information. It is probably the most efficient, because it is easy to use, and a range of samples can easily be reached with low investment in time and money.

The online survey is the simplest and most expeditious way to collect information from companies in terms of information sharing and management without unduly disturbing the time of highly trained personnel (Murray & Fisher, 2002). For this survey, a questionnaire was built and designed to complete the literature review. It was important to be as comprehensive as possible, while remaining as brief as possible in terms of duration to minimize the time investment of any candidate who may wish to respond.
The following subjects were addressed:

1. Company and individual description: What type of business role (client, professional or contractor) does the survey respondent represent?
2. Project description: What type of project (civil, industrial, commercial, public or private)? What type of contract/embodiment (traditional, Design-Build, PPP) is involved?
3. Collaboration: Who is working with whom, how and in what capacity?
4. Information technology and transfer: Technological level of the construction company? Do they use an information management system? (identified by program or manual)

5. BIM - Building Information Modelling/Management (Digitalization): How were the project design/drawings made originally? How the digital models are organized and linked together? What other function the digital model is used for?
6. Performance, improvements and expectations: Is it possible to have only one system? What would be your vision of a dream environment in which to build projects?

The approach taken in the first part (1–5) of the survey is quantitative and will help to confirm and understand the actual situation by obtaining the number, percentage and ratio of topics related to the subject of this article. Indeed, the sections 1–5, mainly collect statistics regarding the diversity, spread and frequency of the investigated information. The last part (6) is more qualitative and investigates the actual perception and comments from the selected candidates. Thus, this last section, collect the respondent's opinions, observations and comments.

3.4.2 Distribution of the Survey and Data Collection

The online survey method was chosen to gather the needed information for the reasons mentioned above. It was decided to target a specific group of candidates instead of openly distributing it at large. This selective approach was used with specific criteria, these candidates were all involved directly in a construction project, had a management position and had experience in their field. This approach was also chosen because the author has thirty years' experience in this field and this experience was used to get this specific group of candidates.
According to (Strausss & Corbin, 1990) and cited by (Hoepfl, 1997), theoretical sensitivity, which refers to a personal quality of the researcher, can add more validity to a research study. Theoretical sensitivity indicates an awareness of the subtleties of the meaning of data. It refers to the attribute of having insight, the ability to give meaning to data, the capacity to understand, and the ability to separate the pertinent data from meaningless data. Theoretical sensitivity is believed to be developed from a number of sources, including professional literature, professional experiences, and personal experiences. The profile of the author, with 30 years' experience in this field, is in line with Strauss and Corbin's theoretical sensitivity outlook and has been used for this research.

One hundred candidates were selected, based on the author's 30 years' experience. Among the one hundred candidates invited, forty-four responded, the rest did not acknowledge receipt of the survey. In the ones who have responded, thirty-two completed the survey, five completed partially and seven responded but declined to answer it.

Once selected, each candidate was sent an email which included an introduction that explained the context of this research, its objectives, scope and timeline. An explanation of the procedure and the sequence of the survey was also included, along with a link to the online survey.

To manage the survey, an online platform (Limesurvey) that allows for several types of questions (true or false, multiple choice and even with essay questions) was chosen. The results of the survey were compiled by categories and each question was developed with tables and graphics to show the spread of data. While the Limesurvey platform was able to sort the collected data and could generate graphics, it was still necessary to review the results before using them. To do so, they were exported to Excel, from which new tables and graphics were generated to be used in this article.

3.5 Results and Analysis

The goal of the survey was to explore the perception of practitioners involved in large industrial and civil construction projects and to provide an understanding of their practices and expectations regarding the use of CDEs. The results are presented from which an interpretation is proposed.

3.5.1 Companies and respondent's Information

Most of the respondents are in a direct management position. Those positions are shown in figure 3.1. It is notable that there was no architect in this survey, due to the nature of the selected projects, which is more civil and industrial. Two - thirds of the respondents are directly involved with the owner and have a direct contact with him. Most respondents have been involved on an average of twenty-one and half months on their project. The major fields of expertise of respondent's companies are shown in figure 3.2. Half of the respondent's companies have over 1000 employees.

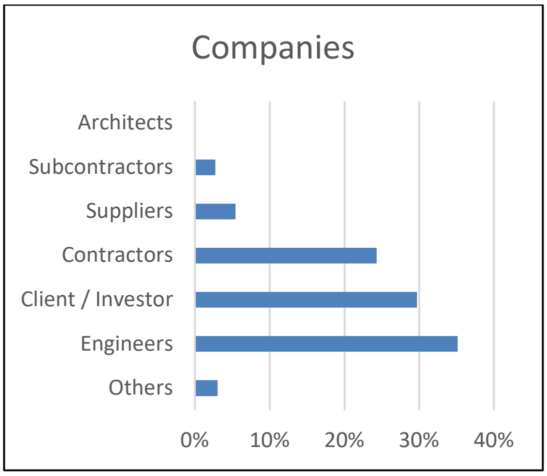

Figure 3.1 Respondents

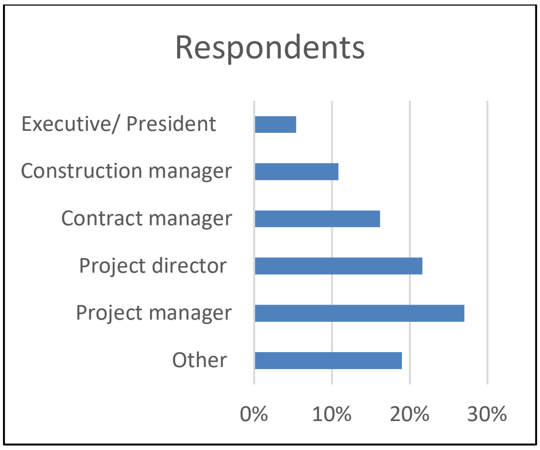

Figure 3.2 Companies

3.5.2 Projects' Information

The types of projects in this survey are represented in figure 3.3. Most are from the civil and industrial sectors. Among these, 50% are from the public sector, 45% from the private sector and 5% from Public and Private Partnerships (PPP) (figure 3.4). Half of the projects are under 50M$, and 33% of those over 50M$ have budgets of over 1 billion dollars. The average duration of these projects are 27.4 months. They are mostly located in Canada (24), with Morocco (5), the USA (2), Australia (2), France (1) and Saudi Arabia (1) making up the rest.

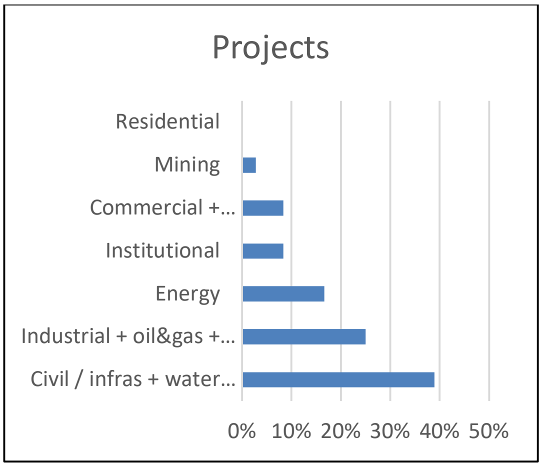

Figure 3.3 Projects

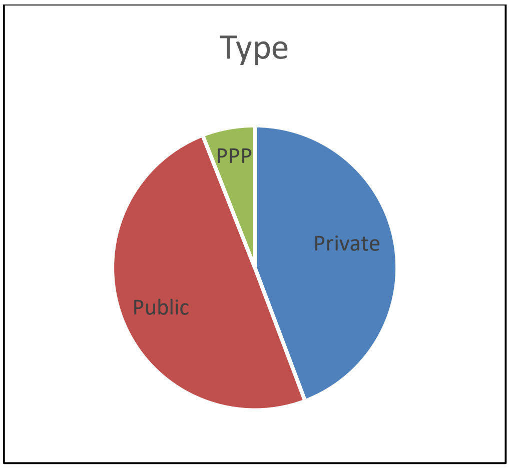

Figure 3.4 Type of projects

3.5.3 Collaboration Inside the Projects

The delivery modes are shown in figure 3.5. The Design Bid Build (35%) is the most used project delivery mode, followed by Engineering Procurement Construction Management (EPCM) (26%) and Engineering Procurement Construction (EPC) (21%). Only 6% are being made under the IPD mode.

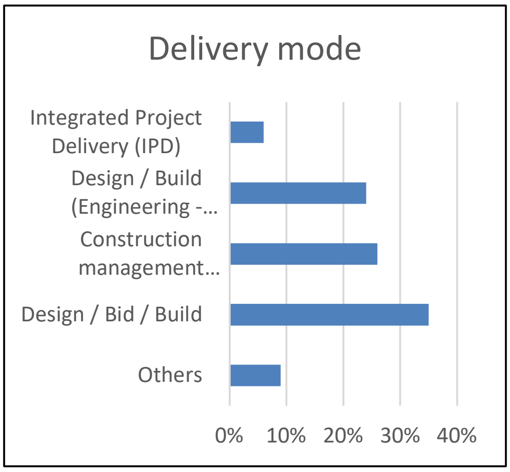

Figure 3.5 Delivery mode

The frequency of communication and the types of documents exchanged between stakeholders (client, project managers, professionals, contractors, subcontractors and suppliers) were indicated as something that occurred mostly on an everyday basis, except for communications with the supplier, which were more on a weekly or monthly basis, if not upon request.

