NET UBIEP

Network for Using BIM to Increase the Energy Performance

TRAINING MATERIAL

for Technicians

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Introduction

Why Net-UBIEP?

Net-UBIEP aims at increasing energy performance of buildings by wide spreading and strengthening the use of BIM, during the life cycle of the building. The use of BIM will allow to simulate the energy performance of the building using different materials and components, both the to be used in the building design and/or in building design refurbishment.

BIM, which stands for Building Information Modeling, is a process that lasts for all the building life cycle from the design phase through the construction, management, maintenance, demolish. In each of this phase is very important to take into account all the energy aspects in order to decrease the environmental impact of the building during its life cycle.

Public Administration needs to be ready to the digitalization of building processes including the energy performance improvement because it brings an economical advantage and the improvement of citizens' welfare.

The competences needed to implement BIM, taking into account the energy performance, vary depending on the phase of the building life cycle (1), on the target (2) and on BIM Profile (3).

This information has been put in a three-dimensional matrix which will be navigated through internet so that it will be clear, for instance, which competence an architect (2) whit specific BIM role (3) should have while is during the design phase (1) in the construction of NZEB and provide the Energy Performance Certificate.

There is a need to be ready to manage the digital model of a real building when installing or maintaining plants as well as structures because the market will require more efficient maintenance services and the use of digital information will allow better services at lower prices.

The technicians will improve their performance by lowering the costs for the customers and increasing their income. The producers of new technologies will be ready to integrate their product into the BIM model, realized by the designers, as "BIM objects".

The main objective will be to teach how to use the BIM to view the plants and facilities, maintain them by updating the model with all the information required for any future use during the entire life of a building.

The role of Technicians

In the **preparatory phase** the craft companies need, first of all to know the specific terms used in BIM (BEP, PIM, MIDP, etc.) and need to have a general overview of rules and technical standards for improving energy performance. They should have passed examination to demonstrate:

- To know what's BIM and why it is useful to know the terminology
- Recognize the advantages of BIM compared to traditional methods
- To know the life cycle of the project information; in particular how the information is specified, produced, exchanged and maintained
- To know the added value of using open solutions to ensure interoperability
- To know how to collaborate in the Common Data Environment
- To know the national legislation for the digitalization of the building sector

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- To know which indicators are considered important in their Regional/Local environment in relation to:
  - Sustainable Energy Action Plan (SEAP) or Sustainable Energy and Climate Action Plan (SECAP)
  - Thermal Plant cadastre
  - Energy performance certification cadastre
  - Green products comprehensive of energy carriers compulsory according to the green public procurement

The majority of technicians are potentially ready for the "digital revolution" because they only need to use their mobile devises or tablets but they lack the familiarity with the BIM nomenclature and they are not aware of the importance of the correct information management during the construction to be used for the management of the building. In general, they will not need to be equipped with special software but they will need to be equipped with free BIM software to visualize the model and have access to the different requirements established by designers and end users. They will also need to communicate any change occurred to the building during installation and/or maintenance.

In the following paragraphs all the information exchange necessary during each phase are described through the identification of tasks and competences.

In Italy, the installers are usually represented by small and micro companies, who do not have financial capability to buy sophisticated software. They usually work as supplier of constructors during the construction phase and work as independent company during the maintenance. Rarely they are involved in the design phase even if it their perspective for maintenance works should be considered. It is therefore very important they get familiar with the BIM world and that they know the importance of sharing the correct information with the contractor and/or with the owner or building manager.

Focusing on the energy aspects, the technicians have to know the best solutions for NZEB both in the case of new buildings as well as for the refurbishment of the existing one. They need to know the national regulatory and legislative requirements for NZEB. In particular they need to know very well the technical standards related to the technology they are installing. At the same time the European BUS initiative has demonstrated that they also need a good understanding of any other technology related to NZEB. They finally need to know the rules for the recycling and/or disposal of obsolete materials/equipment.

Preliminary phase

Tasks:

1. Know the advantages of using BIM
2. Get familiar with the BIM nomenclature
3. Get familiar with BIM model visualization

Preparation and brief

The installers will be involved only if required by the designers. They could be directly involved if dealing with small buildings.

Tasks:

1. Provide the correct information, related to the installed technology, whenever required by public authority, designers, constructors, owners, facility managers, etc.

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2. Navigate a BIM model and be capable to provide information, when required or when considered important for the installed technologies.
3. Participate to the preparation of the maintenance delivery plan if requested by the plant designer

Concept design

As in the previous phase the technician will be involved only if required. They could be involved directly if dealing with small buildings.

Tasks:

1. Ensure that energy performance tasks are respected, and the equipment chosen for NZEB will be compliant with the employers' requirements
2. Navigate the building service design to ensure that maintenance is feasible and without risks
3. Verify that other RES installations or building automation, etc. do not interfere each other

Developed and Technical design

Tasks:

1. Ensure that the technology is installed correctly and that all the necessary information are contained in the BIM model.
2. Contribute to review the handover strategy to ensure correct maintenance and operational instructions
3. Contribute to the preparation of the information delivery manual as long it is related to the installed technology
4. Provide all the information necessary to use and maintain the installed technology
5. Contribute to the respect of all employers' requirements as long as it concerns

Construction

Tasks:

1. Ensure that the required information is properly transferred to the constructor and to the final user
2. Ensure that the BIM model "as built" is updated with the right information for the installed technology and the energy performance requirements, as defined in the handover strategy, are respected.
3. Ensure that all the information to keep the foreseen energy performance are met

Handover and close out

Tasks:

1. Contribute to the correct accomplishment of the handover strategy
2. Contribute to a fine-tuning of the building services to ensure the best energy performance.
3. Establish a measurement and verification plan for the installed technology

In use and recycling

Tasks:

1. Contribute to the evaluation of the building energy performance in relation to the installed technology
2. Contribute, if required, to the delivery of the final model to the cadaster and to the owner

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3. Contribute to the delivery of the maintenance manual of the building in relation to the installed technology
4. Execute the measurement and verification plan

Learning outcomes for technicians

The learning outcome can be viewed in the deliverable: D15.A – D3.2.A Requirements for Learning Outcomes for Target Groups. The deliverable can be downloaded by the web site www.net-ubiep.eu.

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Contents

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0. Introductory Module – Basic BIM knowledge and skills

0.1 Introduction: what is BIM?

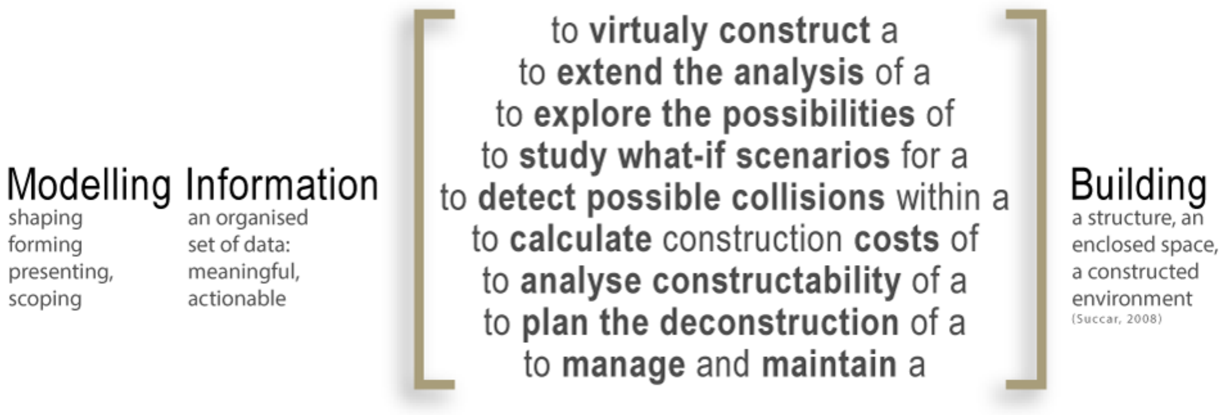
The boundaries of Building Information Modelling as a term-definition, set of technologies and group of processes is fast changing even before being widely adopted by the industry. As a term, BIM seems to have somehow stabilized now but as a set of technologies/processes, its boundaries are rapidly expanding. This boundary expansion (and sometimes mutation) is disconcerting in several ways as BIM continues to lack an agreed definition, process maps and regulatory frameworks. However, these concerns are offset by sheer potentials of BIM (as an integrated process) to act as a catalyst for change poised to reduce industry's fragmentation, improve its efficiency/effectiveness and lower its high costs of inadequate interoperability.

For academic researcher, BIM is a new term representing concepts that are not. To them, Building Information Modelling and the other competing terms embody many of the solutions proposed by academia for a long time. For other industry stakeholders (like designers, engineers, clients, construction companies, facility managers, governments...) BIM is also a new term but represents the commercial maturity and availability of the same research concepts. BIM's prominence, as a re-emerging concept, is being fueled by the increasing availability of processing power, maturing applications, interoperability discussions (IAI, NIST and GSA) and proactive regulatory frameworks.

BIM, how to read the term:

- Building: a structure, an enclosed space, a constructed environment…
- Information: an organized set of data: meaningful, actionable
- Modelling: shaping, forming, presenting, scoping…

To best understand this inadequate array of meanings, let's flip the order of the words:



The conceptual frameworks of Building Information Modelling stems from the mid 1980's but the term itself is a recent incarnation. As an acronym, BIM appears to be gradually wining over many competing terms representing mainly similar concepts.

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0.2 BIM Glossary

2

2E Index: An objective index that includes time, cost and a suitable evaluation obtained by means of a simulation process of a virtual prototyping able to determine its Eco Efficiency.

3D: Detailed geometric representation of each part and the totality of a building or facility, inside of an integrated information instrument.

3D Scanning: Collecting data from a physical object, building or any place by means of a laser scanning — normally with point clouds — to, subsequently, generate a BIM model.

4.0 Construction: Transformation and development of the construction industry supported by emergent technologies modifying established business models through the people, on the basis of interoperability of human means and materials, processes virtualization, decentralization of decision-making, real time exchange of information and focused on customer service.

4D: A dimension involving the use of some models in order to allow all the activities and time management process (planning, assessment and time controlling).

5D: A dimension involving the use of some models in order to allow all the activities and cost management process (cost estimates, determination of the budget, cost control).

6D: A dimension involving the use of some models in order to make energy and sustainability analyses.

7D: A dimension involving the use of some models in order to carry out activities and management process and operations throughout the entire building or facility lifecycle.

A

AEC (Architecture, Engineering and Construction): Acronym referring professionals and enterprises related to Architecture, Construction and engineering industry.

AECO (Architecture, Engineering, Construction and Operation): An extension of the AEC acronym which includes professionals and enterprises related to the operations and maintenance of buildings and infrastructures.

Agile movement: It is an incremental, iterative work cadence-based project management approach where requirements and solutions evolve over the time according to the need for the project. The work is realized by means of teams' collaboration self-organized and multidisciplinary, immersed in a process shared of short term policy-making.

AIA (American Institute of Architects): Association of Architects of the United States. Among their contributions to BIM, they have developed a BIM protocol that establishes a series of standards that are part of the documentation of contracts.

AIM (Asset Information Model): Information model (documentation, graphic model and non-graphic data) that supports the maintenance, management and operation of an asset throughout its life cycle. It is used as a repository for all the information about the asset, as a means to access and link with other systems and as a means to receive and centralize information of all the participants throughout the project stages.

As-Built, model: A model that gathers all changes experienced by projects in the construction process in such a way that it may be possible to obtain an accurate reality BIM model.

Augmented reality: Vision of a physical environment of the real world through a technological device through which tangible physical elements are combined with virtual elements, thereby creating a mixed reality in real time.

