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MASTER OF SCIENCE IN BUILDING ENGINEERING

A comparative analysis of common data environments focusing on the use of Aconex

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ABSTRACT

Building Information Modelling (BIM) is now a global digital technology which is widely believed to have the potential to revolutionize the construction industry. With the increasing complexity of construction projects, a collaborative environment becomes essential to ensure effective communication during the project lifecycle. To do so many solutions have been proposed by different companies to facilitate the collaboration among the users in construction management which are so-called "common data environment". Although this can be seen as a positive development, one cannot ignore how it has overwhelmed many professionals who cannot easily distinguish between these solution systems. This study aims to conduct a comprehensive appraisal of a wide range of BIM CDE systems currently being used in managing construction project information. To achieve this, first, an analysis has been conducted to compare the famous CDEs available in the market and highlight what different features they have to offer. Then, among those CDEs, "Aconex" has been chosen as one of the most popular CDEs used in the market to evaluate how it functions as a solution and appraise its benefits and disadvantages compared to others.

Keywords: Building Information Modelling (BIM), common data environment (CDE), Aconex

SOMMARIO

Il Building Information Modeling (BIM) è ora una tecnologia digitale globale che si ritiene abbia il potenziale per rivoluzionare il settore delle costruzioni. Con la crescente complessità dei progetti di costruzione, un ambiente collaborativo diventa essenziale per garantire una comunicazione efficace durante il ciclo di vita del progetto. Per fare così tante soluzioni sono state proposte da diverse aziende per facilitare la collaborazione tra gli utenti nella gestione delle costruzioni che sono il cosiddetto "ambiente di dati comune". Sebbene questo possa essere visto come uno sviluppo positivo, non si può ignorare come ha sopraffatto molti professionisti che non sono in grado di distinguere facilmente tra questi sistemi di soluzione. Questo studio mira a condurre una valutazione completa di una vasta gamma di sistemi BIM CDE attualmente utilizzati nella gestione delle informazioni sui progetti di costruzione. Per raggiungere questo obiettivo, in primo luogo è stata condotta un'analisi per confrontare i famosi CDE disponibili sul mercato ed evidenziare quali diverse funzionalità hanno da offrire. Quindi, tra questi CDE, "Aconex" è stato scelto come uno dei CDE più popolari utilizzati sul mercato per valutare come funziona come una soluzione e valutare i suoi benefici e svantaggi rispetto ad altri.

Parole chiave: Building Information Modelling (BIM), common data environment (CDE), Aconex

ACKNOWLEDGEMENT

PREFACE

The dissertation is an original intellectual work carried out by the author, Seyed Emad Tabadkani. The thesis was carried out as part of the master's program in Building and Architectural Engineering at Politecnico di Milano.

As an international student, the opportunity to study Building Process and Information Management at Politecnico Di Milano as well as the knowledge I gained on other subjects in the course encourages me to search deep for a topic that will be my final dissertation project.

Thanks to Prof. Alberto Pavan for trusting and providing me this master thesis, I also would like to thank my co-supervisor, Prof. Mario Luigi Caputi for guiding me all the time with his points of view and innovative ideas.

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NOMENCLATURE

2D	2 dimension
3D	3 dimension
AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
CAD	Computer-Aided Drawing
CDE	Common Data Environment
COBie	Construction Operations Building information exchange
EN	European Norm
EU	European Union
IFC	Industry Foundation Class
UK	United Kingdom
BMS	Building Management System
BCF	BIM Collaboration Format

1   INTRODUCTION

Building Information Modelling (BIM) is gaining momentum in the AEC industry for design and construction and one of the most significant technological advancements in recent years that has been adopted by the design and construction industry. [1, 2]

Construction projects and their management are naturally complex and demanding systems. Inappropriate control of the system leads to increasing project costs, project delays, reducing productivity and loss of profit. Crucial point of control projects is delivering of right and actual information to person who does work or process. This requirement is hard to accomplish with increasing complexity of the project. During construction project are produced big amount of differentiate data. [3]

Traditional method is mainly concerned with 2D representation of information throughout all the entire project phase[4]; however, Building Information Modelling leads to the re-shaping of the construction industry as it stands for the necessary evolution of the design approach linked to the increasing complexity of the building process. BIM lays down the transition from unidirectional and asynchronous workflows to integrated and shared models[5]. Most research has agreed that BIM is a process of expanding 3D models to computable nD models to simulate the planning, design, construction, and operation of a facility. In particular, 3D BIM makes it possible to perform specific analysis based on the geometrical information of the model, such as 3D visualization, clash detection and code checking [6-8]

In general, the five most important benefits of BIM include:

- better cost estimates
- control, better understanding of design
- reduce construction cost
- better construction planning and monitoring
- improvement of project quality.[9]

Despite many advantages of BIM, the slow adoption to date has inspired researchers worldwide to investigate existing barriers[10]; these barriers include: technical problems (compatibility and reliability), fragmentation of the project team, the inherent resistance to change by construction stakeholders, lack of training, and business process related issues, inadequate organizational support and structure to execute BIM, and lack of BIM industry standards.[9-11]

BIM adoption environment requires a more multidisciplinary collaboration effort of different disciplines against information sharing, building design, construction techniques, [12] and BIM implementation into construction projects needs a lot of efforts to standardize the data environment where BIM teams work together; those whose possibly geographically dispersed members from various organizations and disciplines, perform project tasks on BIM-enabled projects. even though achieving BIM's full capabilities relies on effective collaboration among the team members in BIM-based construction networks, it is still a struggle for these members to collaborate. Nonetheless, only a few studies have been conducted to identify the barriers to strengthening team collaboration in BIM-based construction networks. [13]

During the planning, construction, and operation of a building, the project participants exchange various information from different domains based on agreed procedures. Practical experience has shown that the direct use of a single shared model is not recommended for a number of reasons, not least because this approach does not support accountability which is a problem for legal aspects. [14] For this reason a platform to share information on is vital to have more discipline and collaborative environment. A CDE provides a platform for the changes to be recorded, distributed and resolved at

a lower cost, resulting in a more efficient delivery team and a happier client. [15] This research first compares the famous common data environments available.

2 Methodology

This paper first presents a comprehensive definition of common data environment and its benefits and challenges in implementing in AEC industry. Secondly, it is attempted to make a comparison among the CDE platforms parameter by parameter. Thirdly, It is explained how Aconex functions as a CDE and what features have to offer detailedly. Finally, The pros and cons of Aconex have been highlighted compared to other CDEs.

3   What is Common Data Environment (CDE)

The transit from CAD 2D to BIM 3D for each phase of the process, from strategy to operation), requires the indispensable creation of a specific digital environment where all information generated over time can be collected and managed: Common Data Environment.

The Common Data Environment was originally defined in BS1192:2007, then in PAS 1192-2:2013, finally it has its own international standard, ISO 19650. There are also other standards from Italy and Germany with similar approach. The contents of the CDE are not limited to assets created in a 'BIM environment' and it will therefore include documentation, graphical model and non-graphical assets. In using a single source of information collaboration between project members should be enhanced, mistakes reduced, and duplication avoided. The advantages of implementing a CDE Include:

During Design & Construction Stage

- Greater reliability of data and reduced risk.

- Support more efficient processes in the creation and management of information.

- Shared information reduces the time and cost in producing coordinated information.

- Reducing the time and effort required to check, version and reissue information.

- Any number of documents can be generated from different combinations of model files.

- Enable to improve collaboration and improved outcomes.

- Project team members can all use the CDE to generate the documents/ views they need using different combinations of the central assets, confident that they are using the latest assets (as are others).

During Operational Stage

- Save time to transfer accurate and complete information from construction to operational stages.

- Easy access to relevant and reliable information in the event of failure.

- Enable improved estate planning, procurement and maintenance.

- Support improved analysis across portfolio of built assets.

- Ownership of information remains with the originator, although it is shared and reused, only the originator can change it. [16-18]

The Common Data Environment (CDE) is defined as a common digital project space used to collect, manage and share non-graphical and graphical data and all documentation (i.e. all project information created in a BIM environment) amongst all project team members, facilitating collaboration and avoiding duplication and errors combined with a robust workflow description for sharing and approval processes. [14, 19]
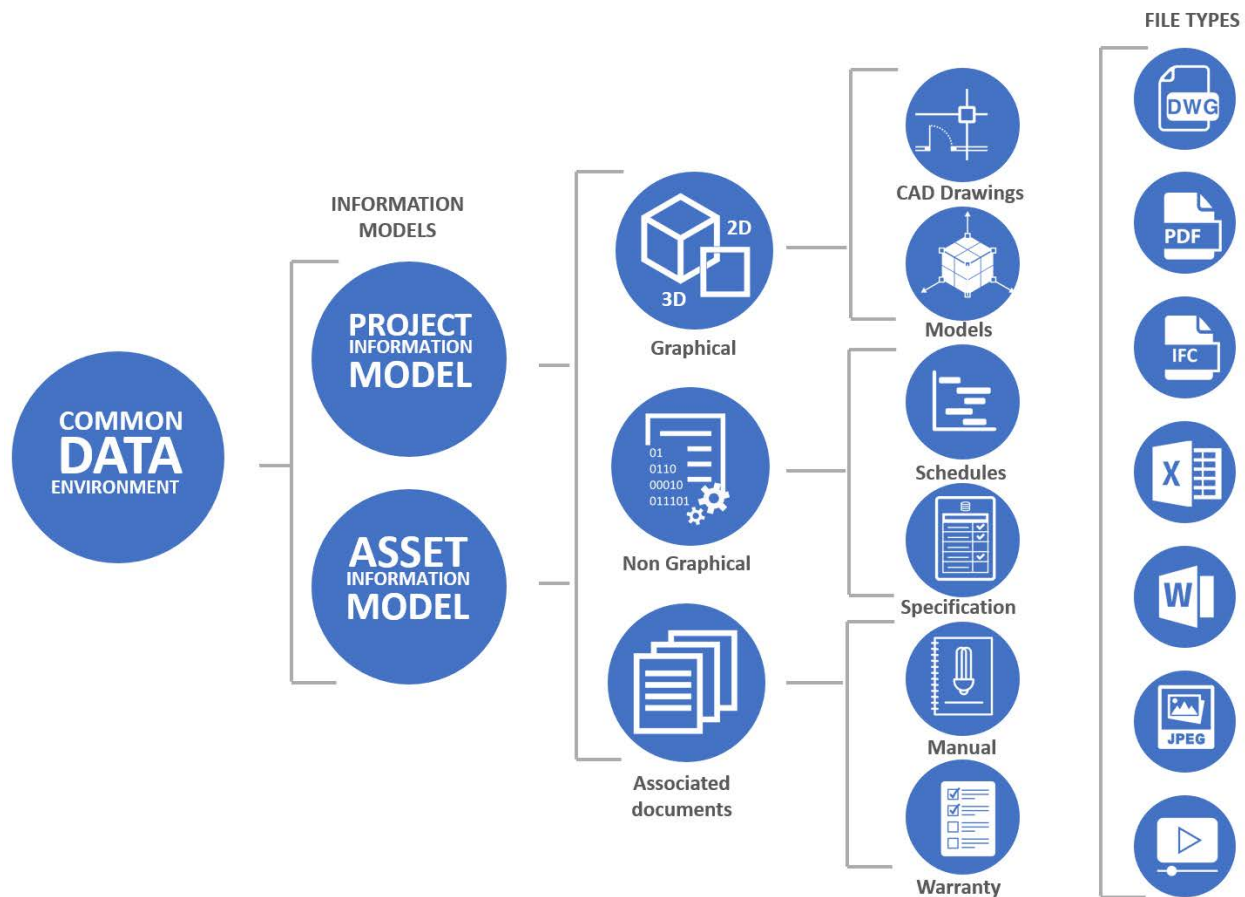
Figure 1 - Common data environment types and content summary

This figures illustrates the CDE contents and different types of information to be shared on CDE in summary. The fundamental principles requires information to be shared within a CDE together with a suitable information hierarchy to be agreed upon which supports the concept of the CDE and the document repository. Essentially a CDE is simply a digital place in which the information comes together. With vast amounts of digital data being created and shared during a project's lifecycle, the CDE becomes an ideal environment in which to promote a collaborative working culture. Regardless of the Level of BIM maturity, the CDE should be a main software priority within any organisation wishing to work within a BIM enabled environment.