Regarding the amount of information management system, the majority (65%) of the projects in the survey have more than one. The owners of this information management system are shown in figure 3.6. The contractors (32%) and engineers (32%) are the ones who own the most common types of systems. As for who are the users of this main system, contractors (70%) and engineers (70%) are the ones who use it the most, as shown in figure 3.7. Another interesting fact is that the clients are involved in all of the projects; 65% are involved in day-to-day activities, and the rest (35%) only for meetings and follow-up efforts. A vast majority

(94%) of the clients required their information in an electronic format, while 41% also required a paper format.

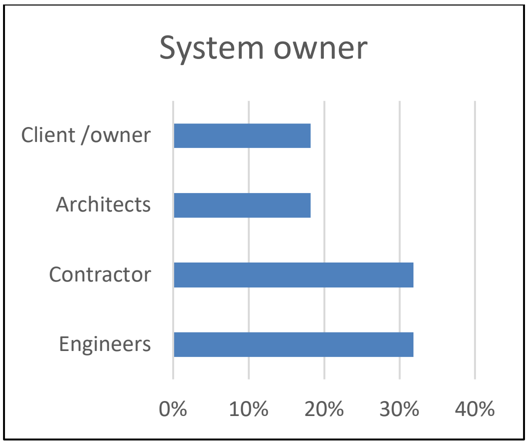

Figure 3.6 System owner

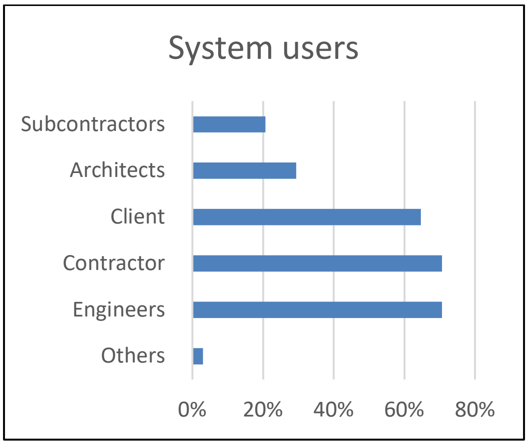

Figure 3.7 System users

3.5.4 Information Technology and Transfer

On the hardware side, it seems that the most used file server belongs to the client, with 40% (see figure 3.8). Figure 3.9 shows what type of servers are used by the stakeholders. The internet/multi-location access (64%) server seems to be by far the most popular one.

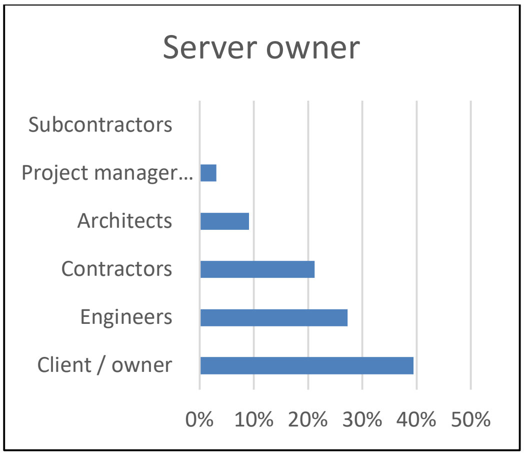

Figure 3.8 Server owner

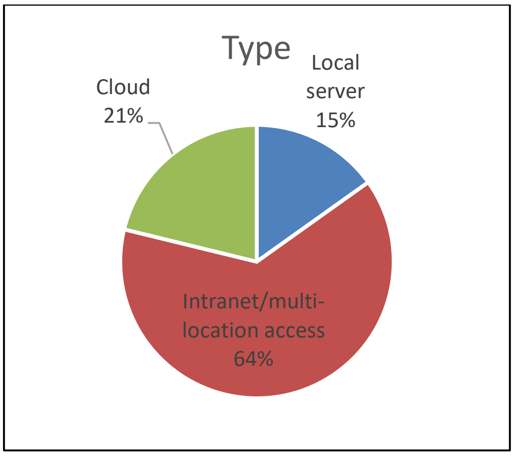

Figure 3.9 Server type

The types of stakeholders who are using that server are distributed as follows: Engineers (73.53%), client/direction (61.76%), Contractors (61.76%), Architects (26.47%), client/operations (17.65%), Subcontractors (14.71%), and Other/don't know (2.94%).

The most of the project information is stored in the main server, with 100% of the documents and 74% of the graphical data. The rest of the information is probably stored on a separate server.

To continue with the hardware, figure 3.10 shows that laptops are the most used hardware to manage the information with 94%, followed by smartphones (for storing and managing information, and in this case not as a phone) with 82%, desktops at 59% and tablets at 47%. Other hardware used on these projects were laser scanners (21%), drones (15%) and AIDCs (Automatic Identification and Data Capture devices), with 3%.

On the software side, among the 57 types that were mentioned by the respondents, Excel is the one most used, followed by custom in-house software, MS Project, Primavera, SAP and Outlook. The only named here were those with 5% popularity and above.

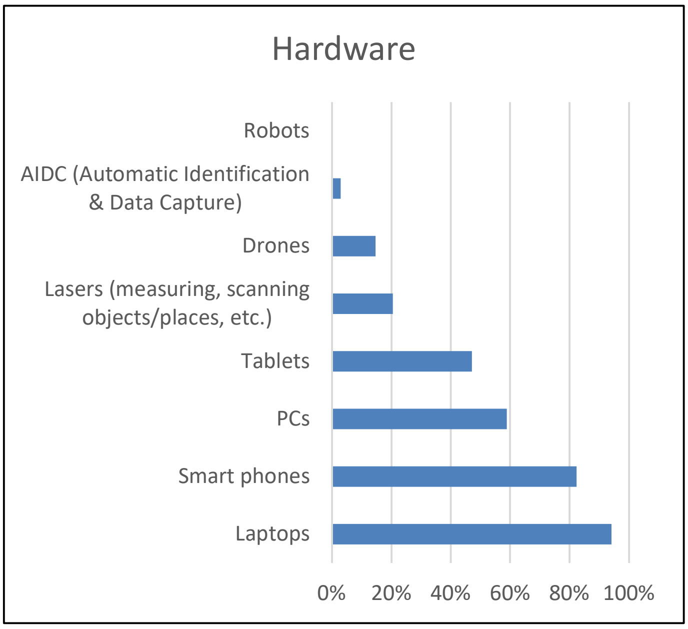

Figure 3.10 Hardware

It is also observed that software is mostly used for communication (11.1%), scheduling (10.6%), drawing management (11.1%), document management (10.2%), cost management and reporting (8.5%). Finally, it is important to note that most of the projects had an internet connection that ranged from average to excellent in terms of connectivity.

3.5.5 3D Digital Model and Management

Somewhat surprisingly, 43% of the respondent's projects are still authored from 2D, mostly done from AutoCAD. Slightly more than 55% originate with 3D CAD and DMU (Digital Mock-up). Only 5% confirmed using DMU, but the respondents may have confused the definition of DMU and 3D. In fact, many of them replied to this question with 3D CAD, but they are using programs which are for DMU, such as REVIT, TEKLA, Aconex and BIM 360 Glue. The others are more likely solely 3D CAD programs such as AutoCAD 3D and Smart Plant. The remaining 3% did not know how their project design was authored. These results are represented in figure 3.11.

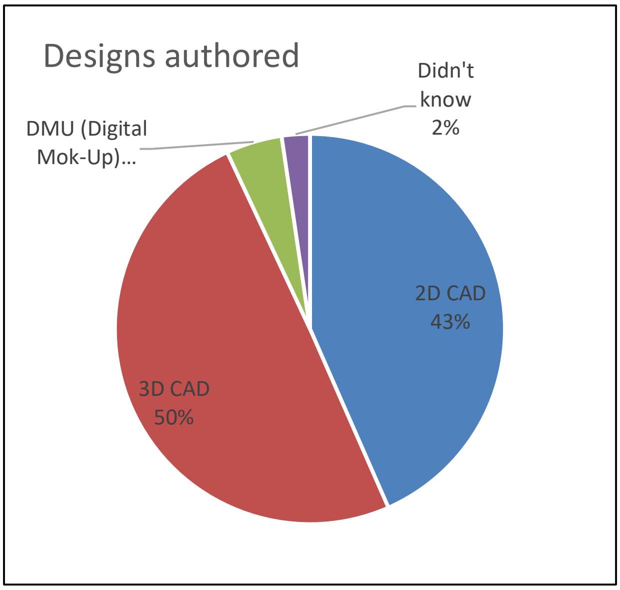

Figure 3.11 Designs authored

According to the respondents, 61% of the projects had a 3D digital model, and of this 61%, 50% was requested by the client, followed by engineers (28%) and architects (22%).

3D digital models can be managed/organized in different ways. Based on the survey's responds, they are organized as shown in figure 3.12. The independent stand-alone model (Level 1) is the most popular option.

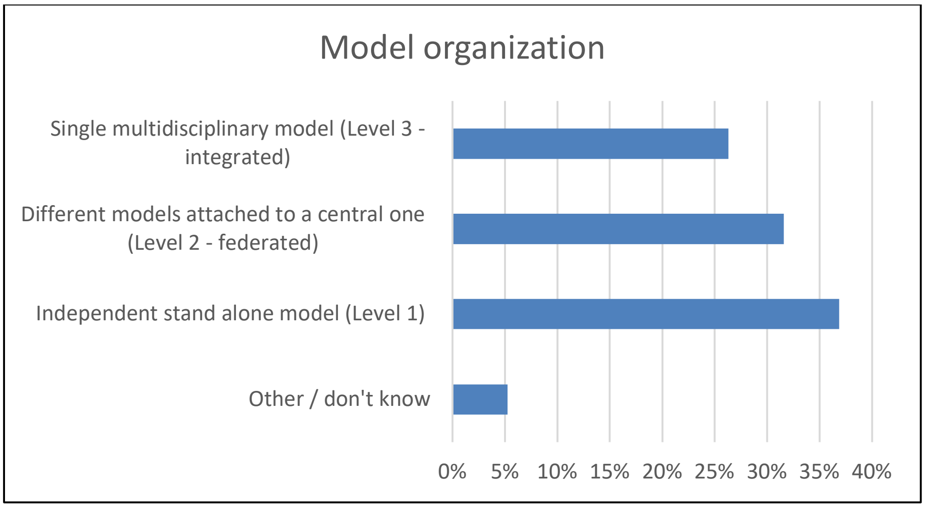

Figure 3.12 Model organization

Aside from the conception and graphical representation, the digital model is mostly used for project management (45%), followed by cost management (33%), and finally for scheduling (22%).