Authoring Software: Software applications providing for creation of 3D models enriched with its set data and its different parts which are used to build the original BIM model. They are usually known as modelling platform.

B

BCF (BIM Collaboration Format): It's an open file format which allows the submission of comments, screenshots and other information in the IFC file of a BIM model in order to promote communication and coordination of the different parts participating in a developed project through the BIM method.

Benchmarking: A process whose objective is to acquire useful information that helps an organization to improve its processes. Its aim is to achieve the maximum learning effectiveness from the bests, helping the organization to move from where it is to where it wants to arrive.

BEP (BIM Execution Plan) or BPEP (BIM Project Execution Plan): A document defining in an overall shape details of the BIM methodology implementation through all Project phases, by defining implementation achievement, BIM processes and tasks, information exchange, necessary infrastructure, roles, responsibilities and model applications, among other aspects.

Big Data: A concept that makes reference to storage of big quantities of database as well as to used procedures to find repetitive patterns within these data.

BIM (Building Information Modelling): A work methodology to manage, comprehensively, construction projects throughout all its lifecycle, based on virtual models related to databases.

BIM Applications: BIM application method during an active lifecycle to meet specific targets.

BIM, Big: Exchanging of BIM path between companies in the building life cycle.

BIM, Coordinator: A profile that coordinates tasks, responsibilities and accountabilities that each part has in the BIM project, in addition to delivery times. It also liaises with team leaders from the different disciplines, coordinating and monitoring Project models.

BIM, Friendly: Those processes and tools that did not grow under a BIM methodology entirely, they do allow certain participation in processes or interoperability within BIM tools.

BIM Implementation Plan: Strategic plan to implement BIM into an Enterprise or organisation.

BIM, Little: BIM processes and methodology implemented in organizations.

BIM, Lonely: The use of BIM tools in a Project by stakeholders without interoperability or information exchange between them.

BIM Manager: A profile which is responsible for guaranteeing the right flow of the information generated by BIM methodology, just as the effectiveness of processes and the accomplishment of the specification laid down by the client. It Is the Manager of the Project database creation.

BIM Maturity Level: An indicator, normally a static or interactive table which evaluates the knowledge level and the BIM practices of an organization or Team Project.

BIM Modeller: A profile whose function is the BIM elements modelling in order to make them represent faithfully, the Project or the building, both graphically and constructively, according to the design criteria and the generation of documents fixed for the Project.

BIM Modelling: Construction or generation action of a virtual tri-dimensional model of a building or facility, adding information beyond geometry to the model in order to smooth the use in the different phases of the life cycle of the project and the building or facility.

BIM Model: Virtual tri-dimensional model of a building or facility, adding information beyond geometry to the model in order to smooth use in the different life cycle phases of a project and building or facility.

BIM Objectives: Objectives set to define BIM employment potential value for a Project or a Team Project. BIM objectives help to define how and why BIM should be applied in a Project or in an organization.

BIM, Open: Overall proposal to promote design collaboration, implementation and maintenance of buildings, based on standards and open workflows.

BIM Requirements: General term concerning all the requirements and the prerequisites which BIM models must meet, as clients, regulatory authorities or similar parts demand.

BIM Role or Profile: The role played by an individual inside an organization (or an organization inside a Team Project) which implies the generation, modification or management of BIM models.

BIM, Super Objectives: BIM parametric objectives that can be programmed with many variations on its inside.

BoQ (Bill of Quantity): A set of measurement of all the work units integrating a Project.

BREEAM Certification: An evaluation method and certification of the building sustainability which manage the Building Research Establishment (BRE), an organization devoted to research in the building sector in the world.

BSSCH (Building Smart Spanish Chapter): Spanish chapter about the Building Smart Alliance.

Building Life Cycle: The view of a building over the course of its entire life, taking into account the designing, construction, operation, demolition and waste treatment.

Building Smart Alliance: International non-profit organisation that aims to improve the health efficiency in the building sector through interoperability open standards about BIM and business models focused on the cooperation for achieving new levels in cost reduction and deadlines.

C

CAMM (Computer-Aided Maintenance Management): Computer system that manages maintenance activities of a property.

CDE (Common Data Environment): Digital central repository where all the information related to a Project is hosted.

Classification systems: Classes and category distribution for the construction industry including, among others, elements, spaces, disciplines and materials (Uniclass, Uniformat, Omniclass, are some of the most commonly used international classification standards).

Clash Detection: A procedure that involves locating the interferences produced within the objects of a model or when leading models of different disciplines in a single model.

COBie (Construction Operations Building Information Exchange): International standard for information Exchange about construction data focused from a BIM methodology point of view. The most popular representation is the progressively development of a calculation sheet throughout the construction process.

Concurrent engineering: It is a systematic effort to make an integrated and convergent product design and its correspondent manufacturing and service process. Designed to make responsible for the development take into account, from the beginning, all the product life cycle elements; from the conceptual design until its availability; including quality, cost and user requirements.

Construction planning: Activities and documentation that plans the execution of the different parts of the work in time. In a BIM model it is possible to assign a parameter to each element or object thereof, so that it is possible to simulate the state of the work at a given time if the planned has been followed.

D

Data Conundrum: A problem area when imposing standards in different cultures with particular circumstances in each of them.

DB (Design-Build): A way of managing a procurement of a construction Project in which the client establishes a single agreement for the design and the construction of the project.

DBB (Design-Bid-Build): Management mode of a construction Project procurement in which the client establishes separated procurements for the design and the construction of the project.

Deliverable: Any product, result or unique and verifiable capability to perform a certain service that must be created to complete a process, phase or project.

Digital twin: A visual representation of the building construction.

Discipline: Each of the main areas in which BIM model objects can be assembled according their main function. The most general disciplines are: architecture, structure and MEP.

E

Eco-Efficiency: Distribution of goods with competitive prices and services meeting human needs and providing quality of life as it progressively reduce goods environmental impacts and the intensity of consumed sources during the entire life cycle, taking this to a level in line with carrying capacity of the earth.

EIR (Employer´s Information Requirements): A document whose content defines customer requirements at each stage of the constructive Project in terms of modelling. It shall form a basis to produce the BEP.

Exemplary parameter: A variable that acts over a specific object independently of the rest.

Extraction: Data collection of a model.

F

Family: A set of objects that belong to the same category that have generation parametric rules to obtain analogic geometric models.

Federated model: A BIM model that links, does not generate different disciplines models. The federated model does not create a data base with data from individual models, unlike an integrated model.

FM (Facility Management): A set of services and interdisciplinary activities developed during the operation phase to manage and provide the best performing of a property by integrating people, spaces, processes, technologies and own installations of properties, such as maintenance or management of spaces.

G

GbXML: A format used in order to allow a smooth transfer of BIM model properties to energy calculation applications.

GIS (Geographical Information System): Information system able to integrate, store, edit, analyse, share and show geographically referenced information.

Global Unique Identifier: Unique number that identifies a certain object in a software application. In a BIM model, every object has its GUID.

Green Building Council: A non-profit association that join representatives from the entire building sector in order to encourage the sector transformation towards sustainability by promoting initiatives that provide methodologies as well as updated and internationally compatible tools to the sector, which allow, objectively, the assessment and certificate of building's sustainability.

H

HVAC (Heating, ventilating and air conditioning): By extension, acronym that makes reference to all referring to air-conditioning systems of buildings**.**

I

IAI (International Alliance for Interoperability): Predecessor organisation of the Building Smart.

ICT: Information and Communication Technologies

IDM (Information Delivery Manual): Standard referring to the processes specified when a certain type of information is required during a property life cycle, and the one that must deliver such information.

IFC (Industry Foundation Classes): A standard filing cabinet made with the Building Smart to smooth the information Exchange and interoperability between software applications in a BIM workflow.

IFD (Information Framework Dictionary): A base that allows communication between construction data base and BIM models. In development by the Building Smart.

Integrated model: A BIM model that links different discipline models, generating a federated model with a unique data base with individual model data.

Internet of Things: A concept that makes reference to digital interconnection of everyday objects with internet.

Interoperability: The ability of several systems (and organizations) to work together in a fluent manner without any data or information loss. Interoperability can refer to systems, processes, file formats, etc.

IPD (Integrated Project Delivery): It is a contractual relation that has a balanced focus in risk and sharing distribution between the main participants of a project. It is based on shared risks and rewards, the early involvement of all interveners in a project and opened communications between them. It involves the use of appropriate technology such as the BIM methodology.

IT: Information technology

IWMS (Integrated workplace management system): Integrated workplace management system that works through a corporate management platform which allows to plan, to design, to manage, to explode and to remove assets located in the spaces of an organization. It allows to optimize the use of sources in the working area including the management of property assets, facilities and installations.

K

KPI (Key Performance Indicator): Performance indicators that help organizations to understand how work is being realized in relation to its goals and objectives.

L

Last Planner LPS (Last Planner System) is a planning, monitoring and control system that follows lean construction principles. It is based on increasing accomplishment of construction activities by decreasing uncertainty associated to planning, creating mid-term and weekly planning's framed within initial settings or the master plan of the project, analysing restrictions preventing normal development of activities.

Lean Construction: Construction management method, a Project management strategy and a production theory focalized on waste minimization in materials, time, effort and maximizing value with the continuous improvement throughout design phases and project construction.

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LEED (Leadership in Energy & Environmental Design): Sustainable building certification system, developed by the United States Green Building Council, which is an agency with chapters in different countries.

Life cycle: A concept referring to the appearance, development and completion of the functionality of a particular item, project, building or work.

LOD (Level of Detail): Quantity and wealth of information evolution of a constructive process. It is defined for each stage of development of the project.

LOD (Level of Development): It defines the development or maturity level of information that a BIM model has, and this one is the composing part, constructive system or assembly of the building. The AIA has developed a numeral classification (LOD100, 200, 300, 400, 500).

LOD 100: The object that can be represented by a symbol or generic representation. Its geometric definition is not needed although it can depend on other objects defined graphically and geometrically. Certain elements can remain in this development level in advanced phases of the project.

LOD 200: The element is defined graphically, specifying quantities, size, shape or location regarding the set of the project. It can include non-graphic information.

LOD 300: The element is defined graphically, specifying quantities, size, shape and/or location accurately, regarding the set of the project. It can include non-graphic information.

LOD 350: It is equivalent to LOD 300 but it indicates interference detection between different elements.

LOD 400: The target element is geometrically defined in detail, as well as its position, which belongs to a specific constructive system, use and assembly in quantity terms, dimensions, shape, location and complete detailed orientation, specific product information for the project, commissioning work and installation. It can include non-graphic information.

LOD 500: The target object is geometrically defined in detail, as well as its position, which belongs to a specific constructive system, use and assembly in quantity terms, dimensions, shape, location and complete detailed orientation, specific product information for the project, commissioning work and installation. It can include non-graphic information. It is the same definition as in LOD 400 but for element which really have been implemented on work.

LOI (Level of Information): Is the level of non-modelled information that a BIM object has. The LOI can be boards, specifications or parametric information.

LOMD (Level of Model Definition): According to the British Convention, the model definition scale level. LOMD = LOD + LOI.

M

Measurement extraction: Measurement collection of a model.

MEP (Mechanical, electrical and plumbing): By extension, acronym referring building installations.

MET (Model Element Table): Board used to identify the responsible section that administrates and generates BIM models, and the level of development. MET, normally includes a list of model components in the vertical axe and the project milestones (or the project life cycle phases) in the horizontal axe.

Model categories: Category that relates to real objects of the building model that take part in its geometry, for instance: walls, coverings, soils, doors or windows.

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Model/prototype: Each of the specific objects that may form part of a BIM model.

MVD (Model View Definition): A standard that specifies methodology for the Exchange of data, content or IFC files, between the different programs and agents during the construction life cycle. In process by the Building Smart.