Challenges to Implement CDE

- Complex IT procurement challenges. (Clear brief/compliance to existing IT procedures)
- Varied CDE market offerings.
- Cost and resources to procure a system.
- Maintain security of data.
- Developing a system solution compatible to existing organisational systems [18]

Interdisciplinary collaboration in the fields of Architecture, Engineering, Construction (AEC) is based on the exchange of 2D drawings and documents. Although the different disciplines use 3D models for development, design, and visualization, the collaboration between them has developed especially in 2D. Traditionally used CAD tools have some significant limitations such as the separation between the design and the information associated with it.
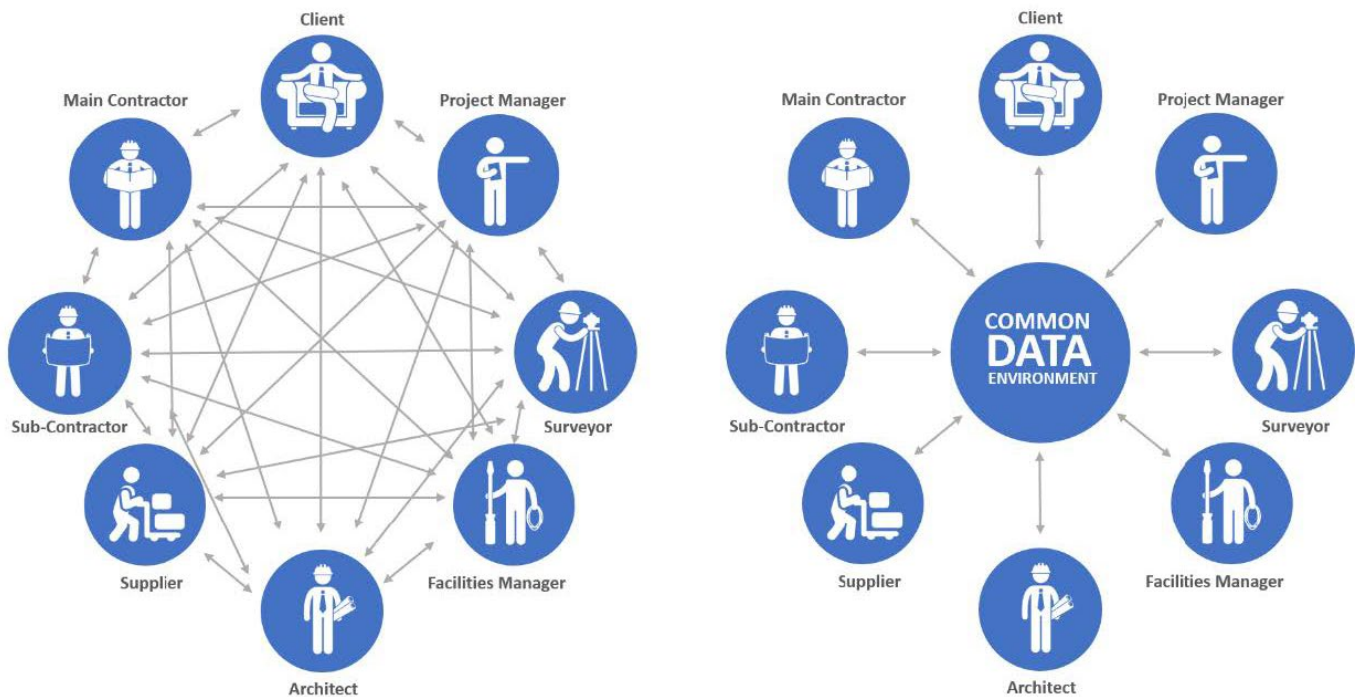
Figure 2 - Traditional approach vs. BIM (CDE-Common Data Environment)

The creation of a common digital space, a source of information, reduces exchange times and costs because it makes an easy collaboration between team members who can draw from a single source.

Unlike what happened in traditional information sharing in which each subject exchanged data with all the other subjects involved thus causing inevitable information losses.

The structured use of a data-sharing environment requires rigorous discipline on the part of all members of the design team, in terms of adherence to agreed approaches and procedures, differently from what happens for more traditional procedures.
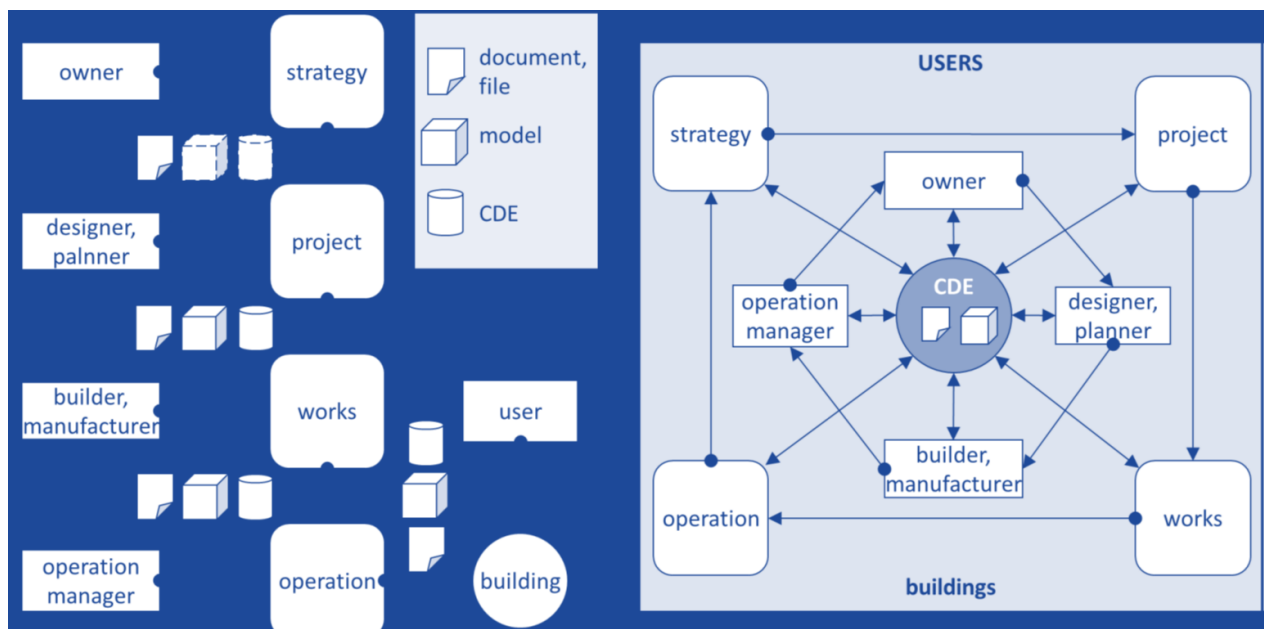
Figure 3 - The BIM information process with CDE's phases (on the left) and the BIM information process on a centralized CDE (on the right)

In these digital sharing environments (CDE) it is possible to carry out an integrated management of files, models (graphs) and documents relating to a project, to an intervention or an Asset, over time. Moreover, using BIM CDEs leads to stop using the traditional procedural flows, more CDEs

differentiated for each phase of the process – see Figure 3, on the left). Indeed, they spur to use collaborative procedural flows, supported by a single centralized CDE, on which all the actors involved operate. Such flows involve the entire lifecycle of the asset, from strategy to demolition and reuse of the land (see Figure 3, on the right). [20]

The European reference regulations that define the Common Data Environment are:

- BS 1192: 2007 (UK)
- PAS 1192-2: 2013 (UK)
- UNI 11337: 2017 (Italy)
- DIN SPEC 91391-1: 2019 (Germany)
- UNI EN ISO 19650: 2019 (UK-EU directives)

ISO 19650-1 defines the CDE as:

"agreed source of information for any given project or asset, for collecting, managing, and disseminating each information container through a managed process."

A significant change is the identification of the differences between the terms "model" and "information container": the model is a set of structured and unstructured information containers, while the information container is a persistent information set and equipped with nomenclature, linkable from a file, from a system or from the hierarchy of any information system. An information container is all that is placed hierarchically below the federated model: it can be a single disciplinary model, a document, a table, but also a sub-folder in the CDE or a chapter of the document itself, of a layer, of an element in the model. ISO 19650-1 simplifies the phases/environments system, which in PAS 1192-2 it found a much more complex configuration. It comes back to 4 phases/environments, of which 3 are active (*Work in progress, Shared, Published*). The fourth phase, *Archive*, becomes a space that keeps track of all the containers that have been in the Shared and Published sectors. It is no longer an archive of verified elements (closed and definitive), as in the PAS 1192-2, but returns to be the history of the project (as in the first versions of BS 1192). [21]
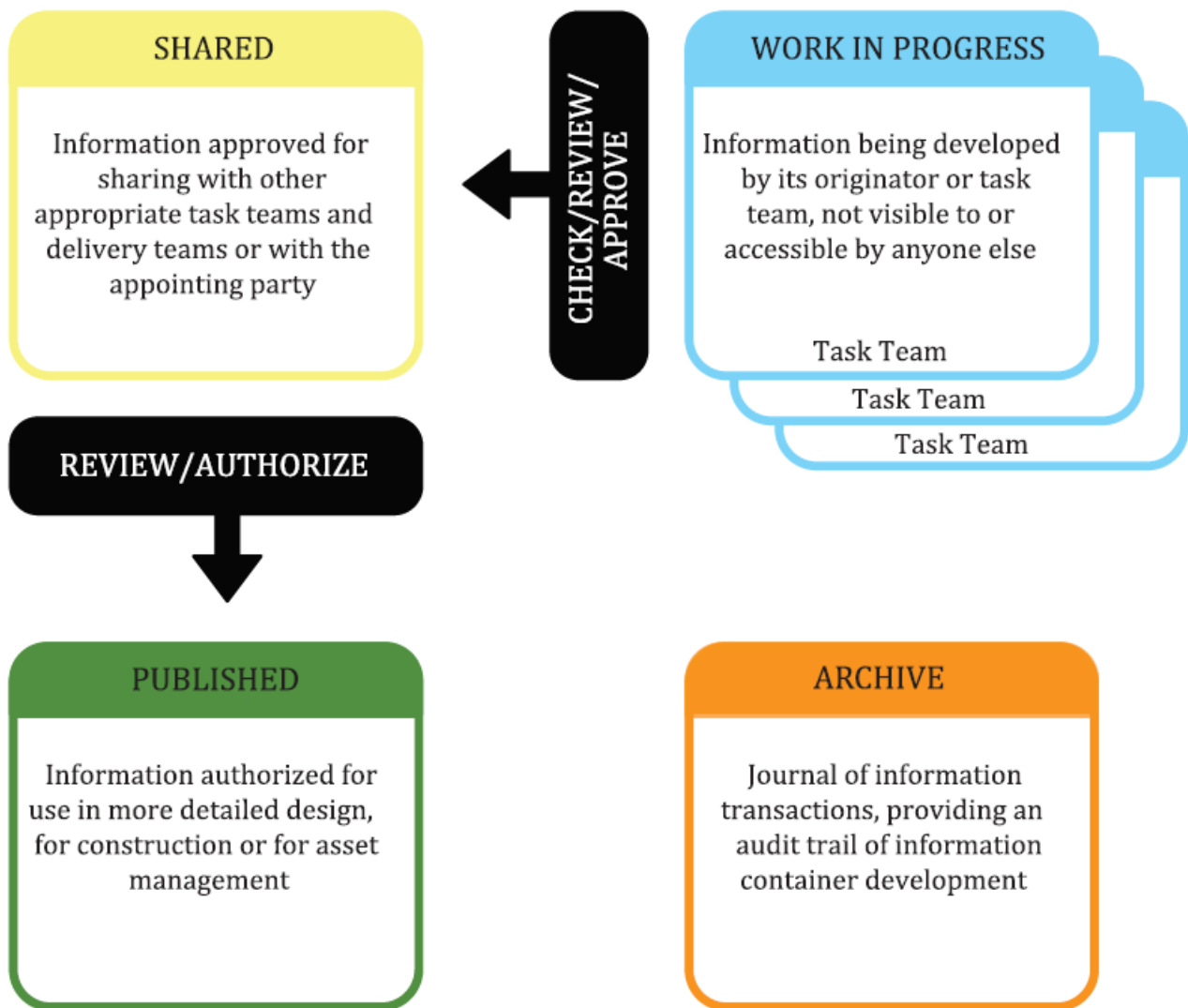
Figure 4 - CDE defined in ISO 19650

In a nutshell, the four stages of processing work through CDE are:

1) Work in progress: Area of the CDE where team carries out their own work using their organization's software systems. Non-verified design data used by in-house design team only.

2) Shared: Area of the CDE where the team shares verified design data with other members of the project team.

3) Published: Area of the CDE for coordination and validated design output for use by the total project team.

4) Archive: Area of the CDE for project history maintained for knowledge and regulatory and legal requirements. It is also a repository of the project information for non-asset portfolio employers.

The requirements of a CDE define the precise functions that the corresponding platform must have. Having said that, attention has been paid to identify the features that commercial platforms offer and which of their functionalities comply with the legislation. Therefore, features are highlighted that meet the requirements of CDE.

3.1 Commercial CDE platforms

For an efficient BIM information flow, it's important to choose a hardware and software infrastructure that supports the minimum functionality required by law. Accordingly, a detailed analysis of the commercial platforms on the market has been carried out so that they can perform the CDE function. [21]

Each software is analyzed and described underlining which features they possess that meet regulatory requirements.

In this research the CDEs analyzed were categorized into two groups: the ones that have a unique platform which is designed by the developers of its company and the ones which are suite based.

Unique platform

- Trimble Connect (Trimble)

- Aconex (Oracle)

- BIMPlus (Allplan)

- usBIM.platform (Acca)

- BIMX (Graphisoft)

- Bimsync (Catenda)

- Simplebim

- BIMcollab

- BIMXtra (Clearbox)

- BIManywhere (Procore)

- BIM 360 Docs (Autodesk)

- Asite (Asite)

- BlueCielo Meridian

Suite of software

- Projectwise (Bentley)

- Viewpoint (Viewpoint)

- STR Vision Teamwork (TeamSystem)

3.1.1 BIM 360 Docs (Autodesk)

It is a collaborative platform Autodesk, is part of BIM360 platform. It is a common data environment for building, covering the entire life cycle of a building project, from design to maintenance.

It is a single centralized database for documents, all information is contained in a single cloud can also be used from smartphones and tablets (even offline).