Surprisingly, only 43% of the clients were interested in keeping the 3D digital model after the project.

During this survey, it was verified if the respondents use Geographic Information System (GIS) as topographic coordinates, cadastral and numeric data related to position. It is interesting to note that 18% did not know about GIS. On the remaining, 36% use it and 46%do not.

3.5.6 Performance, Improvement and Expectations

Regarding their satisfaction with the existing system, 75% of the respondents were satisfied with the communication system, even though they stated that there are too many emails and the chain of communication is not respected, or there are poor identification and traceability. Some respondents mentioned that in large projects, basic methods and tools were still being used and new technologies would have been appreciated and helpful considering the size of the project (12bb$). The respondents, who used collaborative platforms, found them very complete and very useful.

In terms of documentation management systems, 60% were satisfied with their existing system. Better integration between the 3D CAD and the document management system was indicated as a practical improvement. On the 40% unsatisfied, some respondents noted that it would have been appreciated to simplify to a single system instead of using two or more, which is time-consuming. When a system was imposed by a client, very often it did not respond to the needs of the contractor. Access management was heavy since they needed to go through the IT department. Some other had no technological support and needed to do it all manually. One respondent mentioned the need of a dedicated BIM manager to ensure data to be well input. Finally, some of them mentioned that they are looking for new updated system.

Only 22% of the respondents find it difficult to work with a company that is geographically distributed. They all agreed that the new technologies facilitated overcoming the distance in practical management. Good connectivity is also important, as it is necessary for handling documents electronically and remains an important factor.

Seventy-five percent of the respondents believe that it is possible to have all project information in a single place/system, while acknowledging that this would require early planning and the need to set up the structure, processes and rules in the early stage of the project. A single system would also require a dedicated team to implement, monitor and maintain it in good order. This single system approach is possible with the necessary restricted access level for various levels of privacy. One respondent reported; “The system we’re using have all information in the same place, but it’s not being used as a coordination platform to share BIM models, etc., it’s more of a document management system.” Another respondent has worked on other projects where this was implemented successfully.

It seems that the biggest obstacle/problem to having a single source of information would be that there are often too many information systems involved (obstacle cited by 28% of the respondents). A summary of the most-mentioned obstacles is shown below in figure 3.13.

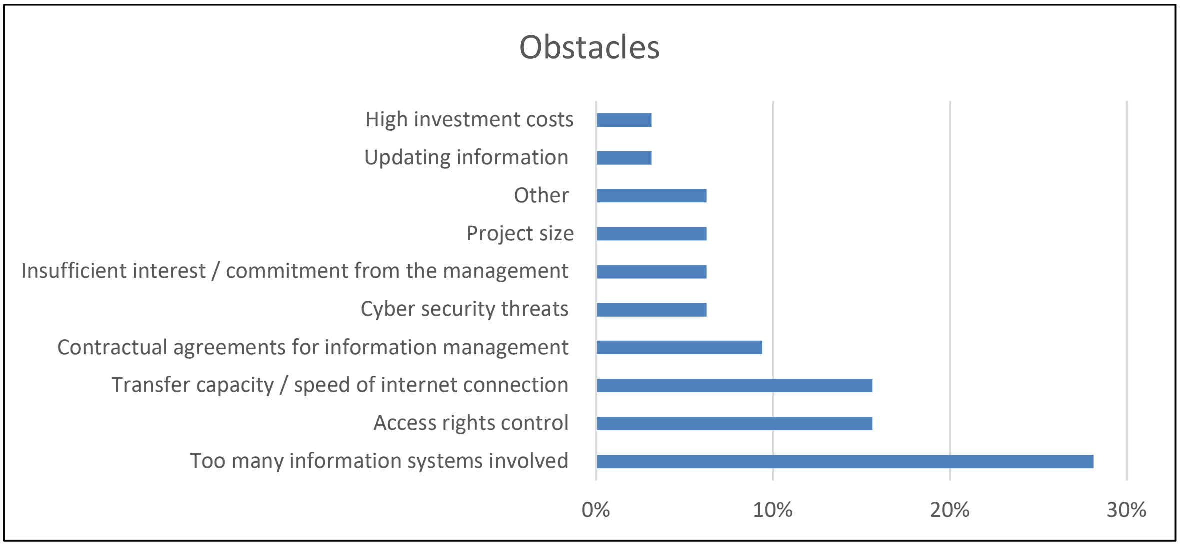

Figure 3.13 Obstacles to a single information system

The perceived benefits of using a single source of information are indicated in figure 3.14:

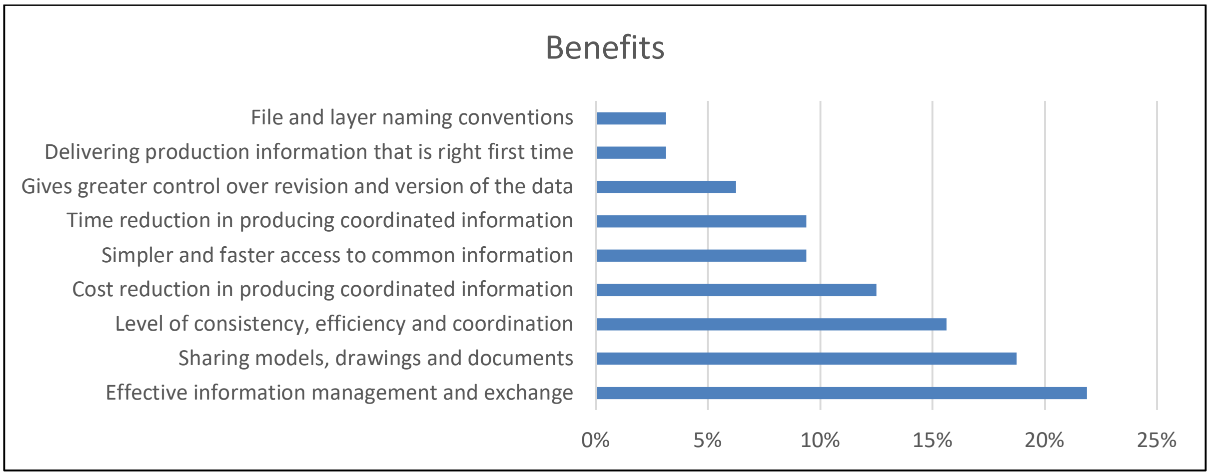

Figure 3.14 Benefits of implementing a single source of information

According to the respondents, it seems that having a central system for collecting, managing, evaluating and sharing all information is the best option (50%). Having different systems that are linked together also seems an interesting option for many (44%). Everyone seems to agree that having different systems that are not linked together is not a good way to organize work on a project (6%).

As for the position of the 3D model in the information management system, 56% see it as a complementary role: the 3D model is just another source of information attached to a centralized main system, while 38% see it as having a central role: The 3D model is in the centre and all information will emerge from/to it. A small minority of respondents see it as being disconnected, so that the 3D model is treated separately as an independent source of information with no link to other systems.

Finally, regarding the CDE, only 28% of the respondents have heard of the wording "CDE" (Common Data Environment) before! Among the respondents who know about the CDE, 56% are knowledgeable and 44% only a rough idea.

3.6 Discussion

In this section the results presented above will be discussed. First, they are compared with the literature and then draw a path forward regarding CDEs. To build this path forward, the four main questions of the research will be answered: What should a CDE be? What information is really needed? How it should be structured? How and who should access it?

What should a CDE be? "The CDE is defined as a common digital project space that provides distinct access areas for the different project stakeholders combined with clear status definitions and a robust workflow description for sharing and approval processes" (Preidel et al., 2018). The (PAS-1192-2, 2014) has also described the CDE as a "single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multidisciplinary teams in a managed process.”

Very few of the respondents had heard of the wording “CDE”! While most of them may not know the terminology, they all know about information management systems. That is why in the survey the terminology of CDE was only introduced at the end in order to keep the respondents in known surroundings. For project managers, it has always been an objective to have a central place to put all the information together and to provide the necessary information where and when it is needed. For most of the respondents, it is possible to have all project information in only one single place/system and for half of them, one central system in comparison of different systems linked together. From that point of view, an open mind should be kept about how a central space can also be different systems linked together. According to them, while it is possible, it would require early planning so that the structure, processes and rules can be set in the early stage of a project. They also recommend dedicating a team to implement, monitor and keep this system in good order. Finally, they believe that this system would require the necessary restricted access levels for various levels of privacy.

CDE might not be a well-known terminology but it is clear that information management was and will be there and the goal to simplify the process is the continuous effort to ease this necessity. Before BIM era, it was very difficult, even impossible to reach those objectives. It is now possible and feasible to manage information throughout the entire lifecycle of any artefact, and the limits exposed previously are becoming less and less. In a general way, the CDE is this effort or result to simplify the information management through the all lifecycle of a project. The precise definition would be to reach a common and universal referral system and procedure to make it recognized and use by everyone.