N

Native format: Working files original format from a certain computer application that normally is not useful as a direct way to exchange information with different applications.

O

Object category: Sorting and grouping objects inside a BIM model according to its constructive typology or purpose.

Open BIM: Exchanging of BIM Data by using open formats.

Operating phase: Is the last stage of a building life cycle. It includes all construction subsequent activities and the creation of the building.

P

Parameter: A variable that allows the control of object properties or dimensions.

Parametric model: A term concerning 3D models where objects/elements can be manipulated using explicit parameters, rules or restrictions.

PAS 1192 (Publicly Available Specifications): Specification published by the CIC (Construction Industry Council) whose main function is to be the frame that supports BIM objectives in the United Kingdom. It specifies the requirements to meet BIM standards and it establishes the bases to collaborate in enabled BIM projects, including available reporting rules and data exchange processes.

Passivhaus: Energy-efficient construction standards with a high interior comfort and affordability. It is promoted by the Passivhaus Institute from Germany, which is an institution on the international scene.

PIM (Product Information Management): Data management used to centralise, organise, classify, synchronize and enrich information related to products according to business rules, marketing strategies and sales. It centralises information related to products in order to feed multiple sales channels accurately and consistently and with the most current information.

PMI (Project Management Institute): Global organisation whose main objective is to establish Project Management standards, to organize educative programmes, and to administrate globally professionals' certification process.

Point clouds: The result of a data collection of a building or object by laser scanner, consisting in a set of points in the space that reflect its surface.

Procedure: Documented set of tasks developed in a certain order and shape, likely to be repeated multiple times to obtain similar results.

Project: Temporary planned effort that takes place to create a product, service or unique result. In the case of the construction industry, the result will be a building, an infrastructure facility, etc.

Project Management: The application of knowledge, skills, tools and techniques to realise activities necessary to comply with project requirements.

Q

Quality: Compliance measure of the requirements demanded to a product, according to the measurable and verifiable standards.

QA, Quality Assurance: A set of measures and actions applied to a process in order to verify the reliability and correction results.

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QC, Quality control: Operative techniques and activities used to comply with the quality requirements.

R

Reference category: Category that relates to objects that are not a real part of the building but that serve to define it, such as heights, levels, axes or areas.

Restriction: On a BIM model, limitation and blocking over an object, normally over its dimensions or its position relative to another object.

Reverse Engineering: Discipline that obtain information of a physical construction in order to define requirements for a new project.

Rework: Additional effort necessary to correct disagreement on a product.

RFI (Request for Information): The process by which someone participating on the Project (for instance, a contractor) sends a communication to another participant to verify the interpretation of what has been documented or to clarify what has been specified on a model.

ROI (Return on investment): Financial ratio that compares the profit or the profit obtained in relation to the investment made. In relation to BIM, it is used to analyse the financial benefits of implementing the BIM methodology in an organization.

S

SaaS (Software as a Service): Licensing model and software delivery where a software tool is not installed on the computer of each user, but centrally accommodated (on cloud) and it is provided to users by subscription.

Scope: The definition of a desired outcome, product or service related to the project. In BIM, range definition will dictate the model degree of development.

Scrum: Referential frame that defines a set of practices and roles, and that can be accepted as a starting point to define the development process that will be executed during a project. It is characterized by using a strategy of incremental development, instead of the planning and complete execution of the product, base the quality result on people's knowledge in self-organized teams and overlapping of the different development phases, instead of making one after the other on a sequential cycle or cascade.

Simulation: The process of designing a virtual model's object or real system and complete experiences with it in order to understand and predict the system or object's behaviour, or evaluate new strategies – inside the limits imposed by a certain or set criteria – for its functioning

Smart City: Technologic vision/solution inside an urban environment to connect multiple information and communication systems to manage constructed assets in a city. A Smart City vision/solution depends on data collect through motion sensors and monitor systems and is aimed at improving life quality of residents through the integration of different types of services and assets.

Social BIM: Term used to describe organization methods, project teams or the whole market, where multidisciplinary BIM models are generated, or where BIM models are exchanged in a collaborative way between participants on the project.

Soft skills: A collective name for personal qualities, social skills, communication skills, consensus skills, personal habits and friendship that give color to the relationships with others.

Space: Opened or closed area or volume, delimited by any element.

Specification: A document specifying in a comprehensive, precise and verifiable manner the requirements, design, behavior and other details of a system, component, product, result or service. Procedures are often determining if these dispositions have been fulfilled.

Stakeholder: Person, group of people or entities that intervene or have interests in any part of a process.

Standard: A document established by common consent and approved by a recognized entity that provides common and recurring rules, directives or characteristics for activities or their results, aimed to achieve an optimal level in the context given.

T

Take-off: See extraction

Taxonomy: Multilevel classification (hierarchy, tree, etc.) introduced to organize and name concepts according to a clear structure, for example the objects of a BIM model.

Total cost of ownership: Estimation of all costs of a building/construction during the building life cycle.

Type of object: Subset of objects in a BIM model belonging to the same family and sharing parameters.

Type parameter: A variable that acts over all the objects of the same type existing in the model.

U

uBIM: Initiative promoted by the Building Smart in Spain in order to elaborate some guides to facilitate the implementation and use of BIM in Spain.

V

Value stream mapping: Visual tool that allows to identify all activities in planning and manufacture of a product, in order to find improvement opportunities that have an impact on the whole chain and not in isolated processes.

VBE (Virtual Building Environment): Consist on creating integrated shapes to represent the physical world in a digital format in order to develop a virtual world that reflects enough the real world creating the Smart Cities base in a constructed and natural environment, to ease the efficient design of infrastructures and programmed maintenance, and to create a new base for the economic growth and social welfare through the analysis based on evidences. Building and facilities BIM models will be part of this virtual entourage or they would increasingly be incorporated to it.

VDC (Virtual Design and Construction): Multidisciplinary integrated management models for the execution of construction projects, including the BIM model asset, work processes and the organization of the design, construction and operation team in order to meet with the project objectives.

W

WBS (Work Breakdown Structure): Hierarchical structure normally used as a tree that is broken down in works to be done to fulfil the objectives of a Project and to create the deliverables required aimed at organizing and defining the full-scope of it. Inside the construction industry it specifies the activities and tasks necessary to design or construct a new Project that results from this task.

Workflow: A study of the workflow operational aspects: how tasks are structured, how they are realized, what is its correlative order, how they are synchronized, how information supporting task flows and how completion of tasks are tracked. A workflow application automates the sequence of actions, activities or tasks used to execute the process, including the track of the state of each of its parts and the contribution of new tools to manage it. An essential concept to create BIM models, as well as essential to increase interoperability between the different tools that work in BIM environments.

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0.3 Advantages and value of using BIM for different uses

The move from 2D drawings to 3D models is well underway and gaining steam in the architectural, engineering, and construction industries, thanks to tangible bottom-line returns from streamlined workflows.

The model-based approach increases efficiency within individual organizations and truly shines during coordinated project delivery. Building Information Modelling (BIM) offers the advantage of time and budget savings for building and infrastructure projects.

Here are the top 11 benefits of BIM:

1. **Capture Reality**: the wealth of information that's easily accessible about project sites has expanded greatly with better mapping tools and images of Earth. Today, project starts including aerial imagery and digital elevation, along with laser scans of existing infrastructure, accurately capturing reality and greatly streamlining project preparations. With BIM, designers benefit from all of that input compiled and shared in a model—in a way that paper isn't able to capture.
2. **Waste Not, Want Not**: With a shared model, there's less need for rework and duplication of drawings for the different requirements of building disciplines. The model contains more information than a drawing set, allowing each discipline to annotate and connect its intelligence to the project. BIM drawing tools have the advantage of being faster than 2D drawing tools, and each object is connected to a database. The database aids such steps as the number and size of windows for quantity take-offs that are updated automatically as the model evolves. The quick, computerized counting of components alone has been a significant labour and money saver.
3. **Maintain Control**: the digital-model-based workflow involves aids such as auto save and connections to project history so that users can be certain they've captured their time spent working on the model. The connection to the version history of the model's evolution can help you avoid disastrous disappearances or corruption of files that can make blood boil and impinge productivity.
4. **Improve Collaboration:** sharing and collaborating with models is easier than with drawing sets, as there are a lot of functions that are possible only through a digital workflow. Much of this added project-management functionality is now being delivered in the cloud, such as Autodesk's BIM 360 solutions or Solibri model checker by Graphisoft. Other software houses are providing analogous products. Here, there are tools for different disciplines to share their complex project models and to coordinate integration with their peers. Review and mark-up steps ensure that everyone has had input on the evolution of the design and that they are all ready to execute when the concept is finalized and moves forward in construction.
5. **Simulate and Visualize: a**nother of the advantages of BIM is the increasing number of simulation tools that allow designers to visualize such things as the sunlight during different seasons or to quantify the calculation of building energy performance. The intelligence of the software to apply rules that are based on physics and best practices provides a complement for engineers and other project team members. The software can do much more of the analysis and modelling to achieve peak performance, condensing knowledge and rules into a service that can run with the click of a button.
6. **Resolve Conflict:** the BIM toolset helps automate clash detection of elements such as electrical conduit or ductwork that run into a beam. By modelling all of these things first, clashes are discovered early, and costly on-

site clashes can be reduced. The model also ensures a perfect fit of elements that are manufactured off site, allowing these components to be easily bolted into place rather than created on site.

7. **Sequence Your Steps:** with a model and an accurate set of sub-models for each phase during construction, the next step is a coordinated sequencing of steps, materials, and crews for a more efficient construction process. Complete with animations, the model facilitates coordination of steps and processes, delivering a predictable path to the expected outcome.
8. **Dive into Detail**: the model is a great end point for a lot of knowledge transfer, but there's also a need to share a traditional plan, section, and elevation, as well as other reports with your project team. Using automation and customization features, these added sheets can save valuable drafting time.
9. **Present Perfectly**: with all of the design completed on a capture and alteration of existing reality, the model is the ultimate communication tool to convey the project scope, steps, and outcome. The fact that the design is fully 3D also means that there are fewer steps to render impressive views and fly-through that can be used to sell commercial space or to gain necessary regulatory approvals.
10. **Take it with You**: having a model that's tied to a database is an added benefit of BIM, granting you a great deal of intelligence at your fingertips. Combining this capability with a cloud, there are, means that you have access to the model and project details from anywhere, on any device.
11. **Reduce Fragmentation**: in the days before BIM, getting a truly global view of a project proved difficult—with thousands of unconnected documents in play, sometimes it took years for design teams to see the forest for the trees. By pulling all of a project's documents into a single view, BIM enables teams to collaborate and communicate more effectively.

Nevertheless, the rush to standardize every process and deliverable has evidently taken precedence over the efforts to simplify the collaboration process and minimize project complexity. Model Uses offer a structured language for translating project goals into project outcomes, and thus brings clarity to services' procurement and performance improvement.

According to the BIM Dictionary, Model Uses are the “intended or expected project deliverables from generating, collaborating-on and linking 3D models to external databases”. Each Model Use represents a set of defined requirements, specialised activities and specific project outcomes, grouped together under a single heading so they can be more easily specified, measured and learned.

The main drivers for generating - and publicly sharing - a comprehensive Model Uses List are to contribute towards the reduction of project complexity by:

- Identify project deliverables: After project goals has been identified, Model Uses provide a structured language for populating Requests For Proposals (RFP)s, Pre-Qualification Questionnaires (PQQ), Employer’s Information Requirements (EIR)s and similar documents;
- Define learning objectives: Model Uses allow the collation of specialised competencies to be acquired by individuals, organizations and teams;
- Assess capability/maturity: Model Uses act as performance targets to be used for measuring or pre-qualifying the abilities of project stakeholders;
- Allow assignment of responsibilities: Model Uses allow Project Team and Work Team capabilities to be matched to particular Model Uses and the assignment of responsibilities;
- Bridge the semantic gaps between project-based industries: Model Uses represent the deliverables of multiple information systems – BIM, GIS, PLM and ERP [3] - and help bridge the semantic gap between interdependent industries (e.g. Geospatial, Construction, and Manufacturing).