The Team Administrator (BIM Manager or Project Manager), through special permission management, assigns roles and responsibilities. The platform can manage two-dimensional data, 3D models, and other project documents, including IFC, PDF, and REVIT. The system allows to explore the 3D model, using an internal viewer, add the tables directly from these and read all the properties of the elements from Revit template file. The system also supports OCR functions to recognize capabilities of the attributes within the cartouches for automatic population of metadata. BIM 360 DOCS permits comparisons between different Revit models and/or between pdf tables. Using annotation and revision digital tools, you can annotate digital review or revision clouds (Markups and Issues). Furthermore, you can add hyperlinks.

All documents uploaded are subjected to approval by the reference manager, after which they can no longer be changed.

Whenever you make a change or upload new files, automatically a notification is sent to all project managers. The system stores the updates of the different files and upload models, allowing the execution of comparison between different versions so that you can monitor the progressive advancement of the design.

Through Revit software (Autodesk) you can directly integrate the models in the cloud. By using Desktop Connector, you can also manage files linked to the Revit model within BIM360 DOCS centralizing documentation into a Common Data Environment. [21]

3.1.2 ProjectWise (Bentley)

"ProjectWise from Bentley Systems is a suite of collaboration complementary software for projects of architecture, engineering, construction that work on a single platform.

Through ProjectWise Edge, you can access ProjectWise content from desktop and mobile. The suite allows administrators to create multiple layers of security to assign specific access rights to certain individuals or workgroups throughout the life cycle. User authentication allows the configuration of individual access points using credentials at the operating system level.

ProjectWise stores and manages all types of AEC project content including DGN, DWG, Adobe PDF, and Microsoft Office and indexes the content themselves stored in the document DGN, DWG and Office. 3D models, 2D drawings, hypertext information, and document flow related to a project are organized in the archiving system in which each user can access to acquire or modify files.

The suite allows you to follow each stage of work in progress so that they meet the financial criteria and the work schedule (ProjectWise EADOC).

The suite creates a history of all operations performed on each document. Each user is responsible for the created documents.

Organizations can manage the life cycle of documents from creation to approval. Users can define workflows, including ordered groups of stages through which a document passes before reaching the final completion.

It allows a Web feature that allows users in large groups to review and revise the project documents with the addition of storing the cache.

Through versioning capabilities, the suite can store and manage multiple versions of a document. It compares the designs in different versions of digital plots, records the activities at the document and folder level.

ProjectWise allows the generation of RFI and notifications (for review and validation) and sends them to people prepared to receive answers, clarification or refuse within an automated approval process.

The platform allows you to send automatic notices to the recipients of the project by keeping track of them and recognizing late jobs giving priority to them.

ProjectWise can handle any type of CAD data, BIM, geospatial, and design. It integrates with applications and other Bentley products including Autodesk and Microsoft Office software.

ProjectWise manages file operations for MicroStation, AutoCAD, Microsoft Office, and many domain desktop applications. This process includes the maintenance of links to references and the management of files related to a specific application." [21]

3.1.3 BIMPlus (Allplan)

BIM PLUS is the platform Open BIM cloud, to coordinate all disciplines in construction projects. Each data and information is centrally managed within a single environment throughout the life cycle of the building, accessible from any device, including mobile.

The software allows you to assign permissions and roles to the different actors of the process and handle tasks of each. Activities can also be linked to the model.

The system, which allows transposing the partial models of different specialized disciplines, gives the ability to integrate project data from any design software. Information is grouped in a BIM model of central coordination and remains available for all subsequent processes.

The revision management allows you to manage the revision levels of the respective model and its versions. It keeps track of each modified version of the model so you can see any changes made over time. The BIM manager can constantly monitor the situation, controlling which activities are still open and which have already been concluded.

You can customize the view of each model (IFC and Sketchup) and navigate in the central coordination model to take over inconsistencies.

The use of a central coordination model, constantly updated, allows us to find any discrepancies and to co-ordinate the tasks of the various parties involved. A notification is sent to the users when a model is loaded, an activity is opened, or an invitation is sent.

An important feature of BIMPLUS is the Task Board connection with structural analysis software SCIA Engineer, so that professionals who deal with the structural design and who work with this software, can collaborate. [21]

3.1.4 BIMX (Graphisoft)

BIMx is a cloud application of Graphisoft that allows the 2D and 3D view also from mobile.

The BIMx model can be shared with members of the BIMx community and with other partners through the online service for sharing of GRAPHISOFT.

This platform provides access to 2D documentation, the 3D model, and any other unincorporated geometric information in the model, allowing browsing, and querying. The BIMx PRO version includes real collaboration tools. It provides instant messaging tools and integrated review tools (e.g send notifications to Markups). It allows the use of interactive 3D models and 2D documentation created with the BIM Authoring ARCHICAD software, without the requirement to have the latter. [21]

3.1.5 Trimble Connect (Trimble)

"Trimble Connect is a collaborative cloud platform that allows you to view, upload, and share all the files in a shared space.

The platform is accessible from desktop applications, from web browsers, smartphones, and tablet devices.

The project administrator defines access permissions to different sections of the platforms or individual files and/or models as a function of the different roles assigned within the process. It also allows the creation of worklists to be done and assign team members.

The software allows you to upload files of the 3D model, 2D files, and documents in any format (PDF, DWG, DWF, Revit formats, etc.). For each element of the 3D model loaded, the system recognizes the properties and associated information. Each 3D model is navigable and queryable. In addition, there is the possibility to compare several documents that are displayed simultaneously. You can also layer models, such as IFC, and files in DWG format.

It is also possible to connect "attachments" to each element of the model so then you can find the documents associated with that element. For each created action you can define the status and activity history. The software enables communication between the various actors through messaging and notifications functionality. It also supports the creation of reports and RFI function." [21]

3.1.6 Aconex (Oracle)

"Aconex is a cloud platform that connects the construction and engineering projects team. It is a unique platform, viewable in the cloud and mobile, from the design and feasibility stage to construction until the closing and delivery.

Aconex is built on Open BIM standards and enables interoperability through IFC, BCF, and COBIE.

With Aconex each company taking part in a project can control access to his personal data, it retains legal ownership and set sharing rules.

The 3D BIM models can be viewed online directly from the platform, thanks to a built-in viewer. You can request information about an item with a direct link to the object in the project.

Project teams can upload the model's files and display in a personalized way, browse, and query the model. The system keeps track of all file versions (versioning) and maintains traceability of all actions done (business history). Workflow can be set and the time within which the different activities must be conducted, and the cycles of review and approval can be automated.

The tracking and reporting workflows provide real-time analysis to identify and manage criticalities. An online archive is also available.

Predefined reports allow you to have an updated and detailed overview of the status of file revisions. There is also a chronology of all correspondence that cannot be eliminated. A project e-mail-room is also provided." [21]

3.1.7 Asite

"ASITE is a data-sharing platform on which you can read, upload, and modify files and documents. You can work through PC or from mobile devices and even offline.

The administrator shall define the roles of different users that can access the platform. The platform interface is customizable, adapting to the needs of the user. The administrator can report, through comments, any problems in the project.

The platform supports various file formats (IFC, DWG, Excel, etc.). Through Revit plug-in, you can automatically load the 3D model and display it directly on Asite. You can detect inconsistencies in patterns, compare the changes and automatically send an email to all responsible for the project in the case of verification.

Asite allows to report a problem, assign the type, and define the maximum time within which must be solved by the responsible designer. Various workflows can be set and that must be followed during the process and the expiry of the various workflow steps, defining users responsible.

Asite allows you to compare and save all file versions (versioning).

The platform is equipped with a system that allows you to send email notifications whenever a document or information is exchanged or modified making it traceable. The system allows integration with multiple software." [21]

3.1.8 Viewpoint

"Viewpoint offers a suite of solutions designed to bring together the entire design usable in the cloud, from pc to mobile devices.

The accesses to the folders or files are regulated by specific permits, according to user roles.

The platform allows you to manage all the financial part of the project.

Is included a viewer for 3D models with the ability to save files automatically from Revit, federate the various models and create comments and tags.

There is the functionality of file versioning, automated backup, disaster recovery, and activity history.

There is an automatic notification system, the ability to create reports and manage the RFI. A calendar, viewable through the schedule, allows you to coordinate all team members." [21]

3.1.9 USBIM (ACCA)

usBIM.platform BIM is a collaborative platform developed in response to the Procurement Code and the UNI 11337.

With usBIM.platform you can manage BIM models and documents of all disciplines (architecture, equipment, energy, structures, construction, and maintenance) in a Data Sharing Environment (ACDat).

The platform offers the ability to display and manage the BIM model in the cloud, navigate the ACDat content and interact directly with objects, data, and documents related to the model.

The system provides access control to the project, assigning roles, and responsibilities according to which the access to the platform is regulated.

There are an IFC viewer and the ability to federate the different disciplinary models into a single model of coordination to perform clash detection and code checking (verifying the correspondence of the model to specific regulations).

You can open files, documents, and templates shared on usBIM.platform platform available in various digital formats (such as IFC, EDF, RVT, RFA, OBJ, OBJZIP, DAE, 3DS, DXF, DWG, SKP, SVG). Files of other formats uploaded to the platform (such as JPEG, DOC, XLS, etc.) can be viewed in standard mode via the web-browser.

You can connect any documents to the elements of the model directly from usBIM.browser, create logical links between the digital model objects and documentation present in the platform or to associate additional information (drawings, descriptions, technical specifications, and other documentation).

The platform keeps track of previous versions and / or states of approval of all ACDat files present It is also possible to associate the #TAG attributes that allow you to quickly search the contents of files.

The platform can also be integrated with usBIM.gantt, a specific application that allows to plan and manage the contract with a 4D approach, managing, and optimizing the time variable in the construction process.

The platform automatically manages the file revisions and any notifications to be sent to the other users. It's available automatic data backup and disaster recovery by answering the rules dictated by the code of conduct CISPE, from GDPR and European rules on privacy.

All actions are recorded by allowing the traceability of versions.

You can set a workflow that defines the sequence of workflows procedures, production, revision, and validation of the design documentation. They represent the tasks that each user must perform if involved in a work process.

There is instant messaging functionality for direct communication between the users involved in the project. [21]

3.1.10 Accruent BlueCielo MERIDIAN

BlueCielo Meridian is a management engineering software available as a cloud server or local service. It is a unique shared environment, also accessible from mobile devices and in offline mode.

The allocation of permits can take place up to a single file, you can also assign roles to each user of the project. The software manages files of various formats including 2D and 3D. There is a feature of versioning and automatic backup.

It permits the simultaneous change management and maintenance of master data As built for operations and maintenance. The platform uses reports and dashboards (for operating system interface) to analyze performance and make decisions. The software allows you to send instant messages and create reports.

You can save 3D models directly from Revit, uploading attachments and links on it.

BlueCielo Meridian allows for different integrations. Are possible integrations with EAM (Enterprise Asset Management): IBM Maximo, SAP EAM, Infor with ERP (Enterprise Resource Planning): SAP, Oracle, Microsoft Dynamics AX. Also, with enterprise content management systems and Office applications (Microsoft Office) and finally integration with authoring applications: AutoCAD Family, MicroStation, Inventor, Solidworks, Revit, and DWG-based CAD applications. [21]

3.1.11 Vision Teamwork SUITE CDE (Teamsystem[1])

Vision Team-work Suite CDE is a TeamSystem STR platform that integrates a document system and allows storing and sharing of project documents. The platform can be used both in the design, which in the construction phase. In the same platform, modules are also available for the next phase of management.

Within the platform, you can schedule periodic inspection checks aimed at Quality, Safety, Environment, and Health checks. These checks are carried out with the help of a configurable Check List.

It manages the project documentation or documentation produced during construction. Based on a powerful DMS (Document Management System), it allows the definition of processed lists to produce (Deliverable list) in the individual phases of the project (task).

For each document, you can check the list of revisions that it has undergone and seen the preview.

You can calculate the progress of the task as a function of the projects approved and were to be produced.

The system supports several file formats, it is possible to load and display CAD elaborate, IFC models, points clouds, flow Sheet, 3D models, photo tags, CSV data, SHP files, folders, documents. Within Vision Team-work CDE Suite you can upload, browse, and query both CAD and BIM models. It has a specific plug-in for the main design environments (AutoCAD, Revit, Navisworks, etc.) and the upload tools that import major graphic formats (DWG, DXF, IFC, etc.).

The Vision Suite Teamwork CDE main module collects all the information and project documents. On the platform, you can manage the WBS project and monitor the status of task progress and any problems. It allows to assign the time and the resources planned to each stage of the process, in order to perform analysis of the needs and overlaps.

You can create a list of products to be produced. For each loaded document, after it being subjected to verification, it is associated with a state (Validation, Approved, needing attention, etc.) that is modified over time based on the specific workflow set in the platform. Also, the list of file revisions remains in memory and can be accessed at any time (versioning).

The suite allows you to manage the workflow of all requests for information or variation. It keeps track of the process by facilitating interaction between the parties involved in the decision. [21]

3.1.12 Bimsync (Catenda)

Bimsync is a BIM collaboration tool with support for all of the buildingSMART standards (IFC, bSDD, BCF, COBie). It comes with a range of APIs for easy implementation into you own software.