What information is really needed? It is important to note that the survey was made among large construction projects, mostly from the civil, industrial and energy sectors, half from the private sector and half in the public domain. While there are still projects authored from 2D, half utilized 3D Digital Mock-ups that were requested by the client. In a more closely look to the digital model, after being used for the design process and graphical representation, the digital model was mostly used for project management, followed by cost management and finally for scheduling. As for the use of a common server (hardware), it seems that documents, such as reports, memos/emails and 2D drawings are the most-used items in it. Graphical data came second, which is a positive surprise since it means that new IT is being used. It was also noted that, on the software side, the mostly used is for communication, scheduling, drawing management, document management, cost management and reporting. These activities were accomplished with basic software like Outlook, Excel, MS Projects or SAP oriented for accounts and invoicing, as well as customized software for project-specific tasks. The challenge remains to simplify and connect those softwares or replace them by one.

With the new technology, as mentioned earlier, the possibilities become limitless. More people are using it and an increasing number of people want to use it. However, it is clear that this new technology requires proper training to allow people to explore the possibilities. The fact that basic software is still the type most commonly type used shows this lack of knowledge and education. The potential is huge and new hardware and software are available.

How should a CDE be structured? First, “a comprehensive definition of the construction process should clearly include the whole lifecycle of civil engineering artefacts, including design, construction, operation and maintenance” (Björk, 1999). It is important to set up any structure for a long-term vision and to use one that can be effective for the whole lifecycle. The importance of collaboration has been seen, and IPD is a type of delivery mode that favours collaboration. Our survey results show that very few of the projects are actually set up as IPDs, but half of them are managed as EPCs or EPCMs, which can be considered collaborative since they reduce the fragmentation of the processes. Meanwhile, half of the projects are still organized under traditional structure formats. Obviously, that traditional structure still has its place. The need for collaborative approaches is present and is evolving. While it surely will facilitate collaboration, whatever the delivery mode, contractual specification remains the key to CDE implementation. Based on the survey, the contractors and engineers are the ones who own most of the information systems used during a construction project. Without a long-term vision, it seems obvious that those two actors drive the flow of information until the delivery of the project. If that flow is not aligned with the end user (the Client), it could pose a problem. Even if the client does not own the system, it appears that the client is getting more and more involved in the projects, meaning that those clients are participating in the construction phase. This involvement indicates a potential alignment with the handover at the end of the construction phase. On the other hand, as mentioned by one respondent, when the system was imposed by clients it might not respond to the needs of the contractor, and vice versa.

Indicating a good step toward technology, the majority of the clients required electronic format, but still half of them, still included a paper format. This shows that while there is not yet a full trust in electronic systems, that trust is definitely in a process of transition. More than half of the projects have more than one information management system. Some respondents have mentioned that it would have been appreciated to simplify their projects to exploit a single system instead of using two or three. Along the same lines, other respondents said there are too many systems and that the situation could be simplified. This brings us back to collaborative platforms. Only one respondent mentioned using a single platform and found it useful and applicable. The CDE needs to be developed correctly and the stakeholders need to know that there are tools to facilitate this main activity.

The use of Digital Mock-up (3D models) is becoming more and more popular, and it is important to discuss its location within the information management system. More than half of respondents see it as a complementary role, so that the 3D model is just another source of information attached to a centralized main system. This confirms the definition of CDE as being the central system, and BIM (model) part of it. This shows the evolution toward the single source of information.

In the literature review, several guidelines were mentioned to establish the structure and operation mode of the CDE. As a condition of compliance, it is important to have a universal known structure. Among those described previously, ISO is already known world wild for its publication of many standards, especially ISO 9001, which is now the world reference for quality. Can it be the same with information technology? It is crucial to agree on a universal standard, as it was established that collaboration is the main key for success in modern construction. As with English for communication, or ISO9001 for quality, a common ground needs to be established on how to manage information and the new ISO can be a very good option.

Finally, for a structure to be accepted and functional, the following points must be considered: 1) It is critical to understand its future use in order to ensure information can be used and reused throughout a building project and throughout the life of the asset (PAS-1192-2, 2014);
2) A common PMSS or collaborative platforms must be agreed upon a mechanism put in place to ensure updates are done regularly; and 3) Finally, information exchange should take place exclusively via the CDE so that it can be retrieved later and so that the CDE serves as a central archive (Preidel et al., 2018).

How and who should access the CDE? The most used file server belongs to the client. This makes sense, as it is the client who initiates the project, and he is the one who will receive and keep all the information at the end. This set-up is in line with the objective to simplify the information management through the all lifecycle of a project. With real-time information sharing becoming more common, it is interesting to note that the intranet/multi-location is the most popular way to operate with the server. Clients, engineers and contractors are the ones who use it the most. Accessibility does not seem to be an issue, as most of the projects report their internet connection as being from average to excellent. Most of them find it easy to work with a company that is geographically distributed. They all agreed that the new technologies facilitated managing the work over distances. This is more and more important now that the national economy is becoming more connected worldwide.

The main problem remains the responsibility of safeguarding the information. This is why the accessibility of information will remain an issue until a collaborative agreement such as IPD can be put in place to facilitate collaboration and share risks and opportunities. Meanwhile, it may be difficult but should be possible to grant access to various participants in terms of their rank and need for specific information.

Globally, most respondents were satisfied with their existing communication and documentation systems. The use of many systems, access and security, rapid internet connections seem to be the main gaps to fill to complete the respondents' satisfaction. Having a single source to manage information, documents and communication can be achieved, but not without obstacles. The survey showed us that those obstacles are real but that they can be overcome. Table 1 shows the obstacles mentioned in the literature review vs. those observed in the survey.

Tableau 3.1 Obstacles

Obstacles from the literature review	**Obstacles from the survey**
Stored information accessible to all parties ****	Access rights control
Threat of cyber security *	Cyber security threats
Speed of Internet connection *	capacity / speed of internet connection
Contractual agreements ***	Contractual agreements for information management
Not compatible software ****	
Continual demand for upgrading **	
Investment cost too high **	High investment costs
Insufficient interest from management **	Insufficient interest/commitment from management
Preference for keeping the old ways of doing things **	
	Project size
	Too many information systems involved
	Updating information
*Ref. * (Khan et al., 2016)*	
** (Samuelson, 2002)	
*** (Ruparathna & Hewage, 2015)	
**** (Crotty, 2012)	

It is clear that in today’s world, technology is ubiquitous, and the technology to manage any size of project is already available. It seems that those obstacles can be overcome. There will be almost no limitations apart from the human factor! The main challenge won’t be the technology but to agree upon a common structure, who will access it and most of all, to make sure it is used and updated properly and regularly.

3.7 Conclusion

The theoretical and practical definitions of CDE were explored to determine the needs for its implementation in large civil and industrial construction projects with today's technology. This process began with a literature review dealing with project structures, collaborative work and computer-supported collaborative work [CSCW]. The literature review was completed with a definition of CDE, its requirements and organization, the existing guidelines and the known challenges and obstacles. A survey was then designed and sent to experts in the field to gather their feedback regarding information management. The survey included collecting the project and respondent's information, their collaboration within their project, the IT and transfer methods used, the type of 3D digital model utilized (if any) and details about their IT's performance, along with improvements and expectations. The analysis and the discussion of the results were processed and the research questions about CDE were able to be answer.

The results will serve not only to better understand the problem, but also to guide the construction industry with the new information-sharing technologies. Incorporating CDE should lead to more effective communication and information management that will result in an increase of productivity and a reduction of misunderstandings and disputes, all with cost and time savings. The survey allowed for an update of the current situation in the field and brings a new perspective to the understanding of the practices and dynamics of collaboration and digital tools. At the scientific level, this work will add to the understanding of CDE and proposes a direction for further research.

Any construction project needs updated information, communication and collaboration for its execution and completion. As humans and technology are constantly evolving, the main challenge is to adapt to those changes. All of the respondents described how they use information management systems in their own words. The major new aspect today is the technology called Digital model, collaborative platform, BIM and CDE. It is clear to define vocabulary and approaches in order to speak the same language for good communication and collaboration, but defining the vocabulary and approach is not enough. It is also very important to make these universal and to teach them to the whole construction community. It was shown that ISO 19650 could be a good start, as ISO is already well known and established in most countries. With or without technology, the success will be in the discipline and willingness of the construction community to establish and follow a common structure.

It is difficult to cover all aspects about CDE for the full lifecycle of a project. It would be interesting to analyze the involvement of the different stakeholders in the different lifecycle phases. This research was done for large civil and industrial construction projects and was limited to a certain number of respondents. This could be extended to other types of projects and be targeted to a wider number of participants. The relational project structure was limited to IPD, but additional options can be explored.

Finally, there has been limited research into collaborative platforms. It will be worthwhile to develop more on this subject as well as the concept of digital twins since the use of information technology is increasing every year.

Data Availability Statement

Some or all of the data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

CHAPITRE 4

DISCUSSION DES RESULTATS

4.1 Discussion des résultats

La discussion sur les résultats a bien été présentée dans le chapitre précédent (sections 4 et 5 de ce dernier). Par contre, nous pouvons en faire un résumé et les comparer à la revue de littérature en répondant aux quatre questions principales énoncées au début de ce mémoire sur le CDE.

Que devrait être un CDE ? Le (PAS-1192-2, 2014) décrit le CDE comme une source d'information unique pour toute sorte de projets, utilisée pour collecter, gérer et diffuser tous les documents nécessaires pour les équipes multidisciplinaires dans un processus gestion de ces projets.