According to buildingSMART, an "IFC View Definition, or Model View Definition, MVD, defines a subset of the IFC schema, that is needed to satisfy one or many Exchange Requirements of the AEC industry." Also, according to NBIMS, the “aim of the Information Delivery Manual (IDM) (buildingSMART Processes) and Model View Definition (MVD) is to specify exactly which information is to be exchanged in each exchange scenario and how to relate it to the IFC model." To date, only a few Model Views are defined via official MVDs, and even less MVDs have been implemented by BIM Software Tools. Irrespective of the number of MVDs currently available, will be defined in the future, or will be implemented by willing software developers, there is a prior and separate need for a comprehensive list of Model Uses. This is because:

- On the one hand, Model View Definitions are clearly intended to standardise computer-to-computer exchanges based on common use cases;
- On the other hand, Model Uses are intended to simplify human-to-human interactions, and human-to-computer interactions (HCI). Model Uses’ main purpose and benefits - as discussed in Section 1 - are not to improve software tools, but to facilitate communication between project stakeholders and link Client/Employer’s, requirements to project outcomes and team competencies.

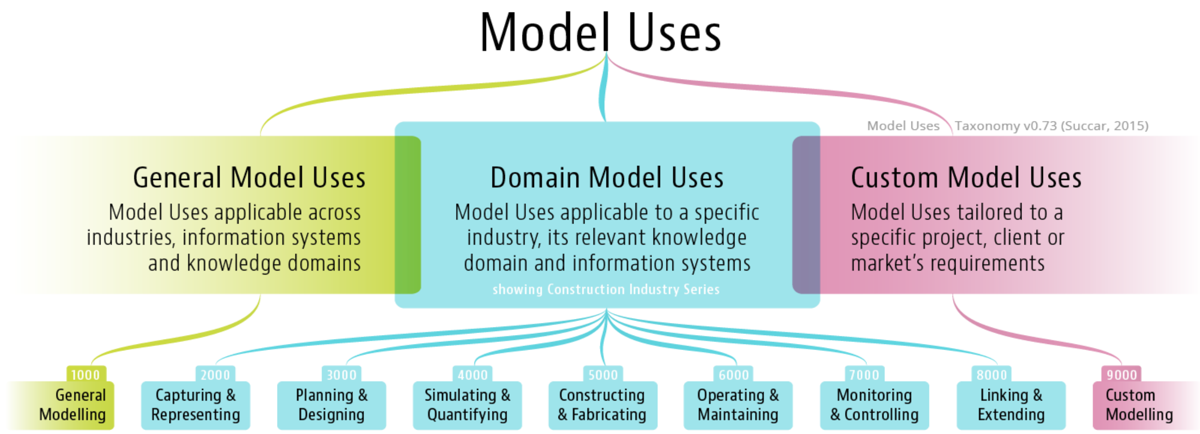
It is possible to define tens or even hundreds of Model Uses (MU)s to represent modelled or model-able information. However, it is important to define the minimum workable number (no more, no less) that allows two seemingly contradictory objectives: accuracy of representation and flexibility of use.

With respect to accuracy of representation, if the number of Model Uses is too small, then their definitions would be wide, less precise and sub-divisible into sub-uses. However, if the number of Model Uses is too large, then their definitions would be narrow, include overlapping activities/responsibilities and thus cause confusion. What we need is a Model Use breakdown which is ‘just right’ for effective communication and application.

With respect to flexibility of use, and to allow the application of Model Uses across varied contexts, Model Use definitions must exclude unnecessary qualifications that vary from user to user, and from one market to another. To this end, Model Uses are defined independently from their user, industry, market, phase, priority, and inherent activities:

- ✓ Model Uses are defined independently from Project Lifecycle Phases and thus can apply, depending on stakeholder's BIM Capability, at any/all phases of a project;
- ✓ Model Uses are defined independently from how they will be applied: this allows their consistent use in project procurement, capability development, organizational implementation, project assessment and personal learning;
- ✓ Model Uses are defined without a built-in priority: this allows each MU's priority to be set by stakeholders on each project; and
- ✓ Model Uses are not pre-assigned to disciplinary roles: this allows the assignment of responsibility for Model Uses based on project participants' experience and measured capability.

By combining the two objectives - accuracy and flexibility – and after identifying the point of balance between them, the below Model Uses List has been developed:



0.4 Open BIM tools and standard format

One of the basic assumptions of Building Information Modelling is the easy and secure exchange of data between the different figures involved at distinct levels in the project (principle of interoperability). An "open BIM strategy" supports a transparent, open workflow, allowing project members to participate regardless of the software tools they use and creating a common language for widely referenced processes, allowing industry and government to procure projects with transparent commercial engagement, comparable service evaluation and assured data quality.

Open BIM provides enduring project data for use throughout the asset life-cycle, avoiding multiple input of the same data and consequential errors. Small and large (platform) software vendors can participate and compete on system independent, 'best of breed' solutions. Open BIM energizes the online product supply side with more exact user demand searches and delivers the product data directly into the BIM.

As a matter of fact, the specialized software developed for the management and processing of data within specific sectors - such as Engineering & Construction - lacked the ability to integrate each other; the transversely of the BIM approach necessarily requires maximum accessibility of such project and process information to all those involved.

The solution through which it is possible to guarantee access to data to all operators is called IFC. Acronym of "Industry Foundation Classes", IFC is the open international standard developed by buildingSMART and used by the most popular design software. On one hand, the IFC format allows the designer to continue working with familiar tools; on the other hand, it allows the use and re-use of all the data contained in the project by relating them to other software platforms used by other stakeholders dedicated to other aspects (structural, management, construction, etc.) of the work. IFC is continuously integrated with new items to take into account the AEC needs. In the last years, for instance, IFC for infrastructure is under development and experts of many countries are defining new IFC for rail, highways bridges and tunnel. It is very important the support of the main stakeholders so that the software applications will meet their needs.

Standardization activity born from the need to address problems of industrial-technical nature and benefits of standardization include:

- ✓ Benefits for business: ensure that business operations are as efficient as possible, increase productivity and help companies access new markets;
- ✓ Cost savings for suppliers and customers: optimize operations, simplifies and reduces project time and reducing wastes;
- ✓ Enhanced customer satisfaction: help improve quality, enhance customer satisfaction to assure customers that products/services are of the appropriate degree of quality, safety and respect for the environment;
- ✓ Protection of consumers and the interests of the community: sharing of best practices leads to the development of better products and services;
- ✓ Access to new markets: help prevent trade barriers and open up global markets;
- ✓ Increased market share: help increase productivity and competitive advantage (helping to create new business and maintaining existing);
- ✓ Increase market transparency: leads to common understanding and solutions;
- ✓ Environmental benefits: help reduce negative impacts on the environment.

There are three main levels of organizations for standardization: national, regional and international. At European level there is a complete standardization framework on energy calculation methods under the EPDB:

EN 15643-1: 2012 – General Framework:

- Provides the general principles, requirements and guidelines for the sustainability assessment of buildings;
- the assessment will quantify the contribution of the assessed construction works to sustainable construction and sustainable development;
- applies to all types of buildings (new and existing buildings).

It is widely known that the construction sector is a key sector for achieving sustainable development. Because of that, systems for description, quantification, assessment and certification of sustainable buildings have been developed at international level and in Europe. CEN/TC350 “Sustainability of Construction Works” has the task to establish the European set of rules for sustainability of construction works:

EN 15643-2:2012 - Framework for the assessment of environmental performance:

- provides specific principles and requirements for the assessment of environmental performance of buildings;
- assessment is on life cycle assessment;

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- environmental information expressed through quantified indicators (for example: acidification of land and water resources, use of freshwater resources; non-hazardous waste to disposal);
- applies to all types of buildings (new and existing buildings).

EN 15643-3:2012 - Framework for the assessment of social performance:

- provides specific principles and requirements for the assessment of social performance of buildings;
- focus on the assessment of aspects and impacts of a building expressed with quantifiable indicators;
- the indicators are integrated in the following categories: accessibility, adaptability, health and comfort, impacts on the neighborhood, maintenance, safety/security, sourcing of materials and services and stakeholders involvement;
- applies to all types of buildings (new and existing buildings).

EN 15643-4:2012 - Framework for the assessment of economic performance:

- provides specific principles and requirements for the assessment of economic performance of buildings;
- addresses the life cycle costs and other economic aspects, all expressed through quantitative indicators;
- includes economic aspects of a building related to the built environment within the area of the building site;
- applies to all types of buildings (new and existing buildings).

EN 15978:2012 - Assessment of environmental performance of buildings - Calculation method:

- assess the environmental performance of a building, and gives the means for the reporting and communication of the outcome of the assessment;
- the assessment covers all stages of the building life cycle and is based on data obtained from Environmental Product Declarations (EPD), and other information necessary and relevant for carrying out the assessment;
- includes all building related construction products, processes and services, used over the life cycle of the building;
- applies to all types of buildings (new and existing buildings).

EN 16309+A1: 2015 – Assessment of Social Performance - Calculation methodology:

- provides specific methods and requirements for the assessment of social performance of buildings;
- in this first version the social dimension of sustainability concentrates on the assessment of aspects and impacts for the use stage of a building expressed using the following categories: accessibility, adaptability, health and comfort, impacts on the neighborhood, maintenance and safety/security;
- applies to all types of buildings (new and existing buildings).

EN 15804: 2012+A1:2014 - Environmental Product Declaration:

- provides the Product Category Rules (PCR) for developing Environmental Product Declaration (EPD);
- apply to any construction products and construction service;
- EPD is expressed in information modules, which allow easy organization and expression of data packages throughout the life cycle of the product;
- there are three types of EPD with respect to life cycle stages covered: “cradle to gate”, “cradle to gate with options” and “cradle to grave”.

EN 15942: 2013 – Environmental product declarations — Communication format business-to-business:

- specifies and describes the communication format for the information defined in EN 15804: 2012, to ensure a common understanding through consistent communication of information
- aimed the business to business communication (B2B);
- is applicable to all construction products and services related to buildings and construction works.

CEN/TR 15941: 2011 IN - Environmental product declarations - Methodology for selection and use of generic data:

- this technical report supports the development of Environmental Product Declarations (EPD);
- provides guidance for the selection and use of different types of generic data available for practitioners and verifiers involved in the preparation of EPD;
- aimed to improve consistency and comparability.

The following list contains other standards not under CEN/TC350 that support EPBD:

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EN 15217:2012 - Energy performance of buildings – Methods for expressing energy performance and for the energy certification of buildings:

- specifies overall indicators to express the energy performance of whole buildings, including heating, ventilation, air conditioning, domestic hot water and lighting systems. This includes different possible indicators;
- specifies ways to express energy requirements for the design of new buildings or renovation of existing buildings;
- specifies procedures to define reference values;
- can be applied to a group of buildings, if they are on the same lot, if they are serviced by the same technical building systems and if no more than one of them has a conditioned area of more than 1000 [m2].

EN ISO 52000-1:2017 - Energy performance of buildings (EN 15603):

- introduces calculation procedures and an indicative list of indicators for the evaluation of the energy efficiency: final energy needs (constructive quality of the envelope), total use of primary energy, total non-renewable primary energy use, and total use of non-renewable primary energy considering the impact of the exported energy.