It improves BIM collaboration by saving time, reducing risk and increasing quality. No installation necessary, everything runs in browser. Visualization of information is a core feature of Bimsync. High performance 3D viewer combines with auto-generated 2D floor plans to get a full overview of all of the models in your projects. You can stream map data from external sources. [22]

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[1] Formerly known as STR

3.1.13 Simplebim

Simplebim is an application for editing IFC BIM models. Import IFC2x3 files, trim unnecessary objects and properties and edit property data. Preview the result and export the model into a new IFC2x3 file that is smaller, imports better into other IFC enabled applications and contains data that can be trusted. You can clean-up and focus the data by removing unnecessary objects and properties; add your own standardized properties to the model; map properties and their values; combine and derive property values; automatically classify and group objects with you own classification systems; move models to project coordinates; manage element assembly structures; normalize containment structure; change object colors; merge data from outer source to the model; calculate consistent and normalize quantities with the industry leading Basic Quantities tool; resolve locations with Simplebim's unique Location Editor; merge models and their data and structures or split the building elements.[23]

3.1.14 BIMcollab

BIMcollab is an issue collaboration platform for BIM, built on the widely accepted IFC and BCF open standards. BCF issues contain all relevant information enabling communication about BIM models.

BIMcollab simplifies issue management, and offers a structured way of storing, sharing and solving issue including reliable history tracking in any BIM development process. Simplify communication. Set deadlines to issues, assign them to team members, who directly get an email notification. Or choose to receive a daily or weekly activity overview. A really unique feature of BIMcollab and part of your Connected Plan is the approval workflow: define per issue which team members need to approve a resolution before the issue can be closed.

The Autodesk BIM360 integration provides BIM teams access to models stored in BIM 360 Docs, directly from the BIMcollab web application. Team members can review the federated model, create issues or review existing issues without the need for uploading files to a secondary repository or installing a model viewer.

All data is backed up daily. The data is safe and securely stored in a datacenter in The Netherlands. The datacenter of Interconnect is ISO27001, ISO9001 and ISO14001 certified.

BIMcollab can be integrated with BCF managers; they are plugins available for many BIM tools. They enable you to create, multi-edit, filter, comment and lookup issues directly in the context of your BIM model. In this way you can share issues with team members via BIMcollab whether they are working with the same or different BIM tools. The BCF manager for Navisworks allows you to import thousands of clashes at once from the clash-detective or saved viewpoints. Meta data can easily be added to issue descriptions and comments (e.g. clash status, clash point, assigned to, approval data and more). [24-26]

3.1.15 BIMXtra (Clearbox)

BIMXtra provides a cloud-based common data environment, CDE, where project information can be consolidated, viewed, edited and compiled into intelligent, revision-controlled information, which can be accessed through a standard web browser. You can grant access to all project stakeholders in a fully integrated, controlled and collaborative solution, based around a central federated source of information to deliver a true, single source of information.

Its Document Management System (DMS) is aligned with BS1192 and ISO19650 standards. It ensures that all project documentation is securely stored and located in one location. The DMS workflow tool provides admins the ability to configure automated file distributions, file copying and notifications in the DMS, and also report on and monitor the status and progress of files as they progress through the workflow. This helps to ensure that users follow processes and everyone can see what needs doing when.

The information may be drawn from different software programs, and is then combined in BIMXtra for use by different members of a project team. At the end of a project, BIMXtra can also be used to create COBie outputs from data collected through the job and linked O&M manual. Clearbox also offers a related mobile product called Insight. [27-29]

3.1.16 BIManywhere (Procore)

BIManywhere is a visual BIM collaboration platform for construction and facilities management. It streamlines communication across teams, improves operational workflows, and manages issues before they impact cost and schedule. The solution gives everyone access to complicated BIM information. The mobile app gives quick and easy access for superintendents, foremen, and facilities engineers in the field. The web application gives convenient access in a computer browser for project managers, and BIM specialists benefit from access on coordination software. BIManywhere is now part of Procore corporation.

Procore reporting and dashboards establishes a canvas to see all of your information at once. Most reports can be exported to a PDF or CSV file to be shared with project executives, owners, or anyone looking for summaries.

Store as many electronic documents as you need; Procore doesn't charge by the megabyte or gigabyte. In fact, users receive an unlimited amount of storage. Procore makes your electronic documents available to any member of your extended team with varying permission levels. Users without permission won't see any documents, while team members with the proper authority can upload, view, and download project documents as needed.

Procore's Document Management tool not only archives your documents, but also ensures they are stored securely and privately. Procore automatically provides backup for all of your electronic documents, from any application, on multiple server hard drives located in different areas around the country. [30-32]

4   Comparative tables

The search was carried out based on information made public by the software houses and not on the actual use of them. The following tables show all the requirements of a CDE based on various regulations (the first two columns) and for each software it is indicated whether these requirements are met. The requirements criteria to compare the CDEs are:

- Environment usability

What kind of environment each platform has whether it is unique or a suite one; If it is a cloud or local server; If they can be managed through smart phones or not; Whether they need to be managed online or offline.

- Data management

What file formats can be used in the software system; if it is possible to extract data from models in solutions or not; if they have back up or not.

- File management

 How the CDE platforms manage the files, whether they have the ability to archive or version or recover the file.

- Workflow management

If the programs have predefined workflows according to standards or not, and if they have approval stages for information workflow management.

- Users management

If there is an option in the software to assign responsibilities, tasks and roles.

- Communication

If the platform provides the mail or messaging option inside the program or not ; if the software has notification section, supports the creation of reports or RFI function.

- Traceability

If it is possible to track the information down or not; if the software has history or not.

- Propriety graphic files visualization

If it is possible to integrate the 3D viewer; read properties of elements; create and recognize a parameter for a title block; read, compare, federate models; if it is able to load from Revit, attach files, create links, tag or write comments and notes.

- Software integration and plug-ins

What types of software programs can be used or added as CDE; if it can be connected to other BIM software programs to import or export of them. "Yes" means the company has their own software to work on with.

- Check and validations

If there is the option of clash detecting, code checking, conflict resolution system in the platform.

- Availability

Whether it is an open source or commercial which is shown as "F" or "C".

- Import/export

What types of file formats can be managed in the platform to import or export

		Bim 360 DOCS	PROJECTWISE	BIMPLUS	BIMX	TRIMBLE CONNECT
Environment usability	Environment	Unique	Suite	Unique	Unique	Unique
	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server
	Mobile devices	Yes	Yes	Yes	Yes	Yes
	Connectivity	Online+ Offline	Online	Online	Online	Online
Data management	File format	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats	2D-3D	2D-3D-other formats
	Data extraction and query from models	Yes				
	Back up (Disaster recovery)		Yes	Yes	Yes	Yes
File management	Archive	Yes		Yes	Yes	
	Versioning	Yes	Yes	Yes	Yes	Yes
	Disaster recovery	No	Yes		Yes	
Workflow management	Predefined workflows	Yes				
	Verification and approval stages	Yes	Yes			
Users management	Responsibility assignment	Yes	Yes			
	Task assignment	Yes	Yes	Yes		
	Role assignment	Yes	Yes	Yes		
Communication	Mail/Messaging	Yes	Yes		Yes	Yes
	Notifications	Yes		Yes	Yes	Yes
	Reports					Yes
	RFI (Request For Information)					Yes
Traceability	Activity history	Yes	Yes	Yes	Yes	Yes
Proprietary graphic files visualization	Integrated 3D viewer	Yes	Yes	Yes	Yes	Yes
	Reading of model elements' properties	Yes			Yes	Yes
	Titleblock parameters recognition	Yes				
	Automatic metadata population	Yes				
	Auto save/load from Revit	Yes				Yes
	Models federation	Yes		Yes		
	Comments/notes	Yes	Yes		Yes	Yes
	Models/ dwg comparisons	Yes				Yes
	Attachments/link				Yes	Yes
	Tag					
Software	Import	DWG,IFC,RVT, DWF,NWC		dxf,dwg,dwt, dxb,pdf,ifc⬜ 3dm	ArchiCAD	DWG, IFC
	Export	DWG,IFC,RVT, DWF, xlsx	xlsx, doc	dxf,dwg,dwt dxb,pdf,ifc⬜ 3dm,xlsx,doc	Share the same model with annotations	DWG,IFC
	Software name/type	Revit	Magnet	Design software	ArchiCAD	
	Plugins/integration	Egnyte Navisworks	Microsoft 365	Revit Excel MS project		SketchUp
	Availability	C	C	F	F	IFC SketchUp F (with a limitation), C for most functionalities
Check and validations	Clash detection			Yes		Yes
	Code checking					
	Conflict resolution system	Yes				

		ACONEX	ASITE	VIEWPOINT	USBIM PLATFORM	BLUECIELO
Environment usability	Environment	Unique	Unique	Suite	Unique	Unique
	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server
	Mobile devices	Yes	Yes	Yes	Yes	Yes
	Connectivity	Online	Online+ Offline	Online+ Offline	Online	Online+ Offline
Data management	File format	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats	2D-other formats
	Data extraction and query from models				Yes	
	Back up (Disaster recovery)	Yes	Yes	Yes	Yes	Yes
File management	Archive	Yes(Online)				
	Versioning	Yes	Yes	Yes	Yes	Yes
	Disaster recovery			Yes	Yes	
Workflow management	Predefined workflows	Yes		Yes		
	Verification and approval stages		Yes		Yes	Yes
Users management	Responsibility assignment	Yes			Yes	
	Task assignment	Yes	Yes		Yes	
	Role assignment	Yes	Yes	Yes	Yes	Yes
Communication	Mail/Messaging	Yes	Yes		Yes	Yes
	Notifications	Yes	Yes	Yes	Yes	
	Reports	Yes	Yes	Yes		Yes
	RFI (Request For Information)	Yes	Yes	Yes		
Traceability	Activity history	Yes	Yes	Yes	Yes	
Proprietary graphic files visualization	Integrated 3D viewer	Yes	Yes	Yes	Yes	
	Reading of model elements' properties				Yes	
	Titleblock parameters recognition					
	Automatic metadata population					
	Auto save/load from Revit	Yes	Yes	Yes	Yes	Yes
	Models federation		Yes	Yes	Yes	
	Comments/notes		Yes	Yes		
	Models/ dwg comparisons		Yes			Yes
	Attachments/link	Yes		Yes	Yes	
	Tag			Yes	Yes	
Software	Import	IFC,COBie,BCF		IFC	IFC	MS Office format
	Export	DWG, DWF		COBie	IFC	CSV
	Software name/type	Aconex	Yes		usBIM. PLATFORM	
	Plugins/integration	Revit Navisworks Solibri	Revit	IFC Viewer	IFC Viewer	Revit AutoCAD Solidworks SAP
	Availability	C	C	C	C	C
Check and validations	Clash detection		Yes	Yes	Yes	
	Code checking				Yes	
	Conflict resolution system					

		STR VISION TEAMWORK	BIMSYNC	SIMPLEBIM	BIMCOLLAB	BIMXTRA	BIMANYWHERE
Environment usability	Environment	Suite	Unique	Unique	Unique	Unique	Unique
	Cloud/Local server		Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server	Cloud/Local server
	Mobile devices	Yes	Yes		Yes	Yes	Yes
	Connectivity	Online	Online	Online	Online	Online	Online
Data management	File format	2D-3D	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats	2D-3D-other formats
	Data extraction and query from models		Yes				
	Back up (Disaster recovery)	No			Yes		Yes
File management	Archive	Yes				Yes	Yes
	Versioning	Yes	Yes	Yes	Yes	Yes	Yes
	Disaster recovery				Yes		Yes
Workflow management	Predefined workflows				Yes	Yes	
	Verification and approval stages	Yes		Yes	Yes	Yes	
Users management	Responsibility assignment				Yes	Yes	
	Task assignment		Yes		Yes	Yes	Yes
	Role assignment		Yes		Yes	Yes	
Communication	Mail/Messaging				Yes		
	Notifications		Yes	Yes	Yes	Yes	Yes
	Reports	Yes		Yes	Yes	Yes	Yes
	RFI (Request For Information)	Yes	Yes			Yes	Yes
Traceability	Activity history			Yes	Yes	Yes	Yes
Proprietary graphic files visualization	Integrated 3D viewer	Yes	Yes	Yes		Yes	Yes
	Reading of model elements' properties	Yes	Yes	Yes	Yes	Yes	Yes
	Titleblock parameters recognition						
	Automatic metadata population				Yes		
	Auto save/load from Revit		Yes		Yes		
	Models federation		Yes	Yes	Yes		Yes
	Comments/notes	Yes	Yes	Yes	Yes	Yes	Yes
	Models/ dwg comparisons				Yes	Yes	Yes
	Attachments/link		Yes				
	Tag						Yes
Software	Import		DWG, IFC, BCF	IFC	BCD, BCF2.0	RVT, MS Excel, IFC	DWG
	Export		IFC,BCF, COBie	IFC, MS Excel	BCF, BCF2.0	COBie	PDF, CSV
	Software name/type		Bimsync Arena Bimsync Boost	Yes	Yes	Yes	Yes
	Plugins/integration		Revit Archicad Solibri	IDA-ICE	Revit BCF Managers		Navisworks AutoCAD
	Availability	C	C	C	F: Limited version	C	C
Check and validations	Clash detection				Yes	Yes	
	Code checking						
	Conflict resolution system						

[21, 33]

An NBS, a BIM specification company-based UK, follow-up question asked respondents to list the CDEs they use. This invited free text responses, and some people cited more than one platform, so the percentages do not sum to 100; the survey suggests Viewpoint For Projects is the most widely used CDE ahead of Aconex/Conject (these businesses merged in March 2016) and Asite. Generic file-sharing applications, including Dropbox (neck-and-neck with Autodesk's BIM360 range), Microsoft's Sharepoint and Google Drive also featured in the most commonly cited answers – although NBS noted many respondents said they used these general tools for "projects of a less complex nature". I understand from NBS that some other solutions (e.g.: GroupBC's CDE) did not feature in the report's final list as they got less than five mentions. [34]