Très peu de répondants avaient entendu parler du terme « CDE » ! Bien que la plupart d'entre eux ne connaissent pas la terminologie, ils connaissent tous les systèmes de gestion de l'information. C'est pourquoi, dans l'enquête, nous n'avons introduit la terminologie CDE qu'à la fin du sondage afin de maintenir les répondants dans un environnement connu. Pour les chefs de projet, il fut toujours un objectif d'avoir une place centrale pour rassembler toutes les informations et fournir les informations nécessaires où et quand elles sont nécessaires. Pour la plupart des répondants, il est possible d'avoir toutes les informations du projet dans un seul endroit / système et pour la moitié d'entre eux, un système central en comparaison de différents systèmes reliés entre eux. De ce point de vue, nous devons garder l'esprit ouvert sur la façon dont un espace central peut également être différents systèmes reliés entre eux. Selon eux, bien que cela soit possible, cela nécessiterait une planification précoce afin que la structure, les processus et les règles puissent être définis au tout début d'un projet. Ils recommandent également de consacrer une équipe à la mise en œuvre, au suivi et au maintien de ce système. Enfin, ils estiment que ce système exigerait les niveaux d'accès restreints nécessaires pour différents niveaux de confidentialité.

Quelles informations sont vraiment nécessaires ? Il est important de noter que l'enquête a été réalisée auprès de grands projets de construction, principalement dans les secteurs civil, industriel et énergétique. La moitié étant dans le secteur privé et l'autre moitié dans le domaine public. Bien qu'il existe encore des projets créés à partir de 2D, la moitié utilisait des maquettes numériques 3D demandées par le client. Si l'on regarde de plus près la maquette numérique, après avoir été utilisée pour le processus de conception et la représentation graphique, la maquette numérique a été principalement utilisée pour la gestion de projet, suivie de la gestion des coûts et enfin pour l'ordonnancement. Quant à l'utilisation d'un serveur commun, il semble que les documents, tels que les rapports, les mémos / courriels et les dessins 2D, soient les éléments les plus utilisés. Les données graphiques sont arrivées en deuxième position, ce qui est une surprise positive, car cela signifie que de nouvelles technologies de l'information sont utilisées. On peut également noter que, côté logiciel, le plus utilisé est la communication, la planification, la gestion des dessins, la gestion documentaire, la gestion des coûts et la génération de rapports. Ces activités ont été réalisées avec des logiciels de base comme Outlook, Excel, MS Projects ou SAP orientés pour la comptabilité et la facturation, ainsi que des logiciels personnalisés pour les tâches spécifiques au projet. Le défi reste de simplifier et de connecter ces logiciels ou de les remplacer par un seul.

Comment structurer un CDE ? Il est important de mettre en place toute structure pour une vision à long terme et d'en utiliser une qui puisse être efficace pour tout le cycle de vie. Nous avons vu l'importance de la collaboration et l'IPD est un type de mode de prestation qui favorise la collaboration. Les résultats de notre enquête montrent que très peu de projets sont effectivement mis en place en tant qu'IPD, mais la moitié d'entre eux sont gérés en tant qu'EPC ou EPCM, ce qui peut être considéré comme collaboratif, car ils réduisent la fragmentation des processus. Pendant ce temps, la moitié des projets sont toujours organisés sous des formats de structure traditionnels. Évidemment, il faut considérer que la structure traditionnelle a toujours sa place. Le besoin d'approches collaboratives est présent et évolue. Si elle facilite certainement la collaboration, quel que soit le mode de livraison, la spécification contractuelle reste la clé de la mise en œuvre du CDE. Sur la base de l'enquête, on peut dire que les entrepreneurs et les ingénieurs sont ceux qui possèdent la plupart des systèmes d'information utilisés lors d'un projet de construction. Sans une vision à long terme, il semble évident que ces deux acteurs animent le flux d'informations jusqu'à la livraison du projet. Si ce flux n'est pas aligné sur l'utilisateur final (le client), cela pourrait poser un réel problème. Même si le client n'est pas propriétaire du système durant la construction, il semble que ce dernier s'implique de plus en plus durant cette phase du projet. Cette implication indique un alignement potentiel avec la remise à la fin de la phase de construction. D'un autre côté, comme l'avait mentionné un répondant, lorsque le système était imposé par les clients, il pouvait ne pas répondre aux besoins de l'entrepreneur, et vice versa.

Indiquant un bon pas vers la technologie, la majorité des clients avaient besoin d'un format électronique, mais la moitié d'entre eux incluaient toujours un format papier. Cela démontre qu'il n'y a pas encore une confiance totale dans les systèmes électroniques. Cette confiance est définitivement dans un processus de transition. Plus de la moitié des projets ont plus d'un système de gestion de l'information. Certains répondants ont mentionné qu'il aurait été apprécié de simplifier leurs projets pour exploiter un seul système au lieu d'en utiliser deux ou trois. Dans le même ordre d'idées, d'autres répondants ont déclaré qu'il y avait trop de systèmes et que la situation pourrait être simplifiée. Ce qui nous amène à la centralisation des informations et aux plateformes collaboratives. Un seul répondant a mentionné utiliser une plateforme collaborative et l'a trouvée utile et positive son utilisation. Très peu d'études ont été réalisées sur les plateformes CDE. Un CDE doit être correctement développé et les parties prenantes doivent savoir qu'il existe des outils/plateformes spécialisés pour faciliter cette activité essentielle.

Un autre élément de la structure est l'utilisation de la maquette numérique (modèles 3D) qui devient de plus en plus populaire et il est important de discuter de son emplacement dans le système de gestion de l'information. Plus de la moitié des personnes interrogées y voient un rôle complémentaire, de sorte que le modèle 3D n'est qu'une autre source d'informations attachée à un système principal centralisé. L'autre moitié peut être partagée avec celui qui y voit un rôle central, où le modèle 3D est au centre et toutes les informations en sortiront ou y entreront et la minorité, qui le voit comme déconnecté : le modèle 3D est traité séparément en tant que source d'information indépendante sans liens avec d'autres systèmes. Cela confirme la définition du CDE comme étant le système central et le BIM (modèle) en fait partie. Cette tendance est en ligne avec l'idée d'avoir une seule source d'information. Enfin, l'échange d'informations devrait avoir lieu exclusivement via le CDE afin de pouvoir être récupéré ultérieurement et pour que le CDE serve d'archive centrale (Preidel et al., 2018).

Comment et qui doit accéder au CDE ? Le sondage démontre que le serveur le plus utilisé appartient au client. Cela a du sens, car c'est le client qui initie le projet, et c'est lui qui recevra et conservera toutes les informations à la fin. Cette mise en place s'inscrit dans l'objectif de simplifier la gestion de l'information tout au long du cycle de vie d'un projet. Puisque nous nous dirigeons vers le partage d'informations en temps réel, il est intéressant de noter que l'intranet / multi localisation est le moyen le plus populaire de fonctionner avec le serveur. Les clients, les ingénieurs et les entrepreneurs sont ceux qui l'utilisent le plus. L'accessibilité ne semble pas être un problème, car la plupart des projets rapportent que leur connexion Internet est de moyenne à excellente. La plupart d'entre eux trouvent facile de travailler avec une entreprise géographiquement répartie. Ils ont tous convenu que les nouvelles technologies facilitaient la gestion du travail à distance. Cela est de plus en plus important maintenant que l'économie nationale est de plus en plus connectée à travers le monde.

Le problème principal reste la responsabilité de la sauvegarde des informations. C'est pourquoi l'accessibilité de l'information restera un problème jusqu'à ce qu'un accord de collaboration tel que l'IPD puisse être mis en pratique pour faciliter la collaboration et partager des risques et des opportunités. En attendant, il peut être difficile, mais devrait être possible d'accorder l'accès à différents participants en fonction de leur rang et de leur besoin d'informations spécifiques.

La plupart des répondants étaient satisfaits de leurs systèmes de communication et de documentation. L'utilisation de nombreux systèmes, leur accès et des connexions Internet rapides et sécurisées semblent être les principales lacunes à combler pour satisfaire les personnes insatisfaites. Il est donc possible de disposer d'une seule source pour gérer les informations, les documents et la communication, mais pas sans obstacles (voir le tableau 1 chapitre précédent montrant les obstacles mentionnés dans la revue de la littérature par rapport à ceux observés dans l'enquête).

D'un autre point de vue, les avantages d'avoir un système central de gestion de l'information ont été notés comme suit : gestion et échange d'informations efficaces ; partage facile des modèles, des dessins et des documents ; un niveau élevé de cohérence, d'efficacité et de coordination ; réduction des coûts de production d'informations coordonnées ; temps réduit pour produire des informations coordonnées ; un accès plus simple et plus rapide aux informations communes ; un meilleur contrôle des révisions et des versions des données ; être en mesure de fournir des informations de production correctes du premier coup ; et les conventions de dénomination des fichiers et des couches normalisées.

CONCLUSION ET RECOMMANDATIONS

Nous avons exploré les définitions théoriques et pratiques du CDE pour déterminer les besoins de sa mise en œuvre dans les grands projets de construction civile et industrielle avec la technologie actuelle. Nous avons commencé ce processus par une revue de la littérature traitant des structures de projet (traditionnelles et relationnelles), du travail collaboratif et du travail collaboratif assisté par ordinateur (CSCW). Nous avons complété la revue de la littérature avec une définition du CDE, ses exigences et son organisation, les lignes directrices existantes et les défis et obstacles connus. Une enquête a ensuite été conçue et envoyée à des experts du domaine pour recueillir des données sur la gestion de l'information dans ce type de projet. L'enquête comprenait la collecte des informations sur le projet et les répondants, leur collaboration au sein de leur projet, les méthodes informatiques et de transfert utilisé, le type de modèle numérique 3D utilisé et des détails sur les performances de leur technologie, ainsi que les améliorations et les attentes. Nous avons procédé à l'analyse et à la discussion des résultats et avons pu répondre à nos questions de recherche sur le CDE.