EN 15316-1:2017 - Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating and DHW generation systems, combustion systems (boilers, biomass):

- specifies methods for the calculation of thermal losses from the heating and the domestic hot water generation system, recoverable thermal losses for space heating from the heating and the domestic hot water generation system, auxiliary energy of the heating and the domestic hot water generation systems;
- specifies the energy performance calculation of water based heat generation sub-systems including control based on combustion of fuels ("boilers"), operating with conventional fossil fuels as well as renewable fuels;
- applicable to heat generators for heating or for combined service as domestic hot water, ventilation, cooling and heating.

EN 15316-2:2017 - Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies. Space emission systems (heating and cooling):

- covers energy performance calculation of heating systems and water based cooling space emission sub-systems.

EN 15316-3:2017 - Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Space distribution systems (DHW, heating and cooling):

- covers energy performance calculation of water based distribution systems for space heating, space cooling and domestic hot water;
- deals with the heat flux from the distributed water to the space and the auxiliary energy of the related pumps.

EN 15316-4:2017 - Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar and photovoltaic systems:

Within this standard, 6 methods are specified each method has its own range of applicability:

- Method 1, is applicable for solar domestic hot water systems characterized by the EN 12976 series (factory made) or EN 12977-2 (custom built). The main output of the method is the solar heat and back up heat contribution to the requested heat use;
- Method 2, is applicable for systems for domestic hot water and / or space heating with components characterized by EN ISO 9806 and EN 12977-3 or EN 12977-4 with a monthly calculation time step. The main output of the method is the solar heat and back up heat contribution to the requested heat use;

- Method 3, is applicable for systems for domestic hot water and / or space heating with components characterized by EN ISO 9806 with an hourly calculation time step. The main output of the method is collector loop heat supplied to the heat storage;
- Method 4, is applicable for photovoltaic systems with components characterized by standards and with an annual calculation time step. The output of the method is the produced electricity;
- Method 5, is applicable for photovoltaic systems with components characterized by standards and with a monthly calculation time step. The output of the method is the produced electricity;
- Method 6, is applicable for photovoltaic systems with components characterized by standards and with a calculation time step. The output of the method is the produced electricity.

EN 15241:2008 - Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in buildings:

- Describes the method to calculate the energy impact of ventilation systems (including airing) in buildings to be used for applications such as energy calculations, heat and cooling load calculation;
- Defines how to calculate the characteristics (temperature, humidity) of the air entering the building, and the corresponding energies required for its treatment and the auxiliaries electrical energy required.

EN 15193:2008 - Energy performance of buildings - Energy requirements for lighting:

- Specifies the calculation methodology for the evaluation of the amount of energy used for indoor lighting inside the building and provides a numeric indicator for lighting energy requirements used for certification purposes;
- Can be used for existing buildings and for the design of new or renovated buildings.

EN ISO 13790:2011 - Energy performance of buildings - Calculation of energy use for space heating and cooling (ISO 13790:2008):

- Gives calculation methods for assessment of the annual energy use for space heating and cooling of a residential or a non-residential building already existing or at the design stage;
- Developed for buildings that are, or are assumed to be, heated and/or cooled for the thermal comfort of people, but can be used for other types of building or other types of use (e.g. industrial, agricultural, swimming pool), as long as appropriate input data are chosen and the impact of special physical conditions on the accuracy is taken into consideration;
- Includes the calculation of the heat transfer by transmission and ventilation of the building zone when heated or cooled to constant internal temperature, the contribution of internal and solar heat gains to the building heat balance, the annual energy needs for heating and cooling to maintain the specified set-point temperatures in the building.

EN ISO 13789:2017 - Thermal performance of buildings - Transmission and ventilation heat transfer coefficients - Calculation method (ISO 13789:2017):

- Specifies a method and provides conventions for the calculation of the steady-state transmission and ventilation heat transfer coefficients of whole buildings and parts of buildings;
- Applicable both to heat loss (internal temperature higher than external temperature) and to heat gain (internal temperature lower than external temperature).

EN 13465:2004 - Ventilation for buildings - Calculation methods for the determination of air flow rates in dwellings:

- Specifies methods to calculate basic whole house air flow rates for single family houses and individual apartments up to the size of approximately 1000 m[3];
- May be used for applications such as energy loss calculations, heat load calculations and indoor air quality evaluations.

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EN 15242:2007 - Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration (PNE-EN 16798-7):

- Describes the method to calculate the ventilation air flow rates for buildings to be used for applications such as energy calculations, heat and cooling load calculation, summer comfort and indoor air quality evaluation;
- The method contained in the standard is meant to be applied to mechanically ventilated building, passive ducts, hybrid system switching between mechanical and natural modes, windows opening by manual operation for airing or summer comfort issues;
- Not directly applicable for buildings higher than 100 m and rooms where vertical air temperature difference is higher than 15K.

EN 15251:2008 - Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics (PNE-prEN 16798-1):

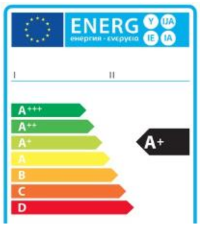
- Specifies the indoor environmental parameters which have an impact on the energy performance of buildings and how to establish these for building system design and energy performance calculations;
- Specifies methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements;
- Applicable mainly in non-industrial buildings where the criteria for indoor environment are set by human occupancy and where the production or process does not have a major impact on indoor environment.

EN ISO 15927-5:2006/1M:2012 - Hygrothermal performance of buildings - Calculation and presentation of climatic data - Part 5: Data for design heat load for space heating - Amendment 1 (ISO 15927-5:2004/Amd 1:2011):

- Specifies the definition, method of calculation and method of presentation of the climatic data to be used in determining the design heat load for space heating in buildings. These include the winter external design air temperatures and the relevant wind speed and direction, where appropriate.

EN ISO 52022-1:2017 – Energy performance of buildings - Thermal, solar and daylight properties of building components and elements:

- Specifies a simplified method based on thermal, solar and light characteristics of the glazing and solar and light characteristics of the solar protection device, to estimate the total solar energy transmittance, direct energy transmittance and the light transmittance of a solar protection device combined to a glazing;
- Applicable to all types of solar protection devices parallel to the glazing.



Environmental labels provide precise and useful information to clients and consumers about the environmental performance of products or services. A very simple sentence, a graphic, or a combination of both can be used in environmental labels. There are mandatory labels, like the EU energy label or the energy certificate of a building. There are voluntary labels, like the EU ecolabel or environmental product declarations. Mandatory environmental labels are defined in laws and regulations. Usually the objectives are to provide important environmental information to clients and consumers and to promote the products and services with the best performance related to some environmental aspects.

The EU energy label for energy-related products is an example of a mandatory environmental label. It is a label with information regarding energy consumption and other performance characteristics of any goods having an impact on energy consumption during use. There are EU energy labels for lamps, luminaires, air conditioners, televisions, tumble driers, washing machines, dishwashers, refrigerating appliances, vacuum cleaners, space heaters and water heaters, among other products.

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The energy certification of buldings is mandatory in all EU countries. The building energy class can be used as a label in advertising providing information on the energy performance of the buiding for buyers or tenants.

Download example of EU label for vacuum cleaner

Download example of EU label for air conditioners

Download example of energy certification of buildings in Spain

There are mainly three types of voluntary environmental labels:

- self-declared environmental claims: are made by producers that wish to inform consumers that their product is better than others in what concerns a particular environmental aspect. In order to become credible among consumers, these claims should follow the requirements established in the international standard ISO 14021.
- environmental labelling programmes: award a product or service with a mark or a logo based on the fulfilment of a set of criteria defined by the programme operator. In order to become credible among consumers, these programmes should follow the requirements established in the international standard ISO 14024.
- environmental product declarations: provide clients with a set of life cycle data describing the environmental aspects of a product or service. In order to become credible among consumers, these declarations should follow the requirements established in the international standard ISO 14025.

According to ISO standards, claims that are vague and non-specific shall not be used, because they are misleading.

The **EU ecolabel** is an example of a voluntary environmental label. The EU ecolabel identify products and services that have a reduced environmental impact throughout their life cycle, from the extraction of raw material through to production, use and disposal. The EU ecolabel awards products and services that fulfill a set of environmental criteria defined for the respective product category.

0.5 The CDE (Common Data Environment)

The CDE - Common Data Environment - can be defined as an application, generally available in Cloud, usable by any device (Computer, Tablet or Smartphone) from which it is possible to manage unambiguously and structured information for project management. The CDE allows distributing information and creating value for the whole chain of operators involved in the process facilitating collaboration among them.

The main areas covered by a CDE are: Document Management, Task Management and Asset Management; all these activities, if properly integrated into a BIM process, are able to offer greater efficiency and control in any process.
To obtain the best results it is also essential that the strategic choices for the correct management of a work are anticipated and shared as early as possible. Moreover, all the choices and the consequent planned activities must be shared in real time in order to allow a high level of collaboration among all the operators; also, in this case the use of a CDE ensures

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greater efficiency in the exchange of information and a greater collaboration level between all the operators involved in the decision-making process.
The adoption of a CDE finally allows to overcome geographical barriers and allow, for example, to create extended work teams, also belonging to different countries or continents; the possibility offered by the CDE to collaborate remotely using a shared technology platform offers the opportunity to create new business opportunities by lowering management costs.

The six key points for building a successful Common Data Environment are:

1. **Choose the right team:** choose team members of the project with necessary skills for performing required activities, motivated to work together to achieve project objectives. A motivated and prepared team is the key to success.
2. **Define roles and responsibilities:** team members who participate in the project and access the Common Data Environment must operate according to the activities assigned to them and their competences with different roles and levels of responsibility; make sure that each of them is assigned the right profile to access the Common Data Environment. A proper setting of the common data environment allows all members of the team to optimizing their needs. Do not skimp on the time it takes to set up the Common Data Environment correctly.
3. **Define workflows:** clearly decide who can do what, for example who can access a certain type of information or documents, define what rules must be approved for documents and activities.
4. **Common language and data availability:** Define a common language, such as which file formats to use, keep in mind that practically all international and national standards require the use of non-proprietary and open formats. The information to be available always and from anywhere must also be accessible from mobile choose a solution that guarantees this fundamental prerogative.
5. **Data security first of all:** the Common Data Environment to guarantee access levels to the H24 data needs to operate in Cloud, which means that data protection must be guaranteed with security levels close to 100% (nobody can guarantee 100%). To ensure an adequate level of security the data must be encrypted and the encrypted communications. Define diversified access with at least three levels of access.
6. **The BIM qualifying factor:** the use of a tool such as the Common Data Environment, combined with the use of BIM, allows to obtain strong cost savings, reliable construction times and a more efficient management of buildings during the entire life cycle of the building. In the Common Data Environment, access to information and the display of federated BIM models must also be guaranteed.

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1. Module 1 – Diffuse BIM

The Module 1 is not compulsory for this Target Group

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2. Module 2 – Apply information management

2.1 Principle of data management in the CDE (Common Data Environment)

The common data environment (CDE) is a central repository where construction project information is housed. 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. (Situation in England: Central to level 1 maturity is the establishment of a CDE. This is the collaboration tool that BS-1192 describes as a repository, which will allow information to be shared between all members of the project team.)

The ultimate aim is to improve the creation, sharing and issuing of information that underpins the delivery of a project. The idea of collaboration to drive improved results and efficiencies is at the heart of implementing a Building Information Modelling (BIM) approach on construction projects.

Construction draws on the skills of a wide range of disciplines and the CDE brings together the information from all who work as part of the wider project team.

As a single source of information there's no arguments about which version of information should be being referenced. The CDE should serve as the ultimate source of 'truth' and bring a number of advantages for all involved:

- Shared information should result in coordinated data which will, in turn, reduce both time and cost on your project.
- 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).
- Spatial co-ordination is inherent in the idea of using a centralized model.
- Production information should be right first time assuming that contributors adhere to processes for sharing information.