Please list the Common Data Environments you use

Viewpoint	32%	
Aconex/Conject	20%	
Asite	14%	
Dropbox	12%	
Autodesk 360 range	12%	
Microsoft Sharepoint	6%	
Bentley Projectwise	5%	
Causeway Livelink	2%	
Google Drive	2%	
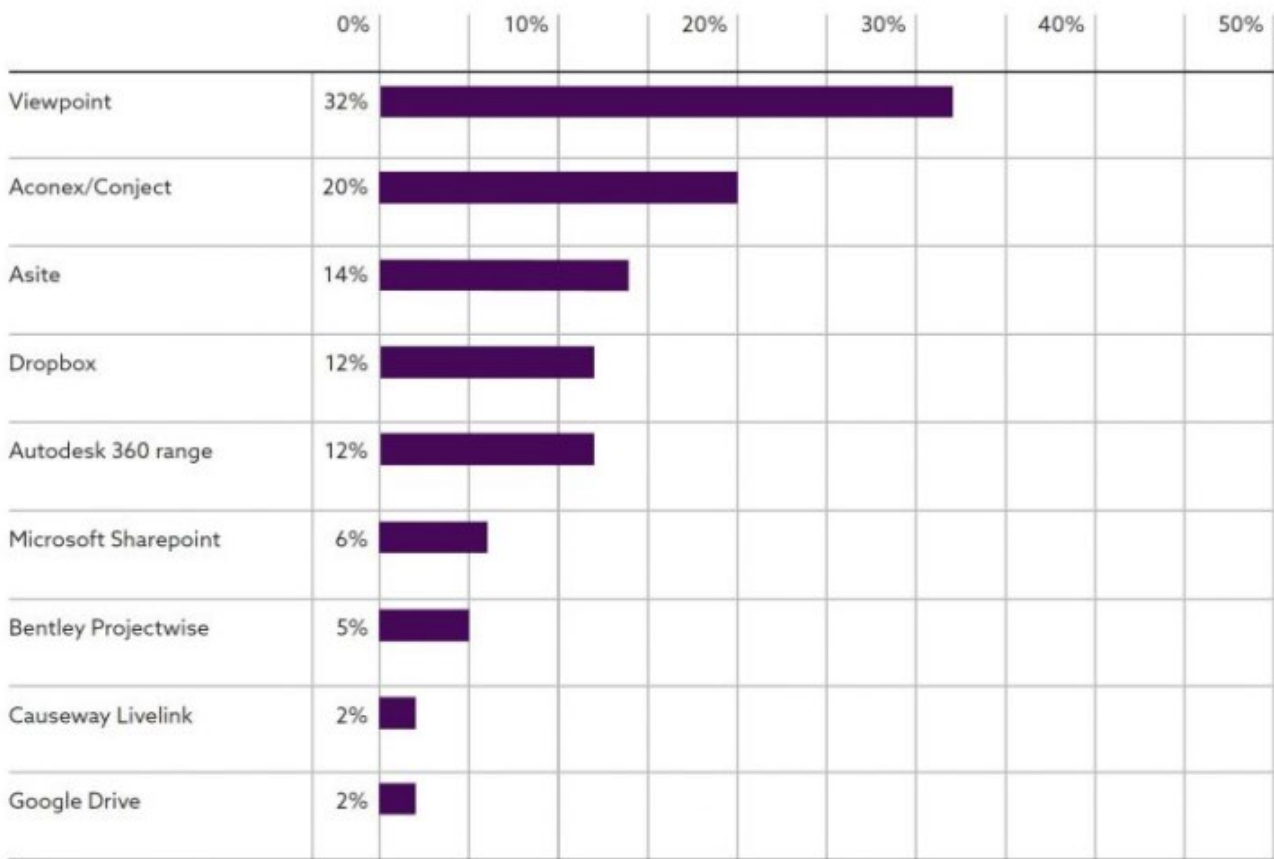
[35]

5 Aconex as a CDE

5.1 Introduction

Oracle Aconex is a cloud-based project collaboration solution for managing information and processes between companies on complex construction and engineering projects. Several functions include document management, workflow automation, bid management, issue management, handover management and control of project correspondence. Aconex also offers BIM file management and process control, field inspections and issues management and the creation and management of digital operations and maintenance manuals.

As a cloud-based solution, Aconex allows project members worldwide to create and review documents and other project information from any location. This includes RFIs, drawings, 3D models, contracts, reports and more. A real-time dashboard allows users to set their KPIs and monitor essential activities from a single screen. It also supports third party integrations which allow users to sync data within applications simultaneously.

Aconex supports construction and engineering projects across multiple industry segments but is primarily designed for asset owners, developers, architects, engineers, general contractors, government contractors, heavy/highway construction firms and mining, power, and oil and gas companies.

5.2 International references

Some of the featured clients:

Engineering, Procurement and Construction (EPC) is a particular form of contracting arrangement used in some industries where the EPC contractor is made responsible for all the activities from design, procurement, construction, commissioning and handover of the project to the end-user or owner.

Nine of the top 10 global EPCs

23 of ENR's top 25 global design firms

500 construction and engineering firm

[36, 37]

5.3   Modules

- Documents

It is used for all document, drawings, specifications, and schedules that need to go through a series of revisions. When you upload documents, you have to tag or classify information against the documents so that it can be easily searched for in your document register. This little work of tagging information up front will save a lot of time down the track when it comes to finding things and it enables workflows and other tools to work properly helping to save time and money across the entire project.

- Tasks

The Tasks page is like your Aconex home page. It lists the tasks that you need to action, which projects you are on and provides shortcuts to some common actions. A task is an item that requires action or attention from you. Any workflow transmittals you receive are listed on the My Tasks page. These documents will stay in the "Awaiting Your Review" list until you complete your review, or delegate your review responsibilities to someone else in your organization.

- Models

Models is a dedicated space for collaborative model management in Aconex.

With Models, it's possible to:

- Share models with everyone on your project.
- View and navigate model files in an aggregated view, without using proprietary model authoring tools.
- Link Aconex documents to specific model objects, to help in construction, auditing and handover.
- Send mail, such as RFIs and other process-related correspondence, relating to Models objects, and attaching marked up model views if they're needed.
- Create BCF files for virtual design reviews and project coordination.

While Models isn't a replacement for proprietary authoring tools, it allows your project team members to access published models without 3D design software.

- Plugins

3rd party plugins are used with Aconex to find and create issues, and to assign them to users who will fix them. Plugins are used with Aconex for one of two reasons:

- find issues and upload them to Aconex – this is done in Navisworks and Solibri (and Aconex)
- fix issues found in Aconex or other plugins – carried out in Revit.

There are a couple of workflows that you could use with these. Data created in Aconex, Navisworks and Revit is automatically uploaded to each of these. If you use Solibri, this process has to be carried out manually. The following scenarios show examples of the basic workflow:

1.   An issue is created in Aconex:

- This is then reviewed in either Navisworks or Solibri.
- The issue is assigned in Navisworks or Solibri. This is an optional step.
- Next, the review data is uploaded to Aconex.
- The issue data from Navisworks or Solibri are assigned to a specific Revit user. This assumes the issue wasn't assigned in either Navisworks or Solibri.
- The Revit user reviews and fixes the issue.

- The fix data is uploaded to Aconex, as a model revision, where it is reviewed and, if accepted, closed as an issue.

2. An issue is created in Navisworks or Solibri:

- The issue is assigned to a Revit user.

- The Revit user reviews and fixes the issue.

- The fix data is uploaded to Aconex, as a model revision, where it is reviewed and, if accepted, closed as an issue.

There are three versions of Models: Model Explore, Explore+ and Coordination. The one you can access will depend on what you're licensed for.

The Models functionality you can use in Aconex depends on the version your organization is licensed for. These are:

Model Explore:

In Aconex this allows your project team to upload models to the document register and view them in the model viewer.

Model Explore+:

In Aconex this has all the features in Model Explore, but also gives your project teams the ability to link documents, raise processes, manage comments, add measurements, and create and share viewpoints.

Model Coordination:

In Aconex this has all the features in Model Explore and Explore+, along with the ability to simplify the coordination process and issue management. You can also create and manage the flow of design issues on a single platform, work directly in your design tools through a live plugin integration, monitor and control progress through a dashboard.

- **Reports**

Process insights

Insights is a reporting dashboard inside Aconex that allows you to see the performance of your processes and understand any issues or bottlenecks in the project. Insights focuses on the processes running in your project regardless of whether they are implemented using Mail, Workflows or Field. The aim is to provide the user with easy-to-understand visualizations of their process information to diagnose risks and performance.

The insights approach

Insights in Aconex is based around a four-level hierarchy.

- It's underpinned by a belief that it's best to show metrics across the portfolio based on a standardized process model.

- The project level allows you to see each of the processes running on a project and check for any correlations and identify a poorly performing process.

- The process level allows you to then diagnose the fault in the process by slicing and dicing the data.

- Finally the detail level gets you to the line level detail below the graphs.

Reporting approaches

- Diagnostic - look at the current situation and determine what is wrong.

- Performance - look at a metric and how it has improved over 6-12 months (e.g. average time to respond on the project).

- Predictive - look ahead at what could go wrong based on the data Aconex holds on the performance of projects.

- Benchmarking - compare performance of your project vs others in your portfolio vs others in the industry.

- Self-Serve - build out your own reports based on the data available in insights.

- Search

It is for finding documents, users, mails, correspondents in Aconex.

- Workflows

Workflow Management - Improves the document control, standardizes best practice across the project and accelerates review and approval cycles.

- Supplier Documents

Vendor Documents Management - Streamlines the management of vendor data through automated processing.

- Tenders and Bids

Bid and Tender Management - Manages the entire process electronically, simplifying administration and reducing the time needed to create and manage packages.

- Mailing

Mailing is for correspondents, question answering, advices and instructions. In mail you group correspondents with mail types; this help provide meaning and make it easier to search and retreat correspondents down the track. Mailing in Aconex works more or less like a Gmail with inbox, drafts, sent sections, but only inside a project. When composing a new mail, first the type is selected which will define the next page tabs. This is where you categorize and tag every piece of correspondence down the track. It is important that to make sure the right people receive the right information. You can also control how users respond to specific mails. It can have restricted fields capturing sensitive information that only certain people of your organization can see it which these advanced settings is usually set up by the administrator. In the mailing section there is an option in which you can create groups for specific people to save time if you want to send an email to a group in your project.

- Support center

is a guide center to give information about any details of the software.

5.4 Functionalities

Aconex stores all the information safely and securely online, then provides tools to help you manage workflows and collaborate with everyone on the project. With Aconex you access your information anywhere and anytime you want as long as you are connected to internet. There is no need that every individual in the project knows the Aconex professionally, they just need to know the basics. All the information is securely stored and selectively shared. Organizations can only see the information in their own document registers, and they decide what they share with others. In Aconex correspondents and documents cannot be deleted. The software keeps a record of everything; therefore, you can always see who has done what. No matter how big the project is, this level of interoperability ensures the sharing capability. Instead of having hundreds of different tools, Aconex is the only source of information that the users need. You always know what the current version of the project is and who is holding up for processing and document reviews. You can also automate correspondents that the right people get the right information and respond with exactly what you need to keep the project moving. In general, Aconex is designed to improve the flow of communication and reduce the amount of rework and disputes that can take place due to the poor communication processes.

- Document register

In Aconex every organization has a private document register for the storage of its documents and drawings. It is like a virtual file cabinet in which the most recent version of documents will be displayed first with old copies still held for your reference. This helps you avoid wasted time and effort on outdated revisions. There is no restriction on file size or data storage, and nothing can be deleted. However, there is an option to share your selective documents with other companies as well.

- Online viewer pdf of Aconex

The online viewer enables you to view PDF documents in your Document Register directly in Aconex. And if you have permission to markup documents in the document register, you'll also be able to add markups and respond to another reviewer's markups.

- Superseding a document

When changes are made to a document, the document is superseded with a new revision; however, the previous versions are still kept having a complete document history. When editing an old file in Aconex, you just need to change the revision number in the document register.

There is also an option to bring back a previous version of document in case it is incorrectly superseded.

If you've just added a new version of an existing document and want to share it with the same organizations that have previous versions, there is the option of an auto update transmittal. they will all be able to see each other listed in the transmittal, as they were the first time.

All versions of a document are available in your organization's document register to maintain a complete document history.

- Uploading documents

You can upload files that are hosted on supported external services into Aconex without having to download the files to your computer. Currently, Aconex supports copying files from Dropbox and Box. If you don't see the option to upload a document from Dropbox or Box, it means you don't have permission.

- Preview a document

There is an option in Aconex which allows you to see the contents of a document from within the document register.

- Using MS Office Online

You can use it with Office files in the Document Register but can't be for reviewing in the Workflows module. Org Admins have to grant the Use office online permission for user roles to be able to use this feature.

You can view and edit files with the following extensions:

- doc/docx
- xls/xlsx
- ppt/pptx

Note that while you can open doc, xls and ppt files in their original format for reading, however, if you edit a file, they are saved as docx, xlsx and pptx files.

Drafts for Office documents are shared across users within the organization. Multiple users can edit MS Office files at the same time (co-authoring), and all their changes are visible in the draft being created. Drafts have the same access permissions as the original document. Editing is allowed only on the latest version of a document. If a draft already exists, editing is only allowed on the draft version.

Superseding using a draft is only possible if no one else is actively editing it. Once a draft file has been used to supersede a document, the draft will be deleted.