Tout projet de construction a besoin d'informations, de communication et de collaboration à pour son exécution et son achèvement. Les humains et la technologie étant en constante évolution, le principal défi est de s'adapter à ces changements. Tous les répondants ont décrit comment ils utilisent les systèmes de gestion de l'information dans leurs propres mots. Le nouvel aspect majeur dans la construction d'aujourd'hui est l'utilisation des technologies de l'information qui regroupe modèle numérique, plateforme collaborative, BIM et CDE. Il est clair que nous devons nous entendre sur vocabulaire utilisé et définir une structure commune pour réaliser les projets d'aujourd'hui. Parmi celles décrites précédemment, l'ISO 19650 semble être une solution à ce défi. ISO est déjà connue dans le monde entier pour sa publication de nombreuses normes, notamment ISO 9001, qui est aujourd'hui la référence mondiale en matière de qualité. Peut-il en être de même pour la technologie de l'information ?

Avant l'ère numérique, il était très difficile, voire impossible d'atteindre cet objectif de centraliser l'information. Il est désormais possible et faisable de gérer les informations tout au long du cycle de vie, et les limites deviennent de moins en moins grandes. D'une manière générale, le CDE est un outil pour simplifier la gestion de l'information tout au long du cycle de vie d'un projet. Avec ou sans technologie, le succès dans l'utilisation d'un système de gestion de l'information sera dans la discipline et la volonté de la communauté de la construction d'établir et de suivre une structure commune.

Il est difficile de couvrir tous les aspects du CDE pendant tout le cycle de vie d'un projet. Il serait intéressant d'analyser l'implication des différents acteurs dans les différentes phases du cycle de vie. Cette recherche a été réalisée pour de grands projets de construction civile et industrielle et s'est limitée à un certain nombre de répondants. Cela pourrait être étendu à d'autres types de projets et cibler un plus grand nombre de participants. La structure relationnelle du projet était limitée à l'IPD, mais des options supplémentaires peuvent être explorées. Nous avons aussi remarqué que les recherches sur les plateformes collaboratives sont limitées. Il serait important de développer davantage sur ce sujet, car l'utilisation des technologies de l'information ne cesse d'augmenter chaque année.

Les résultats de cette recherche serviront, non seulement à mieux comprendre le problème, mais aussi à préparer l'industrie de la construction à la transition vers de nouvelles technologies de partage d'informations. L'intégration du CDE devrait conduire à une communication et une gestion de l'information plus efficaces qui se traduiront par une augmentation de la productivité et une réduction des malentendus et des litiges, le tout avec des économies de temps et d'argent. L'enquête a permis une mise à jour de la situation actuelle sur le terrain et apporte une nouvelle perspective à la compréhension des pratiques et dynamiques de collaboration et des outils numériques. Finalement, au niveau scientifique, ces travaux enrichiront la compréhension du CDE et proposeront une orientation pour de futures recherches.

ANNEXE I

VERSION IMPRIMABLE DU SONDAGE

This survey is focusing on **PROJECT** level. The target is mainly large construction projects through companies' project directors and/or their representatives.

The data collected through this survey will be utilized for the advancement of knowledge in the field. Due to the confidentiality of the information provided, only research team members will have access to this data. Those who are allowed access will be reminded of the limits provided by laws on confidentiality.

The research ethics committee of École de Technologie Supérieure has approved the research project and is monitoring it. For any questions related to survey participation, please click on the survey link and refer to the contact information made available.

It will take you, approximately 20-25 minutes to complete the survey. Thank you for your time and collaboration.

Section A: 1.- Company and respondent information

A1. 1.1 Field of expertise of the company ?

- Client / Investor ☐
- Architects ☐
- Engineers ☐
- Contractors ☐
- Subcontractors ☐
- Suppliers ☐
- Other ☐

Other

☐

A2. **1.2 Number of employees ?**

- 0-50 ☐
- 50-250 ☐
- 250-1000 ☐
- 1000 and more ☐

A3. **1.3 Title of the respondent ?**

- Project director ☐
- Project manager ☐
- Construction manager ☐
- Contract manager ☐
- Other ☐

Other

A4. **1.4 In which level the respondent is involved in this project ?**

- With the owner of the project (Client) ☐
- With the executor of the project (contractor) ☐
- With a supplier of the project (subcontractor) ☐
- Other ☐

Other

Section B: 2.- Project description

B1. **2.1 What kind of project ?**

- Civil / infrastructure ☐
- Energy ☐
- Industrial ☐
- Mining ☐
- Residential ☐
- Other ☐

Other

B2. **2.2 Nature of the project ?**

- Private ☐
- Public ☐
- Other ☐

Other

B3. **2.3 Project value ?**

- 0 to 50 million USD ☐
- 50 to 100 million USD ☐
- 100 to 500 million USD ☐
- 500 to 999 million USD ☐
- 1 billion and more USD ☐

B4. **2.4 Construction phase start date (actual or planned) ?**

B5. **2.5 Duration of the construction phase (months) ?**

B6. 2.6 Location of the project (country) ?

- Afghanistan ☐
- Åland Islands ☐
- Albania ☐
- Algeria ☐
- American Samoa ☐
- Andorra ☐
- Angola ☐
- Anguilla ☐
- Antarctica ☐
- Antigua and Barbuda ☐
- Argentina ☐
- Armenia ☐
- Aruba ☐
- Australia ☐
- Austria ☐
- Azerbaijan ☐
- Bahamas ☐
- Bahrain ☐
- Bangladesh ☐
- Barbados ☐
- Belarus ☐
- Belgium ☐
- Belize ☐
- Benin ☐
- Bermuda ☐
- Bhutan ☐
- Bolivia (Plurinational State of) ☐
- Bonaire, Sint Eustatius and Saba ☐
- Bosnia and Herzegovina ☐
- Botswana ☐
- Bouvet Island ☐
- Brazil ☐
- British Indian Ocean Territory ☐
- Brunei Darussalam ☐
- Bulgaria ☐
- Burkina Faso ☐
- Burundi ☐
- Cambodia ☐
- Cameroon ☐
- Canada ☐
- Cabo Verde ☐
- Cayman Islands ☐
- Central African Republic ☐
- Chad ☐
- Chile ☐
- China ☐
- Christmas Island ☐
- Cocos (Keeling) Islands ☐
- Colombia ☐
- Comoros ☐
- Congo ☐
- Congo (Democratic Republic of the) ☐
- Cook Islands ☐
- Costa Rica ☐
- Côte d'Ivoire ☐
- Croatia ☐
- Cuba ☐
- Curaçao ☐
- Cyprus ☐
- Czech Republic ☐
- Denmark ☐
- Djibouti ☐
- Dominica ☐
- Dominican Republic ☐
- Ecuador ☐
- Egypt ☐
- El Salvador ☐
- Equatorial Guinea ☐
- Eritrea ☐
- Estonia ☐
- Ethiopia ☐
- Falkland Islands (Malvinas) ☐
- Faroe Islands ☐
- Fiji ☐
- Finland ☐
- France ☐
- French Guiana ☐
- French Polynesia ☐
- French Southern Territories ☐
- Gabon ☐
- Gambia ☐
- Georgia ☐
- Germany ☐
- Ghana ☐
- Gibraltar ☐
- Greece ☐

- Greenland ☐
- Grenada ☐
- Guadeloupe ☐
- Guam ☐
- Guatemala ☐
- Guernsey ☐
- Guinea ☐
- Guinea-Bissau ☐
- Guyana ☐
- Haiti ☐
- Heard Island and McDonald Islands ☐
- Holy See ☐
- Honduras ☐
- Hong Kong ☐
- Hungary ☐
- Iceland ☐
- India ☐
- Indonesia ☐
- Iran (Islamic Republic of) ☐
- Iraq ☐
- Ireland ☐
- Isle of Man ☐
- Israel ☐
- Italy ☐
- Jamaica ☐
- Japan ☐
- Jersey ☐
- Jordan ☐
- Kazakhstan ☐
- Kenya ☐
- Kiribati ☐
- Korea (Democratic People's Republic of) ☐
- Korea (Republic of) ☐
- Kuwait ☐
- Kyrgyzstan ☐
- Lao People's Democratic Republic ☐
- Latvia ☐
- Lebanon ☐
- Lesotho ☐
- Liberia ☐
- Libya ☐
- Liechtenstein ☐
- Lithuania ☐
- Luxembourg ☐
- Macao ☐
- Macedonia (the former Yugoslav Republic of) ☐
- Madagascar ☐
- Malawi ☐
- Malaysia ☐
- Maldives ☐
- Mali ☐
- Malta ☐
- Marshall Islands ☐
- Martinique ☐
- Mauritania ☐
- Mauritius ☐
- Mayotte ☐
- Mexico ☐
- Micronesia (Federated States of) ☐
- Moldova (Republic of) ☐
- Monaco ☐
- Mongolia ☐
- Montenegro ☐
- Montserrat ☐
- Morocco ☐
- Mozambique ☐
- Myanmar ☐
- Namibia ☐
- Nauru ☐
- Nepal ☐
- Netherlands ☐
- New Caledonia ☐
- New Zealand ☐
- Nicaragua ☐
- Niger ☐
- Nigeria ☐
- Niue ☐
- Norfolk Island ☐
- Northern Mariana Islands ☐
- Norway ☐
- Oman ☐
- Pakistan ☐
- Palau ☐
- Palestine, State of ☐
- Panama ☐
- Papua New Guinea ☐
- Paraguay ☐