However, not all models or modelers qualify as BIM. Although there are neither clear definitions nor umbrella agreements of what constitutes a Building Information Modeler, researchers and software developers alike allude to a lowest common denominator.

This non-declared denominator is a set of technological and procedural attributes of BIModels (Building Information Models), which:

- must be Three Dimensional;
- need to be built from Objects (solid modelling - object oriented technology);
- need to have encoded and embedded discipline-specific information (more than a mere database);
- need to have interwoven relationships & hierarchies between their objects (rules and/or constraints: similar to a relationship between a wall and a door where a door creates an opening in a wall);
- describes a Building of some sort.

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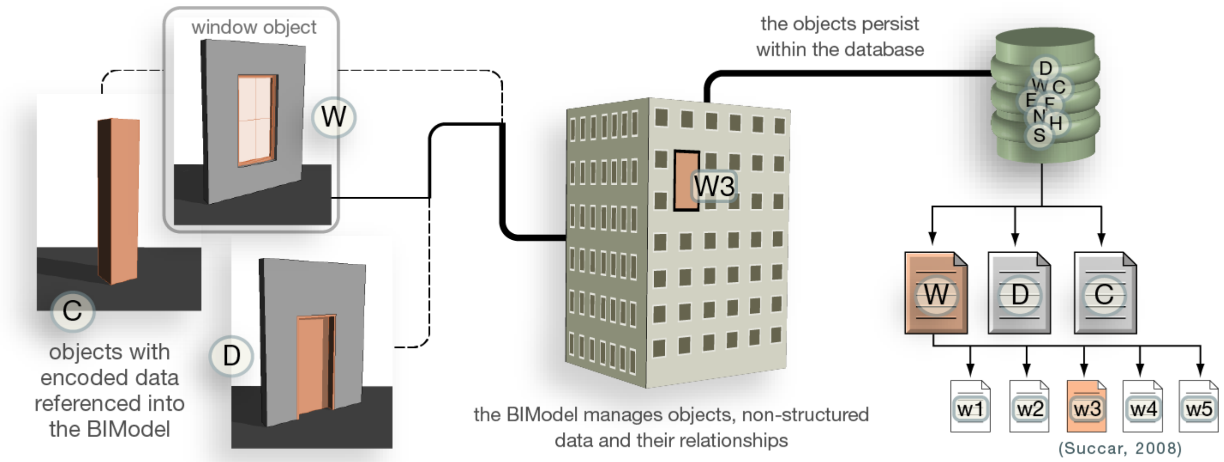

(Succar, 2008)

BIModellers do not depict nor encode the full scope of industry knowledge even within individual sectors (Architecture, Engineering or Construction). To express the matter differently, we first need to decipher what is really meant by “information” within Building Information Modelling. There are five levels of meaning that must be understood:

- Data is/are the basic observations and collectibles. Data is what you can see and collect;
- Information represents connected data whether to other data or to a context. Information is what you can see and say (collect then express);
- Knowledge sets a goal for the information. Knowledge is the expression of regularity. Knowledge is what you see, say and able to do;
- Understanding is the transmission and explanations of a phenomenon within a context. Understanding is what you can see, say, do and able to teach;
- Wisdom is the action based on understanding phenomena across heterogeneous domains. Wisdom is seeing, saying, doing and teaching across disciplines and contexts.

Building Information Modelling deals with Data and Information only although some vendors would like to promote BIModellers as Knowledge-Based. As per the definitions above and if we assume Goals to be synonymous to encoded Rules, BIModels can include Knowledge-Based Models and Models based on Systems Thinking.

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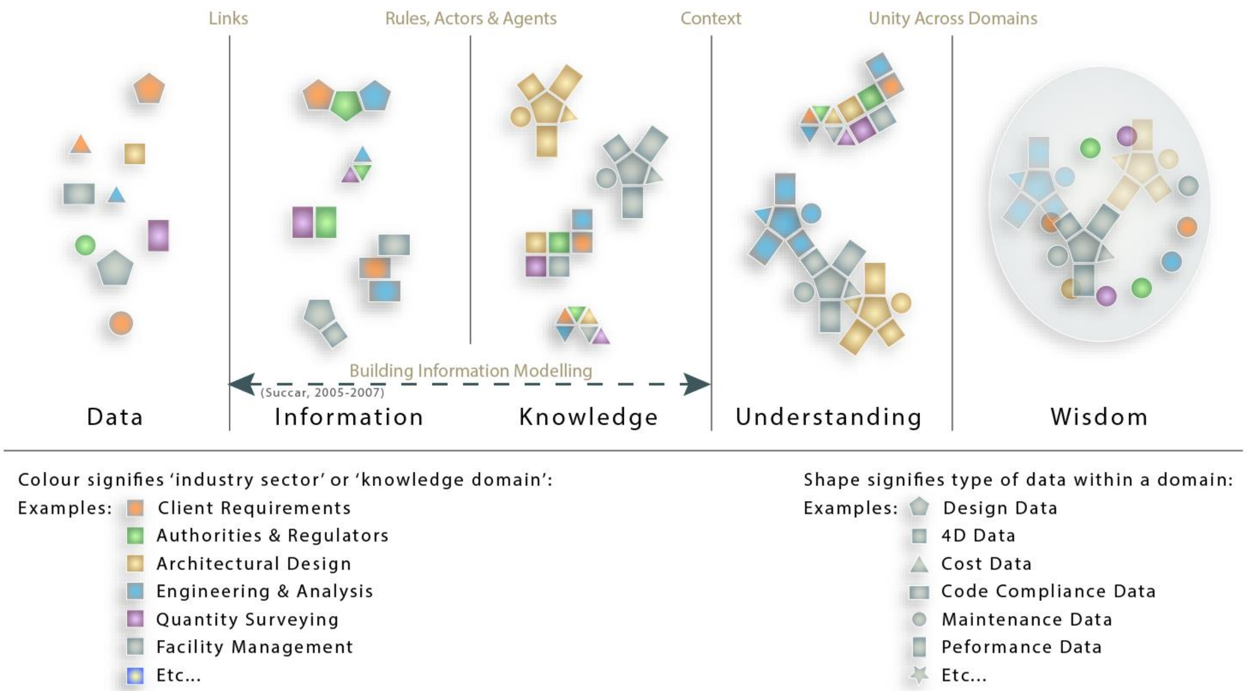

BIM Modellers can share little or much information available across diversified industry domains. The optimal BIM Modeller would have the ability to display, calculate and share all data necessary between disciplines without loss or workflow conflicts. This ability, or lack of, is a function of the technology used, the process deployed and the parties (knowledge workers) involved.

Assuming each domain (industry sector: Architect, Engineer or Constructor) is using a different BIM Modeller, data sharing methodologies, amongst these modelers, can take many forms:

1. **Data Exchange**: Each BIM Modeller keeps its integrity but exports out some of its 'sharable' data in a format that other BIM Modellers can import and calculate (think XML, CSV or DGN for example). This method is arguably the primordial data sharing method and suffers from the highest unintentional data loss rates. Data loss here signifies the amount of data that can't be shared as compared to overall data available in BIM Models. However, not all data must or need to be shared between BIM Modellers all the time. Partial Data Exchange (as compared to unintentional data loss) can be an intentional and efficient method of data sharing.
2. **Data Interoperability**: Interoperability can be in many forms; the one discussed here is merely an example. Assuming file-based data interoperability (not server-based interoperability) one of the demonstrated scenarios for this data sharing methodology is as follows: BIModeller$_1$ produces an IModel (Interoperable Model) that gets imported into BIModeller$_2$ where its worked-on then exported into IModel v.2 (version 2) that gets imported into BIModeller$_3$ where its worked on then exported into IModel v.3 that gets imported into… The amount of data lost/gained between modellers, models and model versions depend on modellers' import/export abilities and the interoperability schema itself (think IFC for example). One major shortcoming of this file-based interoperability is workflow linearity; the inability to allow simultaneous interdisciplinary changes to the shared.
3. **Data Federation**. File linking is a good example of data federation: data in one BIM Model is linked to data in another BIM Model. The files are neither imported nor exported but BIM Modellers (software applications) can read and calculate the data embedded within the linked files. The amount of data loss depends on the amount of

data readable or calculable. Referential Models (RModels) are another example of BIM Data Federation. RModels are single or federated models that host links to outside data repositories; much like a hyperlinks on a webpage.

An example of this would be a virtual building with a referential window object: detailed information (values) beyond the basic parameters are not saved within the BIM Model but are accessed from an external repository whenever the need arises [3] (ex: real-time window cost, availability, installation manual, maintenance schedule).

4. **Data Integration**: The term integration may be understood in many ways including the lower-grade ability to exchange data between software solutions. In a BIM context, an integrated database signifies the ability to share information between different industry sectors using a common model [4]. The sharable data within the BIM Model may be architectural, analytical (engineering) or managerial as well as design, cost or code information. What is important about an Integrated BIM Model is that it co-locates interdisciplinary information allowing them to interact with each other within a single computational framework.
5. **Data Sharing Hybrid**: A combination of any of the data sharing forms discussed above. Most BIM Modellers, whether proprietary or not, coordinate the multi-disciplinary information generated by AEC sectors through hybrid of information sharing methodologies.

A list of documents shared in the CDE is shown below:

Client brief and technical requirements	Test certificates
Appointments and contracts	Product safety information / emergency procedures
Bonds and insurances (including final building insurance valuation)	Product spare parts, tools and resources
Project stage reports	Product maintenance/ cleaning procedures/ manual
Technical reports (planning, design, environmental, impact assessments, etc.)	Product installation guide
Analysis, assessments and calculations	Product batch/ trace details
Sustainability certification, assessment, application, certificate	Technical data
Surveys (topographical survey, condition survey, etc.)	Environmental Product Declaration (EPD)
Meeting minutes	Product Declaration of Performance (DoP) and CE Marking
Project file notes	European Technical Assessments (ETA)
Request for Information (RFI's)	Agreement certificates (NSAI, BRE, etc)
Method statements	Product specification
Correspondence	Snag lists and quality control procedures
Media (photographs, images, presentations, video, etc)	Inspection plans and inspection records
Regulatory application/submission certificates (planning, building control, fire safety, disability access)	Schedules of certifiers, benchmarks, design changes, non-compliance
Non-statutory applications / submissions / certificates (LEED, BREEAM, etc.)	Compliance specification / certificates / opinions on compliance
Models (3D models, 2D models, federated models, Analytical models)	Design requirements (Tests, certificates, samples, etc.)
Design drawings, specifications, schedules and data sheets	Design responsibility matrix

Cost plans and bills of quantities	Health and safety risk assessments and safety plans
Payment certificates	As-built drawings, specifications, schedules and data sheets
Contracts final accounts	Construction / fabrication drawings, specifications, schedules and data sheets
Project plans and programmes	Technical submittals and approvals
Inspection record	Commissioning certificate
Equipment default "settings" (set points)	Suppliers warranty (parts)
Suppliers warranty (labour)	Supplier contact details

2.2 The identification of non-graphic information for the BIM Model

When people think of a model, perhaps the first thing that comes to mind is geometry. This is not surprising as models have been used for centuries to set out a designer's intentions – conveying shape, space and dimensions.

However, while the geometrical or graphical data can tell us the width of a brickwork leaf and the height of the walls, at a certain point during construction it is the written word that is needed to take us to a deeper level of information. It is within this textual environment that we describe the characteristics of the brickwork itself such as density, strength and source, and it is words that are used to describe the kind and type of mortar joint and wall ties.