- Marking documents as no longer in use

No one can delete documents from Aconex, but you can hide a document from your document register. The document won't appear in your organization's document register. The document can still be viewed in history section. If you want to hide the document from other companies' document registers as well, send a transmittal to update the status to these organizations as well.

You mark the documents as no longer in use when for example:

Documents have been transmitted to you in error, and you want to hide them in your register, or A portion of the work will not be carried out, and you want to hide documents relating to this work.

Bear in mind that you shouldn't mark documents as no longer in use to fix a mistake. If someone has uploaded the wrong file. Then, don't mark the document as no longer in use. You can fix the error by superseding the document with the correct file or document information. Add in a comment about why the document was superseded.

- Temporary files

Temporary files are not registered to your project. They're often created as part of a bulk process or by the Aconex system.

Temporary Files are usually created by:

- Document administrators, as part of a bulk process they are running.
- the Aconex system.

Reports, system logs and other files that don't need to be registered into your project will be created in the Temporary Files section.

Temporary Files:

- are not registered to your project
- do not have a document number
- can be deleted.

- Version control

Version control records any change made to a document or its metadata (like the document status or attributes) by keeping a copy of every version of the document.

Version control operates on a Project level. When you update a distributed document, you update the version of that document. It helps ensure that all project participants are using the latest version of a document.

- Audit trail

The Aconex audit trail records the changes made to documents, mail and reports in Aconex. It lets you see who was responsible for which decisions.

- The Documents audit trail includes:
- The Document History tool, which logs all versions and revisions of a document.

The Event Log, which tracks every change made to a document by people in your organization, as well as who made the change, and when. It also links to relevant transmittals, so you can see who the document was distributed to.

The Mail audit trail is the mail thread, which shows who was involved in a conversation, when mail was sent, and what details were included in the mail.

All reports you create in Aconex will also be saved in Aconex, and have their creation recorded by the system.

Every user has access to most of the information making up the audit trail for their own organization, but project administrators and organization administrators can restrict access to some information.

- Locked documents

A locked document:

- is shown with the Lock icon enabled

- cannot be edited or moved while it is locked, except by the user who locked it.

- it is viewable by anyone with permission to see it.

- Supersede candidate

A supersede candidate is a type of temporary file that you can automatically match to an existing, registered document.

A supersede candidate must have:

- the same document number as a document that's already registered in Aconex

- a higher revision number or letter than the registered version of that document.

- Confidential document

If you're uploading documents that only certain people should have access to, mark them as confidential.

- Placeholder documents

If you want to reserve document numbers at the start of a project, create placeholder documents. Placeholders act as 'envelopes' within Aconex: you can set them up at any time to hold individual documents. If you're creating a large number of placeholders at the same time, consider using a bulk process to speed up the time it takes.

Placeholder documents are usually used:

- If you're using Supplier Documents to request documents from suppliers

- If you're using O&M Manuals Solutions

- A Project Administrator is setting up a new project and wants to reserve specific document numbers for certain key documents.

- Related items

Related items create relationships between documents to ensure that other users can access information more readily; in other words, they provide better visibility and tracking of important information and useful for Document Controller. If there is no icon of related items, this means there are no items. You can also add or remove relationships between documents.

5.5 Security

Aconex stores all the information safely and securely online.

In Aconex correspondents and documents cannot be deleted. The software keeps a record of everything; therefore, you can always see who has done what. If you make a mistake, you can always upload a newer version of the file.

When data is uploaded, you can see what your coworkers shared unless it is marked confidential. When working with other organizations on the same project, you can also see the documents that they have sent you and vice versa, but they have their own document register for the project. They

cannot see your documents, and you cannot see theirs. Therefore, there is a complete transparency at the project level, but organizations maintain separate registers.

When the documents are no longer in use, you can hide them, but you cannot delete them.

In the "event log" you can see who from your organization has accessed a document in Aconex.

5.6 Data integration

If you need to upload a newer version of a document, we can locate the old one in the register and select supersede. When an existing document is updated, it's automatically recorded in the document register and the older version is saved in case you need to refer it later. You can also upload and supersede multiple documents in the register once using the box "bulk supersede" tool.

If required, you can reduce your document types in lists to a more focused and manageable number. However, it only shows activities by people within your organization.

If you accidentally upload a new document while you were issuing the next version of that document

or a bunch of different versions of the same document have been uploaded into Aconex under different names.

6   Implementation approach

Organizations can quickly share information with external parties by issuing transmittals. A document transmittal ensures this updated document is added to other organization's document register. Sharing information in a transmittal is better than sharing via mail, because it prevents duplicates and automatically updates all the versions in all document registers.

Rolling out a system like Aconex can be overwhelming at first. In order to implement Aconex, we need to keep people at all levels of business informed, migrate from older systems, train staff to use a new system and manage timelines.

6.1 Process

There are three phases for implementation process.

- Prepare

System neutrality

In Aconex, everyone has equal access to information and not advantaging one company over another. One of Aconex's key features is that no matter how small or large an organization on a project is, everyone has the same rights. Here's what that means and how it's beneficial to you:

As a project member, you'll use Aconex to share thousands of documents and files with companies working on the same project, and they'll share information with you. Only the people you've chosen to share this information with can see it, whether they're within your organization or an external party. The same goes for you, too; you can only see what's been shared with you, so that instead of suffering from data overload, you'll only get the information that's important to your business.

You retain ownership and control over all your information, allowing you to keep files confidential or share them with specific users. That's the case whether you're the project-owning organization or not, and whether you're a sole proprietor or one user out of thousands at an organization.

Files shared within Aconex also cannot be deleted. This is important, because that means there's an electronic record of everything submitted and shared accountability, no matter the size of the project or the organizations that are part of it.

The owner of the project doesn't get to see everything just because they're paying for use of Aconex.

System neutrality ensures that Aconex is a level playing field for all users and organizations, no matter their size.

Difference between project owner and participant organizations

Project owner is the client of company paying for the use of Aconex, they have ultimate control over the configuration and platform; however, they don't get to see all the information just like everybody else they see only information which has been shared with them.

- Deliver

Standard user roles

One of Aconex's advantages is the ability to assign different roles to users. Good to know it comes preconfigured with a selection of roles based on a best practice approach.

User roles control what permissions users have, and what they can and can't do on the platform based on what type of access someone may need.

By default, Aconex comes with five types of user roles:

1. Basic
2. Basic +
3. Document Administrator
4. Organization Administrator (Org Admin)
5. Project Administrator

Roles can be modified to suit your organizational and project needs, and users can have more than one role.

Understanding the different types of user roles and what capabilities each have make it easier when you're adding new people to the project.

Basic

The basic user role allows users to create, view and manage mail, search the document register, and view the global directory. If the primary tasks that a user will need to perform are creating mail, searching mail, or searching documents, then a basic account is a good choice.

Basic +

Basic + users can do all the things of a basic user, in addition to transmitting and superseding documents.

Document Administrator

A Document Admin manages documents on a project for their own organization. By default, Doc Admins are users with either a role of basic or basic +, who are also responsible for specific document control functions. If you have a user who needs to perform the following tasks, assigning them a Doc Admin role makes the most sense:

• Uploading a document

• Creating confidential documents

• Transmitting updated documents

• Working with large amounts of documents

Project Administrator

Project Admins are responsible for managing the way a project is run on Aconex. A project can have as many Project Admins as necessary.

Because Project Admins can change project-wide settings-—which apply to all organizations working on the project—they usually work for the project-owning organization.

Project Admins for companies other than the project-owning organization can administer some settings specific to a project. However, these will only be applied to their organization's work on that project.

Organization Administrator

Org Admins are a key role within Aconex, as they help manage user accounts, answer queries about logins, and more. Note that whoever registered your organization in Aconex automatically became the Org Admin, but you can change this.

If you're the person who's likely to be managing Aconex's settings or configuring and assigning Aconex user roles for people in your organization, you're likely to be an Org Admin. For more information on this role, see our Organization Administrator Guide.

Guest users

While not an official role, people can also be given access to Aconex as a guest user if they don't need full access. If you have someone who only needs to view files, transmittals, and Mail, a guest account might be right for them.

Someone who's started on Aconex as a guest user can also be upgraded to a full account by an Org Admin.

- Support

It's important that all users have the opportunity to receive training. Building knowledge about the system is key to increasing adoption, and successful adoption itself is key to running a successful project.

If we could recommend one action that could improve your project, it would be to mandate a minimum amount of training for all members of the project team – both within your organization as well as external teams. The Getting Started training will give users a good foundation and result in better use of Aconex – this will mean better quality data for you to use managing the project.

There's a number of training options available on Support Central. However, not all of them are applicable to every team member.

If an organization has finished up their work on the project and no longer required to send or receive correspondence or distribute documents, you can change their project access to "Archive".

Awareness and Communication

People don't like surprises, especially when it affects their day-to-day routines. Changing how information is managed and distributed on a project is big. Fundamentally it's a change of behavior.

Let your team know what's coming and why. Get them involved during the delivery of Aconex too. You might think you're over communicating, but you're almost certainly not.

A few actions to develop awareness:

- Set up an intranet page
- Schedule a fortnightly update email to all staff
- Provide a feedback mechanism – a rollout inbox for example – so staff can engage with the implementation team

Leadership and Sponsorship

People need to know that their company and its leaders are supporting (i.e. sponsoring) the use of Aconex. If they're not behind its rollout and use, it's less likely to succeed.

Visible and vocal support is needed. Leaders are not required in every discussion, but they need to get behind any decisions. Set clear objectives and goals for Aconex.

They could:

- Fortnightly senior stakeholder meetings
- Templated progress reports
- Prepare awareness emails to be sent from the leadership team

Knowledge and Information

People need information to support any change. Without it, there will be excuses (i.e. resistance). Adoption will be less likely. It's about having the right information available when you need it.

If people get the answer to their questions quickly and easily, adoption will be better, and resistance will be reduced. Remove the excuses.

Our team will assist with these strategies, but we cannot make them work. That's where you come in.

Most people just want to know why something is happening and what it means to them.

- Provide links to Aconex Support Central
- Mandate minimum training
- Identify "champions" who will help sub-teams on the job

6.1.1 Common processes

- Communications

- Technical Query (TQ)

Technical queries and their management are critical to the success of every project. There are formal ways to communicate which provide structure way of asking questions, seeking clarifications or directions. They keep the project moving, preventing delays and help to keep both cost and time changes to a minimum.

In simple terms, a Technical Query (TQ), like an RFI, is a question that needs answering.

In business terms, it's a process that results in an official communication, one that seeks to confirm something, get clarification or seek direction on an element that could cause delay if it's not answered. It, or the results of it, can often trigger a number of other processes, like Changes and Reviews.

Aconex is routinely used for the management of TQs across many industries and projects and the diagram below depicts the basic steps typically seen in an TQ process.

Projects that don't have a good way to manage and track TQs tend to have more problems than those that do. Having an efficient and effective way to manage these queries ensures that a project progresses as scheduled and allows for the resolution of any issues that might impact construction.

- Change Request

A request to change something that has been contractually agreed upon is common on every project. Change Request of Aconex has a formal way of doing this. You can share information and make sure that the right people understand exactly what the changes are.

Contractual requirements or company practices may mean that a Change Request is called something else, such as a Request for Change, Potential Change Order or Contemplated Change Order.

Though the finer detail of the process varies from organization to organization, the process of requesting a change, receiving approval and then submitting follow-up paperwork is typical.

Aconex is routinely used for the management of Change Requests across many industries and projects.

The response of change request could be "advice", "reject" or "approval". You can also easily track and monitor your request and its result.

- Contractual

- Progress Claim (Progress Payment)

A Progress Claim (or Progress Payment) requests approval to apply for payment for a piece of work. It is submitted on an agreed upon schedule (typically monthly) and provides evidence of the completion of work being claimed.

Aconex is routinely used for the management of Progress Claims across many industries and projects.

Figure 5 – typical process of any request

The response could be "approval" or "reject".

- Delay

A Delay notice allows one party to let another know of a delay to the work they're performing. This notice can simply be a heads up or can be the beginning of more formal actions like Extensions of Time and Claims. A Delays process provides visibility to the project team and allows other parties to adjust plans if necessary. It helps to mitigate against any impacts to your schedule. The use of delay notices can ensure that a proper follow on actions are taking on a timely manner. Mapping out your delay notice process before you can figure Aconex allows you to gain clarity and save time down the track.
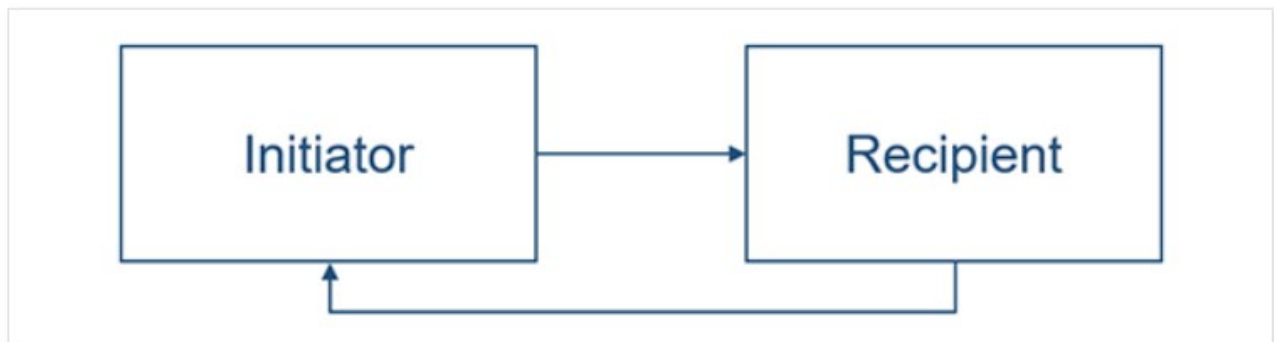

Figure 6 - Delay process

- Extensions of Time (EOT)

An Extension of Time (EOT) is a request to push out a completion or delivery date when there has been a delay caused by something out of the requestor's control. The EOT goes through a process that grants an approval or rejection and, when approved, often leads to the submission of a claim.