Peru ☐
Philippines ☐
Pitcairn ☐
Poland ☐
Portugal ☐
Puerto Rico ☐
Qatar ☐
Réunion ☐
Romania ☐
Russian Federation ☐
Rwanda ☐
Saint Barthélemy ☐
Saint Helena, Ascension and Tristan da Cunha ☐
Saint Kitts and Nevis ☐
Saint Lucia ☐
Saint Martin (French part) ☐
Saint Pierre and Miquelon ☐
Saint Vincent and the Grenadines ☐
Samoa ☐
San Marino ☐
Sao Tome and Principe ☐
Saudi Arabia ☐
Senegal ☐
Serbia ☐
Seychelles ☐
Sierra Leone ☐
Singapore ☐
Sint Maarten (Dutch part) ☐
Slovakia ☐
Slovenia ☐
Solomon Islands ☐
Somalia ☐
South Africa ☐
South Georgia and the South Sandwich Islands ☐
South Sudan ☐
Spain ☐
Sri Lanka ☐
Sudan ☐
Suriname ☐
Svalbard and Jan Mayen ☐
Swaziland ☐
Sweden ☐
Switzerland ☐
Syrian Arab Republic ☐
Taiwan, Province of China ☐
Tajikistan ☐
Tanzania, United Republic of ☐
Thailand ☐
Timor-Leste ☐
Togo ☐
Tokelau ☐
Tonga ☐
Trinidad and Tobago ☐
Tunisia ☐
Turkey ☐
Turkmenistan ☐
Turks and Caicos Islands ☐
Tuvalu ☐
Uganda ☐
Ukraine ☐
United Arab Emirates ☐
United Kingdom of Great Britain and Northern Ireland ☐
United States of America ☐
United States Minor Outlying Islands ☐
Uruguay ☐

Uzbekistan ☐

Vanuatu ☐

Venezuela (Bolivarian Republic of) ☐

Viet Nam ☐

Virgin Islands (British) ☐

Virgin Islands (U.S.) ☐

Wallis and Futuna ☐

Western Sahara ☐

Yemen ☐

Zambia ☐

Zimbabwe ☐

B7. **2.7 How many months the respondent has been involved in this project ?**

B8. **2.8 Project name (optional) ?**

B9. **2.9 Brief description of the project :**

Section C: 3.- Collaboration inside the project

C1. **3.1 What is the project delivery mode used ?**

- Design / Bid / Build ☐
- Design / Build (Engineering - Procurement - Construction) ☐
- Construction management (Engineering - Procurement - Construction - Management) ☐
- Integrated Project Delivery (IPD) ☐
- Other ☐

Other

C2. **3.2 In the table below, indicate your level of COMMUNICATION with each stakeholder :**

1 = None or not applicable

2 = Few (upon request)

3 = Once a month

4 = Once a week

5 = Everyday

	1	2	3	4	5
Client / owner	☐	☐	☐	☐	☐
Operations (owner)	☐	☐	☐	☐	☐
Project manager	☐	☐	☐	☐	☐
Professionals	☐	☐	☐	☐	☐
Contractor	☐	☐	☐	☐	☐
Subcontractors	☐	☐	☐	☐	☐
Suppliers	☐	☐	☐	☐	☐

C6. **3.6 To whom belong the most used one ?**

- Client /owner ☐
- Architects ☐
- Engineers ☐
- Contractor ☐
- Other ☐

Other

C7. **3.7 Who is using this main system ?**

- Client ☐
- Architects ☐
- Engineers ☐
- Contractor ☐
- Subcontractors ☐
- Other ☐

Other

C8. **3.8 How involved is the client/owner or its representative in this project ?**

- Not at all ☐
- For meeting and follow up only ☐
- Constantly (day-to-day activities) ☐

C9. **3.9 Does the client/owner have specific requirements regarding information delivery format (as built, manuals, general information, etc.) ?**

- None ☐
- Paper ☐
- Electronic ☐

Other

Other

Section D: 4.- Information technology and transfer

D1. 4.1 Which file server type each stakeholder is using ?

	Client	Architect	Engineer	Contractor
Local server	☐	☐	☐	☐
Intranet/multi-location access	☐	☐	☐	☐
Cloud	☐	☐	☐	☐
Not using	☐	☐	☐	☐
I don't know	☐	☐	☐	☐
Not applicable	☐	☐	☐	☐

D2. 4.2 To whom belong the common and most used file server ?

- Client / owner ☐
- Architects ☐
- Engineers ☐
- Contractors ☐
- Subcontractors ☐
- Other ☐

Other

D3. **4.3 Which type, is it ?**

- Local server ☐
- Intranet/multi-location access ☐
- Cloud ☐
- Other ☐

Other

D4. **4.4 Who is using/accessing this main file server ?**

- Client / direction ☐
- Architects ☐
- Engineers ☐
- Contractor ☐
- Subcontractors ☐
- Client / operations ☐
- Other ☐

Other

D5. **4.5 Which type of information is stored in this main server ?**

- Documents (reports, communication, 2D drawings, etc.) ☐
- Graphical data (CAO, 3D, etc.) ☐
- Other ☐

Other

D6. **4.6 How is the internet / network connection quality and speed on the site ?**

(1 = very poor and 5 = excellent)

	1	2	3	4	5
Quality of the connection	☐	☐	☐	☐	☐

D7. **4.7 Which type of hardware are you using on the project ?**

- PCs ☐
- Laptops ☐
- Tablets ☐
- Smart phones ☐
- AIDC (Automatic Identification & Data Capture) ☐
- Lasers (measuring, scanning objects/places, etc.) ☐
- Drones ☐
- Robots ☐
- Other ☐

Other

D8.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Communications

Name of software

D9.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Documents management

Name of software

D10.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Drawing management

Name of software

D11.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Project management

Name of software

D12.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Costs management

Name of software

D13.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Scheduling

Name of software

D14.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Tenders

Name of software

D15.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Changes / Claims

Name of software

D16.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Time sheets

Name of software

D17.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Invoicing

Name of software

D18.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Reporting

Name of software

D19.

4.8 Which software are you using on the project ?

(Please write NA when it is Not Applicable or there is none)

Inspections

Name of software

Section E: 5.- 3D digital model and management

E1. **5.1 How the project designs are authored (which format) ? Name the software ?**

2D CAD

Comment

3D CAD

Comment

DMU (Digital Mock-Up)

Comment

Other

Other

E2. **5.2 Does the project use GIS (Geographic Information System) ?**

As topographic coordinates, cadastral and numeric data related to position.

Yes

No

I don't know

E3. **5.3 Is there a 3D digital model of the project ?**

- Yes ☐
- No ☐

E4. **5.4 If Yes, who requested this 3D digital model ?**

- Client ☐
- Architects ☐
- Engineers ☐
- Contractor ☐
- Other ☐

Other

E5. **5.5 How this 3D digital model is managed / organized ?**

- Independent stand alone model (Level 1) ☐
- Different models attached to a central one (Level 2 - federated) ☐
- Single multidisciplinary model (Level 3 - integrated) ☐
- Other ☐

Other

E6. **5.6 What other functions the digital model is used for ? Name the application/program ?**

- None - N/A ☐

Comment

- Scheduling ☐

Comment

Costs management ☐

Comment

Project management ☐

Comment

Other ☐

Other

E7. **5.7 Is the client interested to have the 3D digital model after the project ?**

Yes ☐

No ☐

I don't know ☐

Section F: 6.- Performance, improvements and expectations

F1. **6.1 Are you satisfied with your COMMUNICATION system ?**

Comments are welcome!

Yes ☐

No ☐

F2. **6.2 Are you satisfied with your DOCUMENTS MANAGEMENT system ?**

Comments are welcome!

Yes ☐

No ☐

F3. **6.3 Do you find hard to work with company geographically distributed ?**

Comments are welcome!

Yes ☐

No ☐

F4. **6.4 In your opinion, is it possible to have all project information in one single place/system ?**

Comments are welcome!

Yes ☐

No ☐

F5. **6.5 What would be the biggest obstacle / problem of using a single source of information ?**

- Cyber security threats ☐
- Access rights control ☐
- Transfer capacity / speed of internet connection ☐
- Updating information ☐
- Too many information systems involved ☐
- Contractual agreements for information management ☐
- Insufficient interest / commitment from the management ☐
- High investment costs ☐
- Project size ☐
- Other ☐

Other

F6. **6.6 What would be the biggest benefit of using a single source of information ?**

- Sharing models, drawings and documents ☐
- Time reduction in producing coordinated information ☐
- Cost reduction in producing coordinated information ☐
- Effective information management and exchange ☐
- Level of consistency, efficiency and coordination ☐
- Simpler and faster access to common information ☐
- Delivering production information that is right first time ☐
- Gives greater control over revision and version of the data ☐
- File and layer naming conventions ☐
- Other ☐

Other

F7. 6.7 According to your knowledge, how do you define the best way to manage and transfer information on a project ?

- One central system for collecting, managing, evaluating and sharing all information. ☐
- Different systems LINKED TOGETHER for collecting, managing, evaluating and sharing information. ☐
- Different systems NOT LINKED TOGETHER for collecting, managing, evaluating and sharing information. ☐
- Other ☐

Other

F8. 6.8 Where do you see the position of a 3D model in an information management system ?

- As a central role: The 3D model is in the centre and all information will emerge from/to it. ☐
- As a complementary role: The 3D model is just another source of information attached to a centralized main system. ☐
- Disconnected: The 3D model is treated separately as an independent source of information with no link to other systems. ☐
- Other ☐

Other

F9. 6.9 Before this survey, have you ever heard of CDE (Common Data Environment) ?