In the context of BIM, we are actually looking at a rich information model, which, aside from graphical data − such as geometry and shape − also includes non-graphical information such as performance requirements and associated documentation, presented in a specification or manual format. The technical schema of plants, the instructions manual and any written specification is not new and has been around for centuries. However, it is only now by combining these aspects of graphical and non-graphical information that we get the 'overall picture'.

Today, clients are not only procuring a physical asset: they are also procuring information, typically in a digital format. The amount and level of information increases as we progress through the project lifecycle. For example, at an early strategic briefing stage, when the client is assessing needs, there may just be a requirement for spaces and activities. At concept stage this will be developed into the design intent of elements/systems to meet the Employer's Information Requirements (EIR). This is then further developed at design stage when considering the characteristics of each deliverable in terms of performance requirements; this could relate to security requirements of a plant room space, an external wall element or a door set system. At technical design stage, or at least prior to construction, product selection can be determined by the delegated as 'contractor's choice' based upon generic product performance requirements.

The Government's "Soft Landings" guidance recommends that a building's 'in operation' phase should be considered throughout the whole project lifecycle. By establishing required performance outcomes and operational budget at an early stage, these can then be compared to the actual performance outcomes. From a concept stage, the performance criteria, such as the structural performance of a partition system, can be considered.

An example of a typical masonry construction detail, and its non-graphical considerations, is shown next:

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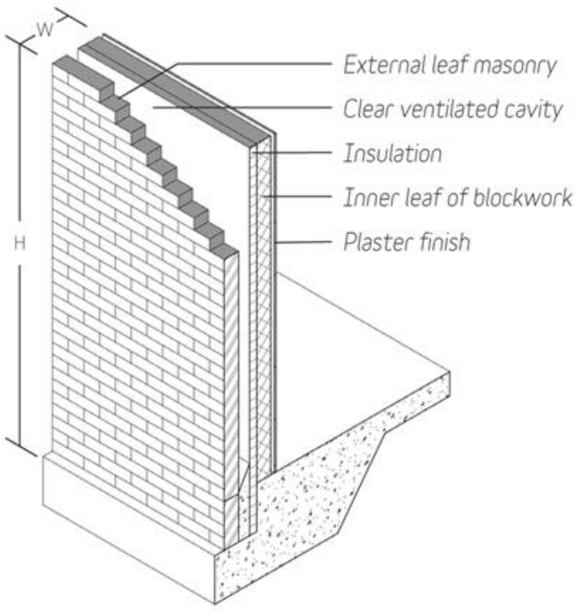
Non-Graphical Information
Performance
Accuracy tolerances (for structural performance)
Design submittals requirements (applicable where there is a contractor designed component)
Working life
Fire performance
Structural performance, impact, M&E (mechanical and electrical) services, vehicular
Heat loss (U value)
Execution
Workmanship during adverse weather
Cleanliness
Reference and sample panel requirements (to monitor workmanship, material quality)
Specific product installation requirements (e.g. installing cavity wall insulation, installing lintels, block bonding new walls to existing, laying frogged bricks in mortar)
Product properties
Thermal conductivity
Freeze / Thaw resistance
Recycled content
Dimensional tolerances for masonry units
Compressive strength



The Level of Information (LOI) in PAS1192-2 defines how much non-graphical data is required to be provided at different stages of the project. A Product Data Template (PDT) is a structured spreadsheet-based digital file format, that product suppliers and manufacturers can use to provide their non-graphical data (as a Product Data Sheet) to project teams, to allow them to incorporate and re-use the information. Obviously, the "naming" of digital attributes is very important, particularly if we want computers to be able to recognize, check/cross-check these against project requirements and across many projects - this is where standardized classification systems become really important, as well as international "data dictionaries", that allow common "terms" are understood in all countries.

The construction industry is well used to producing and providing "documents": drawings, specifications, schedules, bills of quantities, product manuals, certificates, warranties, contracts, etc. While it may use lots of "digital tools" to produce these, they are typically delivered in "static" formats, like printed pages, or scanned .pdf's, for others to use. The problem with "documents" as mentioned above, is that the only way to find information, is to manually open and read the documents, and with hundreds and thousands of documents on a typical project, this can be a very time-consuming (or near impossible) task. In the short-term, we will still need "documents", but as computers get more powerful and connected, we see a trend is towards more "data", which is digital, searchable and manageable (able to be kept up-to-date, analyzed, monitored and assessed). Some forms of "information" may be difficult, or possibly not appropriate, to store as "data", such as long text-based narratives, like manuals, specifications and reports, or officially "signed" documents like contracts and certificates. Documents also provide a fixed historical "record" of the development process of buildings, not just information about the building itself. The software applications are evolving and it is now possible to include “tags” in a pdf file so that it becomes searchable and information embedded in the file can be easily accessed but the technicians.

Documents should be well-organized and indexed, and stored in an accessible system, if they are going to be of any use to anyone. People need some way of knowing that they are looking at the latest version of the correct document, or they will not trust the information. PAS1192-2 refers to the Common Data Environment (CDE) which is a well-managed central repository of information, using a clear file-naming convention, and a carefully managed approvals workflow, to make sure documents are properly controlled and easy to find, as define in Chapter 3.1.

2.3 The maintenance plan in EPC (Energy Performance Contracting)

The EPC (Energy performance contracting) is a contractual arrangement between a building owner or occupier (including public authorities) and an Energy Service Company (ESCO) to improve the energy efficiency of a building. The investment costs are typically covered by the ESCO or a third party such as a bank, so no financial outlay is required by the public authority. The ESCO receives a fee, usually linked to the guaranteed energy savings. After the specified contracting period, the savings from energy efficiency improvements to the building will revert to the public authority. Energy performance contracting is often undertaken in respect of groups of buildings, in order to make the contracts more attractive to potential investors.

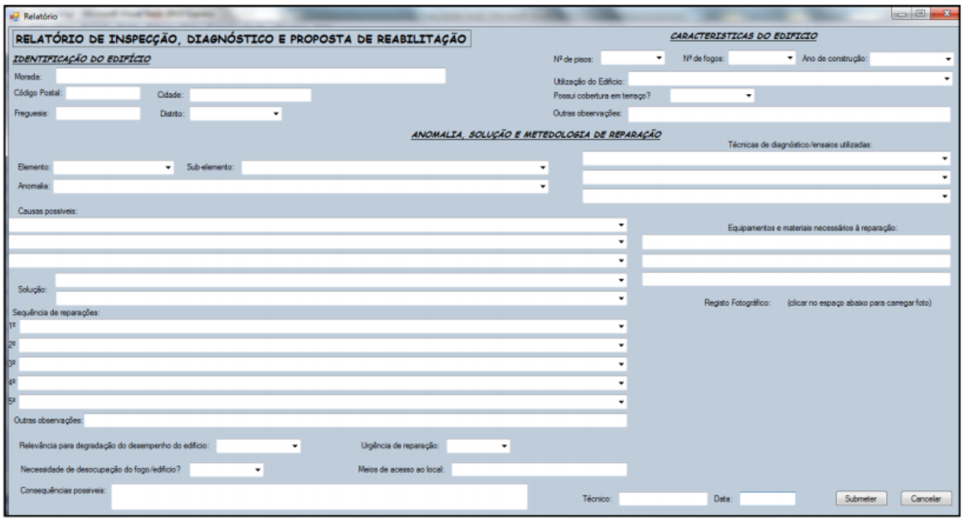
In the EPC the maintenance for the duration of the contract is up to the ESCO proposing the refurbishment. It has been demonstrated that even a NZEB design can bring to higher costs than foreseen for two main reasons: the first is that during the construction some changes occurs that worsen the energy performance, the second reason is that inhabitants do not know how to use the technology and have higher management costs. In both cases the use of BIM will mitigate if not solve those problems. If BIM is correctly implemented, together with the physical building a twin virtual building will be realized and will be enriched with all the information needed for the maintenance. Besides, a remote control of the building functionalities such as a building automation system, will allow the building manager to intervene any time some misuse is identified.

Once the contract ends, the building maintenance is under the responsibility of its owner which must use, whenever appropriate, a qualified technician to perform the inspection. A good maintenance depends on the analysis of the anomalies detected during the inspection of the site.

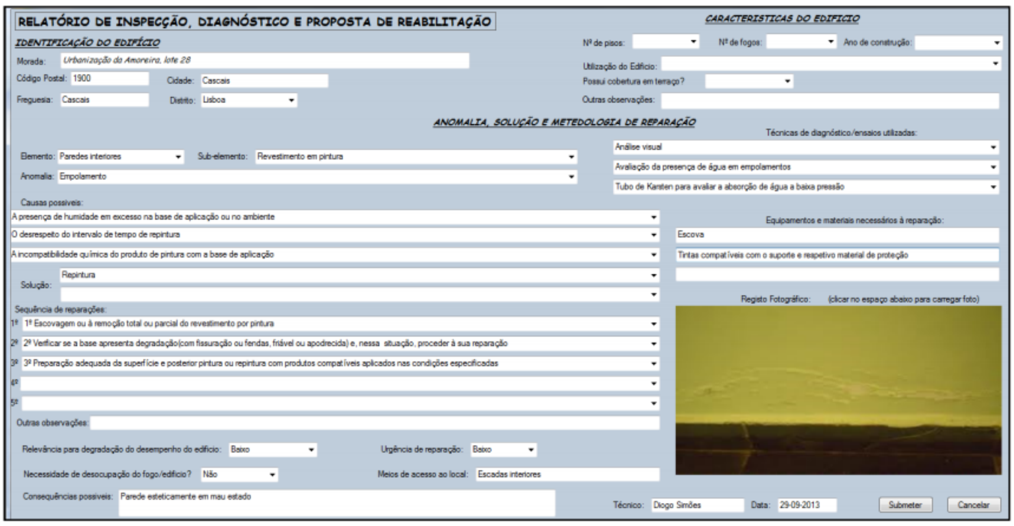
BIM models have revealed themselves as an excellent tool when it comes to supporting maintenance actions, due to their ability to store enough information in one place and by allowing the user to obtain realistic perspectives and exact drawings. During an inspection operation for maintenance purposes, the developed application, containing a rigorous database, allows the user to identify each anomaly present in building components, directly onto the BIM model, automatically associating them with probable causes, repair methods and a photograph of the anomaly uploaded at the site. Therefore, gains in productivity and a decrease in the error probability can be achieved. The inspection data, converted to the PDF format, is stored in the BIM model, making it suitable for consultation when planning maintenance. Additionally, the interoperability between BIM modeling and visualizing software, regarding the preservation of information, is ensured when if IFC format is used.

The interactive inspection operations sheet, created using a particular integrated software, has, as main objective, to support the implementation of an inspection. In the development of a case study in Spain, a database was used. It consisted in the compilation of information from other dissertations also developed for maintenance purposes. The information provided in this work relates to anomalies, causes, solutions and repair methodology concerning constructive components: exterior walls, interior walls, pitched roofs.

Therefore, during an inspection, the maintenance technician, when observing an anomaly, can consult the database support to fill out the inspection sheets and select the identified anomaly on the site. Subsequently, the completed inspection sheet is then converted to the PDF format and inserted into the BIM model. This model should be constantly updated, in order to accurately support the facility with repair and maintenance plans. The developed computer application has its interface illustrated in the figure below.



A sheet of the inspection must include some initial information such as identification of the technician, the date of the inspection and the identity and characteristics of the building (address, city, number of floors, year of construction, etc...). Most of this information is selected from ComboBox elements, so the registration is carried in a fast way. A ComboBox element is defined with a combination of a text box and a list box, allowing the filling of the text box with one of the options provided in the list that appears as a descending menu.



The application also allows including a photograph of the anomaly taken at the site and convert the information presented in the sheet of inspection to a document in PDF format. Such possibilities are essential for an inspection sheet, because the addition of a photograph allows the user to recognize the anomaly, its severity and location, and conversion to PDF format enables the user to save the inspection form in a universal format.