Aconex is routinely used for the management of Extensions of Time across many industries and projects. Projects that don't have a good way to manage and track EOTs tend to have more issues. An efficient and effective process for managing EOTs helps the project stay on time and budget.

- Quality

- Non-Conformance Report or NCR

A non-conformance report, non-conformity report or NCR, is a design and construction-related document that addresses issues where there has been a deviation from the project specification or

where work fails to meet agreed quality standards. The document is used as part of quality control processes by detailing:

- The problem including the: Discipline, Process, Severity and impact
- How it occurred
- How to prevent it from happening again

The NCR process is used to determine a resolution with the customer and documenting any corrective changes made through to the close out of the NCR, typically with acknowledgments of time and cost impacts.

- Hold Point / Witness Point

There are two important inspection actions that must be carried out in respect of the Inspection and Test Plan, they are called Hold Points and Witness points.

They are points in the construction stage where inspection or verification is required.

Their purpose is to make sure specification requirements have complied accordingly and to proceed for the following activities.

The definition of a Hold Point versus a Witness Point:

A Hold Point is a mandatory verification point beyond which work cannot proceed without approval by the designated authority, typically the Engineer or Consultant or 3rd Party Inspector. Work cannot proceed until receipt of a Hold Point Release issued by the person(s) whom inspected the work.

A Witness Point is an identified point in the process where the designated authority, typically the Engineer or Consultant or 3rd Party Inspector may review, witness, inspect method or process of work. The activities, however, may proceed.

- Design & engineering phase

- Design Documentation Review

Design Documentation consists of drawings and specification documents required to begin or continue construction. It illustrates a project's goals and requirements. It also provides information that organizations will use to build their bids and tenders. A review of this documentation takes place to assess the details of these goals and requirements and to ensure nothing's been missed. Approval of this documentation usually leads to the next step in a project's lifecycle.

Aconex is routinely used for the management of both the submission of Design Documentation and the reviews associated with them. The diagram below depicts the basic steps typically seen in a Design Documentation Review process.

Efficient and thorough review of design documentation has been proven to result in fewer issues further down the line. Fewer issues means that a project has a much better chance of staying on time and budget.
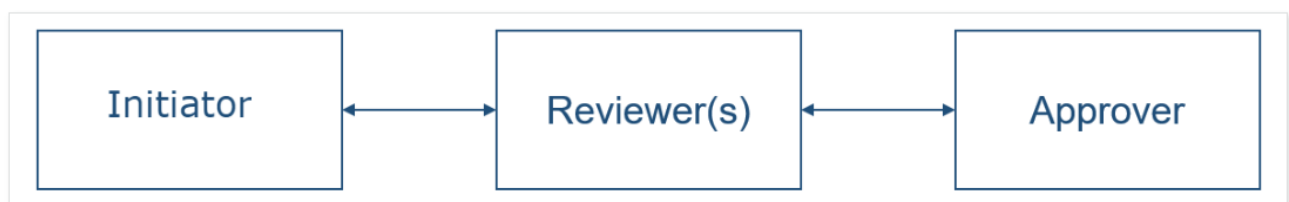

Figure 7 - Design documentation process

- Design Query

A Design Query is, more or less, a question relating to a project's design.

In business terms, it's a process that results in an official communication, one that seeks to confirm something, get clarification or seek direction on a design element that could cause delay if it's not answered. It, or the results of it, can often trigger a number of other processes, like Changes and Reviews.

Aconex is routinely used for the management of Design Queries across many industries and projects and the diagram below depicts the basic steps typically seen in a Design Query process.

Projects that don't have a good way to manage and track design queries tend to have more problems than those that do. Having an efficient and effective way to manage these queries ensures that a project progresses as scheduled and allows for the resolution of any issues that might impact construction.

Figure 8 - Design query process

- Squad check

Overlap between disciplines on a project is a given. A Squad Check is a multi-discipline review done to ensure that all the parts of the project will work together and that nothing has been missed.

Aconex is routinely used for the management of Squad Checks. The diagram below depicts the steps typically seen in a Squad Check process.

Squad checks provide the different discipline teams working on a project the opportunity to review, adjust, raise concerns and validate project during design and engineering phases.

Projects that have a solid Squad Check process improve accuracy and avoid costly mistakes – this is brought about by having the project disciplines working closely together.

- Construction phase

- Issue Capture

Issues can be categorized in a range of ways but typically they are defined as a 'defect' and result in substandard work in the design, workmanship, and/or in the materials or systems used on a project which result in the failure of a component part of a building or structure and causes damage to person or property.

An Issue, or defect work, is managed with a simple workflow. There is the identification step after which the issue is assigned to a responsible person to rectify and notify that work is complete. Of course, there is the 'it wasn't me' option where the assigned party can dispute that the allocation of the work is not their responsibility, all of which is managed in the workflow and track in Aconex.

- Shop drawings

Shop Drawings show how the construction team plans to build a project. A review of these drawings takes place to ensure completeness, to show conformance with the design and construction documents and to allow for approval and sign off of any known changes. Shop Drawings are usually submitted for review as per an agreed schedule and can result in other processes such as RFIs and Change Requests.

Shop Drawing reviews ensure accuracy and provide visibility into the details of the project. Poor Shop Drawing reviews can lead to costly errors and rework, putting the project schedule at risk.
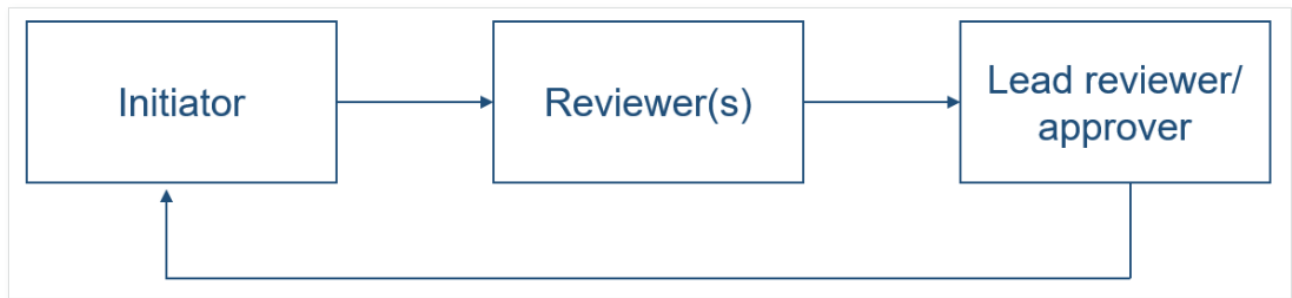
Figure 9 - squad checks and shop drawings process

- Request For Information (RFI)

In simple terms, an RFI is a question that needs answering.

In business terms, it's a process that results in an official communication, one that seeks to confirm something, get clarification or seek direction on an element that could cause delay if it's not answered. It, or the results of it, can often trigger a number of other processes, like Changes and Reviews.

Projects that don't have a good way of managing and tracking RFIs tend to have more problems than those that do. Having an efficient and effective way to manage these queries ensures that a project progresses as scheduled and allows for the resolution of any issues that might have a negative impact.

Figure 10 - RFI process

The response type could be either "advice" or "instruction"

- Deliverables

- Submittals

Submittals, also sometimes referred to as Supplier or Vendor Documents, are groupings of documents that illustrate how the construction team plans to build elements of the project such as installation, procurement, fabrication, operation, maintenance and etc. Submittals are made up of things like shop drawings, material and product data and samples. Submittals are usually issued for review and approval per an agreed upon schedule.

Keeping track of a project's submittals reduces the chances of delays, issues and re-work: ensuring that this process runs smoothly and efficiently is a key factor in a project's success.

Managing submittals process with Aconex allows anyone within your organization to see whether documentation has been approved or finalized or whether anything is outstanding.

- Supplier (or Vendor) Documents

Supplier (or Vendor) Documents are groupings of documents that illustrate how the construction team plans to build elements of the project. They are made up of things like shop drawings, material and product data and samples. They are typically submitted for review and approval on an agreed upon schedule.

Aconex is routinely used for the management of both the submission of the documents themselves as well as the reviews associated with them.

Keeping track of a project's Supplier (or vendor) document packages lessens the chances of delays, issues and re-work. Ensuring that this process runs smoothly and efficiently is a key factor to a project's success.
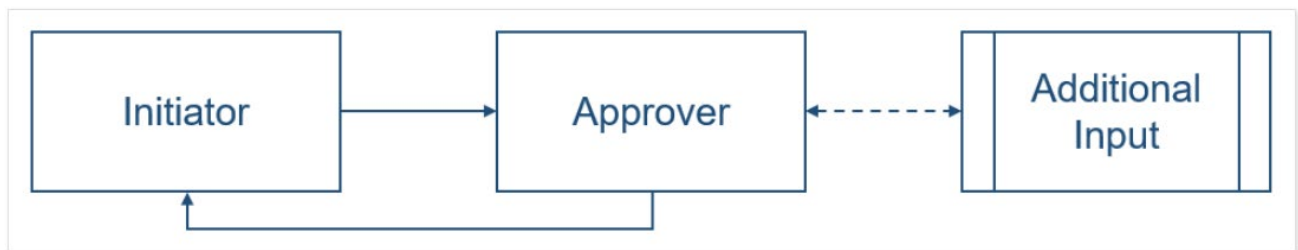

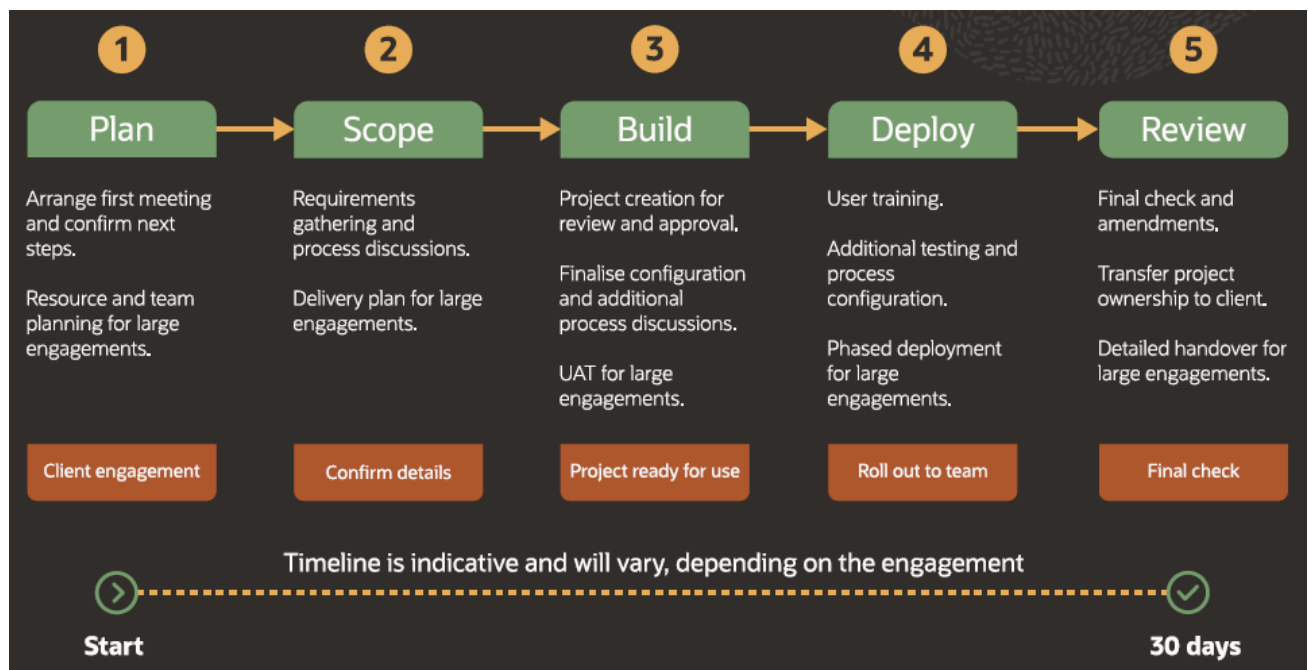Figure 11 - Deliverables process

6.2 Steps

Figure 12 - Implementation process steps

Plan

First, we need to understand what needs to be delivered.

The consultant will look at the information at hand. Most likely a lot was collected already during the Sales cycle.

Armed with that knowledge, your consultant makes contact with you. Together, you'll run through the deliverables that are included in this Implementation and your consultant will answer any questions about the process. It's important that there is a mutual understanding of what is required of each party.

Scope

Now we collect and confirm the information we need to get the system up and running. This is often intensive as we start discussing processes with the key stakeholders. More often than not scoping takes a number of meetings and follow ups before it's finalized.

This step is all about gathering information and context so we can set up Aconex in a way that is right for your project.

Build

Once you've approved the configuration, we'll start building. At this point, you have a clear understanding of what you are getting. And if we need to change anything, we'll make sure to get your approval beforehand.

This part is important to get right, and it's why the Plan and Scope steps are so critical. It's much harder to make changes once you've gone live with your project.