- Yes ☐
- No ☐

F10. 6.10 Do you know what is a CDE (Common Data Environment) ?

- I have an idea ☐
- I know exactly ☐
- I don't know ☐

Section G: 7.- Authorization

G1. **7.1 Do you authorize us to contact you for further investigation and/or clarification ?**

Yes ☐

No ☐

G2. **7.2 Name of the company ?**

G3. **7.3 Name of the respondent ?**

Name

Email address

Phone number

Thank you for your participation. All participants information for this survey will remain confidential. The results will be available to participants upon request.

ANNEXE II

LISTE DES REPONDANTS

Tableau-A II-I Informations concernant les répondants

Nbre	Response ID	Date submitted	1.1 Field of expertise of the company ?	1.2 Number of employees ?	1.3 Title of the respondent ?	2.1 What kind of project ?	2.2 Nature of the project ?	2.3 Project value ?	2.6 Location of the project (country) ?
1	4	2019/05/02	Engineers	1000 and more	Contracts manager	Energy	Private	0 to 50 million USD	Canada
2	5	2019/05/03	Contractors	250-1000	Project director	Industrial	Private	0 to 50 million USD	Canada
3	6	2019/05/03	Contractors	1000 and more	Project manager	Energy	Public	0 to 50 million USD	Canada
4	7								
5	8		Client / Investor	1000 and more	Project manager				
6	9		Engineers	50-250	Project director	oil&gas	Private	0 to 50 million USD	Canada
7	10		Contractors	1000 and more	Contract manager	Civil / infrastructure	Public	1 billion and more USD	
8	11	2019/05/09	Client / Investor	1000 and more	Project director	Civil / infrastructure	Public	0 to 50 million USD	Morocco
9	12	2019/05/10	Engineers	1000 and more	Project director	Energy	Private	1 billion and more USD	Canada
10	13	2019/06/14	Client / Investor	1000 and more	Project manager	Industrial	Private	100 to 500 million USD	Morocco
11	14		Engineers	1000 and more	Project manager	program mine to ship	Public	1 billion and more USD	Morocco
12	15	2019/06/17	Other	1000 and more	Executive	Civil / infrastructure	PPP	1 billion and more USD	Canada
13	16								
14	17	2019/06/18	Client / Investor	1000 and more	Project manager	Institutional	Public	0 to 50 million USD	Canada
15	18	2019/06/18	Contractors	0-50	Construction manager	Industrial	Private	0 to 50 million USD	Canada
16	19								
17	20	2019/06/20	Suppliers	250-1000	President	Civil / infrastructure	PPP	1 billion and more USD	Canada
18	21	2019/06/20	Client / Investor	0-50	Contract manager	Industrial	Private	1 billion and more USD	Canada
19	22	2019/06/20	Contractors	1000 and more	Project manager	Civil / infrastructure	Public	0 to 50 million USD	Canada
20	23	2019/06/20	Subcontractors	1000 and more	Construction manager	Civil / infrastructure	Private	0 to 50 million USD	Canada
21	24	2019/06/23	Engineers	1000 and more	Project director	Civil / infrastructure	Public	0 to 50 million USD	Canada
22	25	2019/06/23	Contractors	1000 and more	Construction manager	Industrial	Private	1 billion and more USD	USA
23	26	2019/06/25	Contractors	1000 and more	Project manager	Civil / infrastructure	Public	0 to 50 million USD	Canada
24	27	2019/06/26	Engineers	250-1000	Project director	Civil / infrastructure	Private	0 to 50 million USD	Canada
25	28	2019/06/26	Client / Investor	50-250	Project manager	Energy	Private	0 to 50 million USD	France
26	29		Suppliers	1000 and more	Contract manager	Naval Maritime	Public	1 billion and more USD	Australia
27	30	2019/06/30	Engineers	250-1000	Design Engineer	Civil / infrastructure	Private	100 to 500 million USD	Canada
28	31	2019/07/01	Engineers	1000 and more	Project manager	Life Sciences	Private	50 to 100 million USD	USA
29	32	2019/07/01	Other	50-250	Architecte	Building renovation	Public	0 to 50 million USD	Canada
30	33	2019/07/02	Client / Investor	1000 and more	Contract manager	Civil / infrastructure	Public	1 billion and more USD	Saudi Arabia
31	34	2019/07/02	Engineers	50-250	Senior Mechanical Engineer	Commercial buildings	Public	100 to 500 million USD	Canada
32	35	2019/07/18	Other	0-50	Contract manager	Industrial	Private	100 to 500 million USD	Morocco
33	36	2019/07/18	Contractors	1000 and more	Inspector	Civil / infrastructure	Public	1 billion and more USD	Canada
34	37								
35	38	2019/07/21	Client / Investor	50-250	Design Coordinator	Civil / infrastructure	Public	1 billion and more USD	Australia
36	39	2019/07/22	Client / Investor	250-1000	Bim manager	hospital	Public	1 billion and more USD	Canada
37	41	2019/07/23	Client / Investor	1000 and more	Design specialist / Coordinator	Commercial / Retail	Private	0 to 50 million USD	Canada
38	42	2019/07/27	Contractors	0-50	Project director	Waste water treatment Plant	Public	0 to 50 million USD	Morocco
39	43	2019/07/29	Engineers	1000 and more	Engineer of planning and estimation	Energy	Public	50 to 100 million USD	Canada
40	46								
41	48								
42	49	2019/10/07	Engineers	1000 and more	Project director	Industrial	Private	50 to 100 million USD	Canada
43	50	2019/12/16	Engineers	1000 and more	Construction manager	Energy	Public	0 to 50 million USD	Canada

Réponse négative Accusé de réception mais déclinaison du sondage)

Réponse partielle

Rouge Autre

ANNEXE III

REPONSE QUESTION 4.8

Tableau-A III-I Résumé des réponses à la question 4.8 du sondage

		Communication	Documents mgt	Drawing mgt	Project mgt	Costs mgt	Scheduling	Tenders	Changes / Claims	Time sheet	Invoicing	Reporting	Inspections	Total by program	Part of each	
	Number of answers	**28**	**27**	**28**	**23**	**24**	**28**	**22**	**25**	**24**	**22**	**24**	**21**			
	NA	2	3	2	5	4	3	11	9	5	5	4	8	**61**		
1	Aconex	1	1	1	1							1	1	**6**		
2	Adobe PDF									1		1	2	**4**		
3	Autocad			6										**6**		
4	Bid2win							1						**1**		
5	BIM360 Glue			1									1	**2**		
6	BST				1	1				1	1	1		**5**		
7	Coreworx		1	1										**2**		
8	Custom system		1	1	1	2		3	2	3	2	2	3	**20**	8,5%	
9	dwg and others			1										**1**		
10	Email	3							1	1		1		**6**		
11	emarket(entreprise contract mgt)							1						**1**		
12	Enablon												1	**1**		
13	Esourcing							1						**1**		
14	EPM				1									**1**		
15	Espri					1								**1**		
16	ETS									1				**1**		
17	Excel		1	1	1	6	1	1	3	2	3	2	1	**22**	9,4%	
18	Famis & Banner										1			**1**		
19	Iplant			1										**1**		
20	JPI (Jacobs company)		3											**3**		
21	Local server			1										**1**		
22	Logesdesk			1										**1**		
23	Lotus		1											**1**		
24	Lotus note	1												**1**		
25	Meridian		1											**1**		
26	Microsoft 360 business	1										1		**2**		
27	Microsoft Exchange	1												**1**		
28	Microsoft Explorer		1							1				**2**		
29	Microsoft Office				1			1	2		1	2		**7**		
30	MS project		1	1	4	1	8		1	1		1		**18**	7,7%	
31	Navisworks			1										**1**		
32	Office suite		1	1	2	1		1	1				1	**8**		
33	One Drive-Cloud		1	1										**2**		
34	Onware	1	1		1				1					**4**		
35	Oracle									1				**1**		
36	Oracle - Unifier				1	1						1		**3**		
37	Outlook	16												**16**	6,8%	
38	Paper copy - hard copy									1				**1**		
39	Plan grid											1	1	**2**		
40	POL (Fluor company)		1		1	1				1			1	**5**		
41	Primavera (P6)				1		16							**17**	7,2%	
42	Prism					1								**1**		
43	Procore		1	1										**2**		
44	Prolog	1	1		1			1	2			1		**7**		
45	Revit			2										**2**		
46	SAP	1	1			3			1	3	6	2		**17**	7,2%	
47	SEAO							1						**1**		
48	Share Point		3											**3**		
49	Sitefolio		1	1	1						1	1	1	**6**		
50	SmartPlant			1										**1**		
51	Smartuse Performa			1										**1**		
52	Team Binder			1					1					**2**		
53	Team Builder		1											**1**		
54	Viewpoint					1			1					**2**		
55	Vision Constructeur					1				1	1			**3**		
56	Word		1									2		**3**		
57	Workday									1	1			**2**		
	Number of answers	**28**	**27**	**28**	**23**	**24**	**28**	**22**	**25**	**24**	**22**	**24**	**21**	**296**	**235**	**(moins les NA)**
		26	**24**	**26**	**18**	**20**	**25**	**11**	**16**	**19**	**17**	**20**	**13**	**235**		
		11,1%	10,2%	11,1%	7,7%	8,5%	10,6%	4,7%	6,8%	8,1%	7,2%	8,5%	5,5%		4,3%	**(10 / 235)**
			Fonctions les plus utilisées							Application / progammes les plus utiliés						

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