Deploy

Aconex is now ready for use and we need to get the broader team onboard and up to speed. Your consultant will ensure access to training is provided.

There may be some user acceptance testing (UAT) – a way for us to confirm that the system is set up to meet your needs. This is an opportunity to make any final changes to the project setup before it's used.

Review

We'll confirm with you that all deliverables agreed to at the start of the Implementation are complete.

If not, this is when we tie up any lose ends. Once that's done, the implementation phase is finished.

The completion of project

Once a project is closed on Aconex, project participants won't be able to access it. If your organization has purchased a Project Archive for the project, you'll be able to access your project information through it or you can purchase a fully searchable Project Archive by emailing.

6.3 Team

In order to implement Aconex, it's important to inform the team members about how to use Aconex, their roles, and signing up. The following steps should be carried out:

- Go-live preparation – what you need to do before getting others involved
- Project introduction – what to tell your team about using Aconex
- Frequently used project and Org Admin tasks – a handy list for your admins
- Email templates and cheat sheets – downloads designed to make life easier

Go-live preparation: Checklist

You'll want to tick off these tasks before your project goes live. This ensures that you and your team are prepared to kick off your project on your go-live date without any delays.

- Create user accounts for colleagues and assign roles to them so that they're ready to get started on Aconex from day one.
- Ensure external organizations are registered on Aconex so that they can access the project without any delays.
- Make sure external project participants have set up their Aconex accounts—their own Org Admins can help with this.
- Finalize project procedure documentation.
- Suggest project participants check out Aconex training on Support Central. We recommend checking out Aconex Essentials to learn more about the most common tasks.
- Upload a logo for your project to keep things looking professional.
- Advise team members of your project's go-live date.

For common Organization Administrator and Project Admin tasks:

An **Organization Administrator** is responsible for:

- Managing Aconex's settings for your organization

- Configuring and assigning Aconex user roles to people working in your organization.

- Keeping your Organization details up to date. Each organization has a user role called the Organization Administrator, who has permissions to configure Aconex for their organization. That includes setting up user roles for their colleagues.

The organization that sets up a project within Aconex is called the project-owning organization.

The **Project Administrator/s**, who usually work for the project-owning organization, have permissions that let them manage the project. They can configure project-wide settings in Aconex that affect everyone working on that project, whether they're part of the project-owning organization or a collaborating organization.

In Aconex the user with the Project Admin role sets up all the other user roles at project level. With that done, they then assign the mail and document types each role is allowed use. The roles are then assigned to the organizations on your project.

7   Comparison

7.1 SWOT analysis

7.1.1 Strengths

- Secure document management

- Save up to 50 percent on document processing times

- Strict version control avoids errors by ensuring everyone is working off the latest documents and drawings

- Custom workflows automate review and approval cycles, reducing complexity, improving data capture, and increasing control

- Work packaging makes it easier to track and control processes, from design and construction to sign-off and completion

- Advanced communications and forms

- Avoid the limitations of manual correspondence with a standardized digital process providing project-wide access and visibility

- Mail routing automates business processes, ensuring best practice and minimizing the chance of human error

- Easily track process communications, keep up to date on progress, avoid bottlenecks, and reduce RFI turnaround times by 50 percent

- All correspondence is automatically logged and cannot be deleted, providing a complete project record and unalterable audit trail

- Model coordination in a common data environment

- Simplify model coordination, connecting teams, models, and project data in a neutral and secure collaborative environment

- A complete set of linked handover information and full audit trail of all decisions at project completion

- Integrated cost management

- Gain visibility into budgets, forecasts, and projective outcomes to enable early corrective action

- Use earned value methods such as cost-performance-index (CPI) and schedule-performance-index (SPI) to forecast your costs

- Keep budgets and schedule in sync using one-click integration with Oracle Primavera P6 Enterprise Project Portfolio Management

- Track portfolio and project performance with real-time cost tracking and variance analysis

- Quality and safety processes

- Automate and standardize any inspection process with Aconex Field—one mobile app for safety walks, quality checks, defecting, and more

- Tailor issue capture to your needs and capture the data that's most important to you, including defects, snags, and punch lists

- Keep using your existing forms exactly as they are and complete them in Aconex Field, eliminating paper inefficiencies

- Leverage real-time health and safety data to keep teams 100 percent accountable and demonstrate compliance with regulatory requirements

- Minimize delays and risks by recognizing red flags early with in-depth visual dashboards that provide insights at the portfolio, project, or organizational level

- Unparalleled service and support

- Inclusive standard implementation scope gets your project off to the best possible start

- Benefit from the wide-ranging industry experience of our network of consultants

- Fee-based professional services complement our standard scope, catering to specific requirements

- 24/7 service desk and online help via support central, no matter where you are

- Stand out from the crowd with Aconex Certified, our accredited training and certification program

- A user-friendly platform

- No installation needed, as long as users have a web browser available, they can use Aconex.

- No upgrades needed, there is no need for managing software upgrades or installing different versions—all upgrades and expansion are performed by Aconex during weekly scheduled maintenance times.

7.1.2 Weaknesses

The users should be connected to internet in order to access the data.

The current structure of cloud-based Aconex does not facilitate clash avoidance and in fact, encourages isolated working in the early design stage by creating "digital information silos". [38]

7.1.3 Opportunities

- Secure document management

- Easily manage millions of documents and models without limits on data or participants, including any size, type, or number of files.

- Workflow tracking and reporting provides real-time analysis to identify and action bottlenecks before they cause delays

- No limit for transmittal file size

- Advanced communications and forms

- From designing forms to creating fields, configure Aconex construction management software to your processes and capture the right data in the right format

- Model coordination in a common data environment

- Seamlessly share, review, and contribute to models without specialized software

- Utilize a single platform to raise, communicate, and manage the coordination process with a dashboard to control and monitor progress

- BIM mobile app provides access to models and data onsite to improve communication and reduce the risk of errors and rework

- Built on open BIM standards for data interoperability through IFC (Industry Foundation Classes) and BCF (Building Collaboration Format)

- Integrated cost management

- Track and report on any project level with unlimited work breakdown structure elements, control accounts, and work packages

7.1.4 Threats

7.2 Improvement suggestions to Oracle

If Oracle can save an offline database of everything on an hourly basis, that would be great, because in case that there is disruption in the internet for the entire project or any of the users, the project members won't be able to transmit data on the platform. This can be problematic when you have something important going on in your project like closing a deal or on casting concrete days, because you need to check everything on that day and if there was no connections between the users, this can delay the process.

8   Conclusion

The BIM method and the accompanying federated model approach require that collaborative processes in the construction industry be adapted. The introduction of the CDE represents a major step towards the digitization of these processes. By centralizing data storage as well as bundling information and data streams, the enormous amount of data stored in models and data objects can be coordinated consistently. However, one should choose the right CDE according to the needs of the project, which in this study, it is attempted to provide that insight. The features of different CDEs have been highlighted; therefore, one can choose the most appropriate platform according to the requirements of the project.

Using Aconex as a CDE can be a good option for those who seek a collaborative synchronized environment to share information in a secure way. There are some advantages about Aconex which some other CDEs don't have such as, the high level of security, mailing and messaging inside the platform to communicate between users, being user-friendly and without the need for installation, integrated cost management, and 24/7 support center. However, only working online with Aconex can hold users back when you have problems with internet connection for any reason. It should be noted that the advantages and disadvantages mentioned for Aconex does not mean that the other CDEs do not provide these features, some have and some do not.

9 BIBLIOGRAPHY

1.   Heaton, J., A.K. Parlikad, and J. Schooling, *Design and development of BIM models to support operations and maintenance.* Computers in Industry, 2019. **111**: p. 172-186.

2.   Khaja, M., J.D. Seo, and J.J. McArthur, *Optimizing BIM Metadata Manipulation Using Parametric Tools.* Procedia Engineering, 2016. **145**: p. 259-266.

3.   Radl, J. and J. Kaiser. *Benefits of Implementation of Common Data Environment (CDE) into Construction Projects*. 2019. Institute of Physics Publishing.

4.   Al Hattab, M. and F. Hamzeh, *Using social network theory and simulation to compare traditional versus BIM–lean practice for design error management.* Automation in Construction, 2015. **52**: p. 59-69.

5.   Succar, B., *Building information modelling framework: A research and delivery foundation for industry stakeholders.* Automation in Construction, 2009. **18**(3): p. 357-375.

6.   Getuli, V., et al., *BIM-based Code Checking for Construction Health and Safety.* Procedia Engineering, 2017. **196**: p. 454-461.

7.   Solihin, W. and C. Eastman, *Classification of rules for automated BIM rule checking development.* Automation in Construction, 2015. **53**: p. 69-82.

8.   Macit İlal, S. and H.M. Günaydın, *Computer representation of building codes for automated compliance checking.* Automation in Construction, 2017. **82**: p. 43-58.

9.   Chan, D.W.M., T.O. Olawumi, and A.M.L. Ho, *Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong.* Journal of Building Engineering, 2019. **25**: p. 100764.

10. Alreshidi, E., M. Mourshed, and Y. Rezgui, *Factors for effective BIM governance.* Journal of Building Engineering, 2017. **10**: p. 89-101.

11. Howard, R. and B.-C. Björk, *Building information modelling – Experts' views on standardisation and industry deployment.* Advanced Engineering Informatics, 2008. **22**(2): p. 271-280.

12. Sebastian, R., *Changing roles of the clients, architects and contractors through BIM.* Engineering, Construction and Architectural Management, 2011. **18**(2): p. 176-187.

13. Oraee, M., et al., *Collaboration barriers in BIM-based construction networks: A conceptual model.* International Journal of Project Management, 2019. **37**(6): p. 839-854.

14. Preidel, C., et al., *Common data environment*, in *Building Information Modeling: Technology Foundations and Industry Practice*. 2018, Springer International Publishing. p. 279-291.

15. *Common Data Environment (CDE): What You Need to Know for Starters*. March 6th, 2020]; Available from: https://blogs.oracle.com/construction-engineering/common-data-environment-cde-tutorial.

16. *Common Data Environment (CDE).* December 10th, 2019]; Available from: https://aechub.io/common-data-environment-cde/.

17. McPartland, R. *What is the Common Data Environment (CDE)?* 2016 December 10th, 2019]; Available from: https://www.thenbs.com/knowledge/what-is-the-common-data-environment-cde.

18. Mordue, S., *Implementation of a Common Data Environment.* 2018.

19. *BIM and construction management: the CDE (Common Data Environment).* January 3th, 2020]; Available from: http://biblus.accasoftware.com/en/bim-and-construction-management-the-cde-common-data-environment/.

20. Daniotti, B., et al., *BIM-based collaborative building process management*. 2020.

21. Mancini, M., A. Pavan, and M. Rotelli, *Data management within a BIM process : the optimization of information flows and infrastructure.* 2019.

22. *Bimsync.* March 4th, 2020]; Available from: https://catenda.no/products/bimsync-arena?__hstc=2887215.faca257a1b5f524b31a468d2a2a71a92.1583161624734.158334686073 7.1583387719259.5&__hssc=2887215.1.1583387719259&__hsfp=868342576&_ga=2.55622 443.101900782.1583161622-908984788.1583161622.

23. *Simplebim.* March 4th, 2020]; Available from: https://simplebim.com/features/.

24. *Bimcollab connected plan.* March 4th, 2020]; Available from: https://www.bimcollab.com/en/Products/BIMcollab/Connected-Plan.

25. *Bimcollab BCF Manager.* March 4th, 2020]; Available from: https://www.bimcollab.com/en/Products/BCF-Manager.

26. *Bimcollab.* March 4th, 2020]; Available from: https://www.bimcollab.com/en/default.

27. *BIMXtra* March 5th, 2020]; Available from: https://www.clearboxbim.com/products/bimxtra.

28. *Clearbox BIMXtra starts with BIM.* March 5th, 2020]; Available from: http://extranetevolution.com/2016/12/clearbox-bimxtra-starts-with-bim/.

29. *BIMXtra forms and mobile.* March 5th, 2020]; Available from: https://www.clearboxbim.com/products/forms.

30. *Procore detailed insights.* March 5th, 2020]; Available from: https://www.procore.com/en-ca/platform/reports#intro.

31. *Procore Secure docuemnts management.* March 5th, 2020]; Available from: https://www.procore.com/en-ca/platform/document-management.

32. *BIManywhere.* March 5th, 2020]; Available from: https://bimanywhere.com/index.php.

33. Abanda, F.H., et al., *A critical analysis of Building Information Modelling systems used in construction projects.* Advances in Engineering Software, 2015. **90**: p. 183-201.

34. Pham, Q. *HOW TO SELECT THE APPROPRIATE CDE TOOL FOR YOUR ORGANIZATION AND PROJECT?* [cited January 5th, 2020; Available from: https://vibim.com.vn/blog/how-to-select-the-appropriate-cde-tool-for-your-organization-and-project.html.

35. *NBS BIM Report covers CDEs.* January 5th, 2020]; Available from: http://extranetevolution.com/2018/05/nbs-bim-report-covers-cdes/.

36. *Featured Customers That Trust Oracle Aconex.* February 23rd, 2020]; Available from: https://www.featuredcustomers.com/vendor/oracle-aconex/customers.

37. *TRUSTED BY THE WORLD'S LEADING*

B2B SOFTWARE & SERVICE VENDORS. February 23rd, 2020]; Available from: https://www.featuredcustomers.com/customer-testimonials.

38. Trebbi, C., et al., *Clash detection and code checking BIM platform for the Italian market*, in *Research for Development.* 2020, Springer. p. 115-125.