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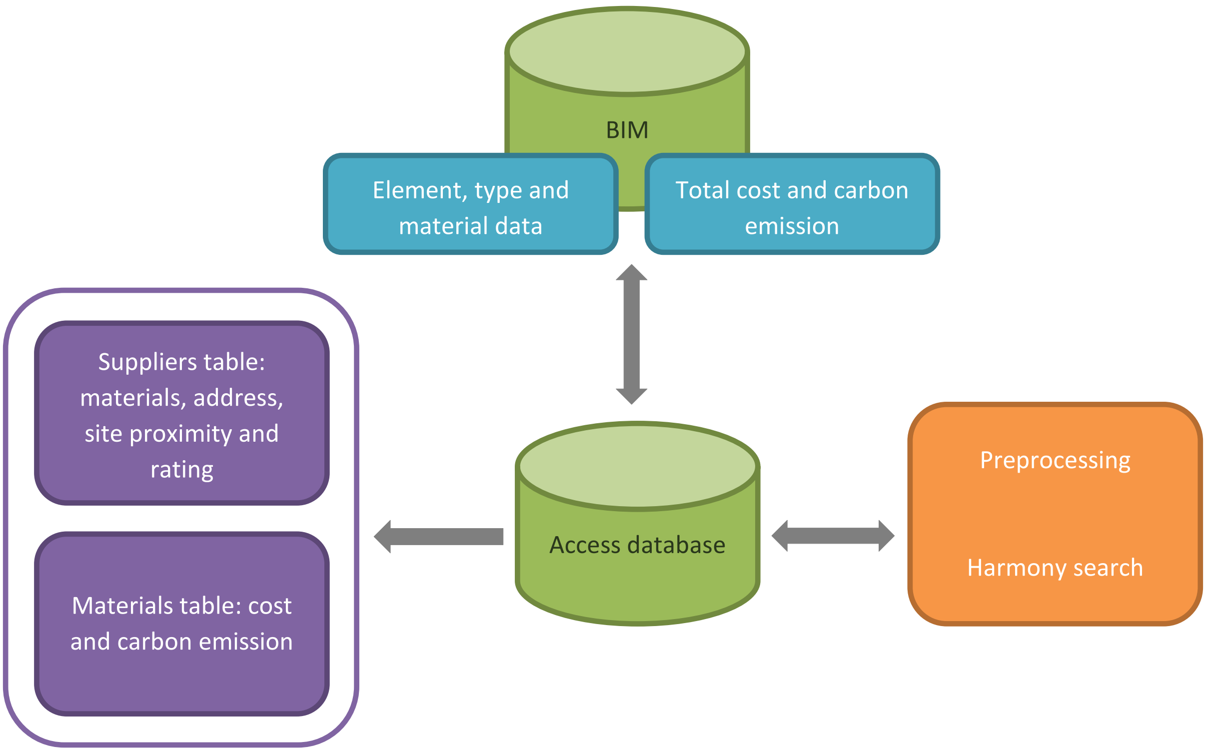
3. Module 3 – Apply procurement management

3.1 Selection of materials and products with BIM

Material and product selection is a delicate process, typically hinged on a number of factors, which can be either cost or environmental related. This process becomes more complicated when designers are faced with several material options of building elements and different suppliers, whose selection criteria may affect the budgetary and environmental requirements of the project, can supply each option.

Over the years, there has been an increasing realization of the need to design buildings that are both cost and environmentally friendly. The environmental implications of such designs include reduction in carbon dioxide emission to the environment, embodied energy in buildings and improvement of indoor air quality. In order to meet design objectives, designers are usually faced with the challenge of selecting the most suitable material and product from different options or alternatives.



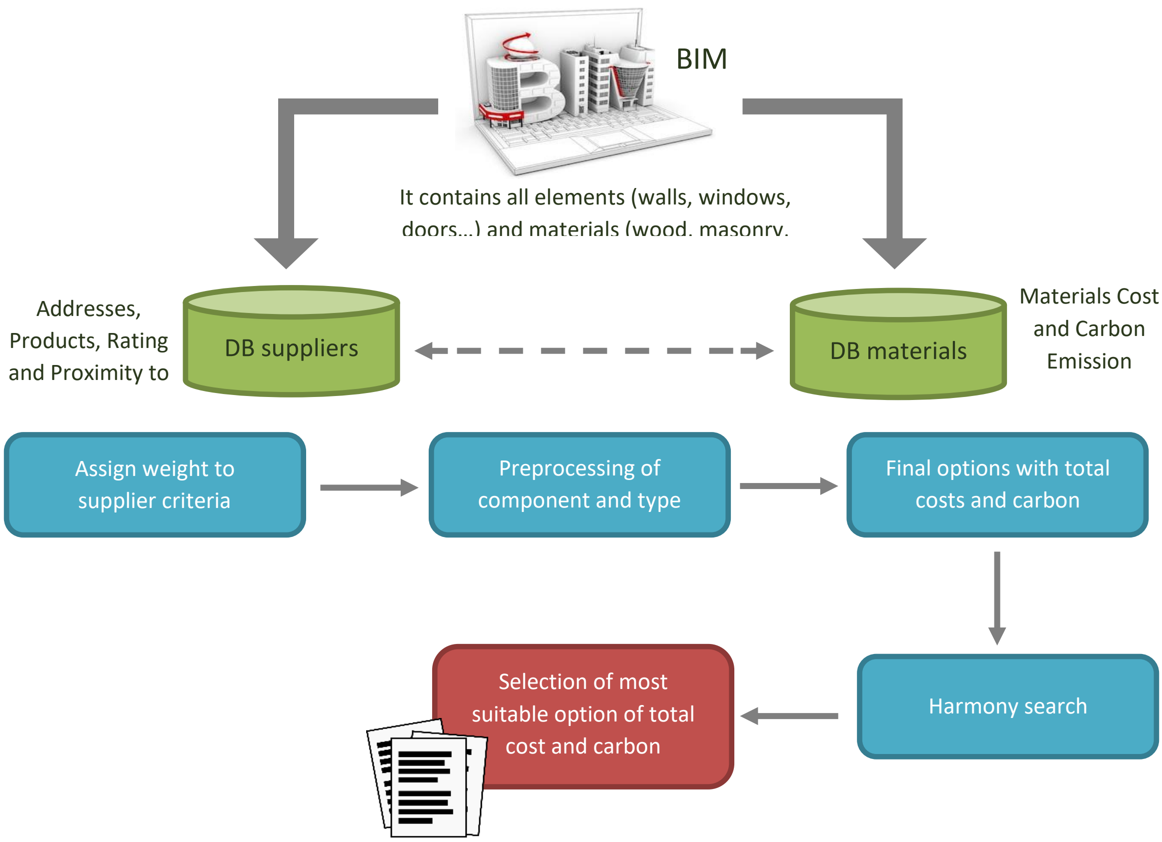
This decision becomes more complicated when different suppliers can supply each option. Additionally, each supplier’s ratings may have different contributions towards the budgetary and environmental requirements of the project in terms of measures or criteria such as price, quality of material and service. Building materials have been known to account for about 50% of the total construction cost. Studies have also shown that this cost is highly influenced by supplier selection criteria. This is analogous to green construction projects, which are also characterized by criteria such as proximity to site and sustainable materials. However, little has been done to understand how the weight of these criteria can affect decision making in material selection. Furthermore, studies have shown that without supplier involvement, decision-making might be far from optimal.

Research on supplier selection has evolved from a cost only criterion to a multi-criteria problem. Depending on the level of importance of each criterion to the designer, the budgetary and environmental impacts of a project could be affected. For example, if the quality of a material is of more importance to the designer, the cost of the material and the project will be higher, and if the supplier is selected for low cost, other criteria such as material quality, distance and environmental considerations may be dissatisfying. The later may result in an increase in the projects total carbon emission and transportation costs.

Contracting firms keep a database of suppliers' performance evaluations over a period of time. The most suitable supplier will typically be selected based on an evaluation of criteria or factors, whose individual weights may affect the cost and environmental considerations of each option.

When choosing the products the cost for the end of life should also be considered. The information about re-use or recycling should be carefully stored in the database of the BIMmodel so that the maintenance technician can use that information when dismissing equipment/materials.

The overview of the information flow among the various applications in the proposed framework is shown in the figure below:



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The steps of the model and role of the applications are explained below:

1. **Step 1 - BIM Module, definition of Building Elements and Properties:** The building elements are defined at this stage and the type of each element is determined based on the materials. Other properties defined at this stage include the alternatives of each material, the elements to be included in the simulation and the elements to be considered for analysis. Any BIM tool can enable definition of element and material within design models. In some architectures, when building elements are defined, materials can also be defined as part of the element properties. However, since the designer may be interested in understanding the total cost and carbon emission of multiple materials, the material alternatives can be embedded in the element properties as separate parameters. The use of local and recycled building materials has been argued to offer the advantage of reducing carbon emissions, producing healthier buildings, in addition to strengthening the local economy. Normally, more credits have been implemented for each material option by the suppliers in 500 miles range around the project's location.
2. **Step 2 - BIM-Microsoft Access Database:** the list of materials and their cost, carbon emissions and the supplier information are contained in two separate tables within a Microsoft access database, other solutions could be used as well. Contractors typically keep records of supplier information such as addresses, materials they supply and performance ratings. Alongside this information, the supplier information table will also contain the proximity of each supplier to the construction site. The proximity is obtained by computing the driving distance between each supplier's address and the construction site using web location mapping systems such as Google Maps. The second table contains a list of building materials, their cost and carbon emission. The later can be obtained from published inventories such as the inventory of carbon and energy. The contents of the database and the inputs defined in stage 1 will be the inputs to the harmony search optimization. It is important to filter and arrange these inputs in such a way that the harmony search algorithm can utilize it. This can be done using plugins. Most BIM software have software development kits that enable developers integrate BIM tools with external applications. Plugins can be developed to extract the inputs defined in stage 1 and the database. The plugin provides quotes of windows and doors from online resources. In relation to this research, a plugin was developed within BIM that enables extraction of supplier data from the supplier database. If a material is to be considered in the analysis, it is checked within the properties. In order to determine the most suitable supplier (from the supplier table) of each material alternative, it is important to evaluate and rate the suppliers. To do this, a set of criterions were established to compare the suppliers.
3. **Step 3 - Harmony Search Optimization:** with the use of harmonization criteria.
4. **Step 4 - BIM Module, Selecting Most Suitable Option:** the objective of this BIM module is to present to the top designer, different designs options and the values of their cost and carbon emissions. Each design will have different combinations of materials. The designer can visualize the different options of total cost and carbon emissions. The selected option is typically the preferred design. However, in order to enable the designer understand the effect of different contributing weights on the supplier criteria, five scenarios were developed. Each scenario represents different weight criterions assigned to each of the supplier selection criteria. In this stage, the lead designer can vary the weights assigned to each criterion depending on the objectives of the design.

   After the harmony search optimization, the designer can select from multiple options of total cost and carbon emissions.

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Download a proposal of harmony search model for material and product selection

3.2 Training on Energy Efficiency

A lot of the time, when architecture and engineering firms talk about BIM training, they're thinking about training their experts—people who use BIM programs day in and day out, who need to keep their skills sharp and stay on the cutting edge of technological developments. Engineers, architects, and project managers need BIM skills, too, to be able to communicate effectively with the rest of the design team and to step up to help meet deadlines in a crunch. However, because of you can't expect the same training for BIM specialists and the casual user, here are eight BIM training tips for designing a program to get everybody in your office up to speed.

- Set well-defined goals. Any successful program has to have well-defined goals: total expertise or only a basic understanding (so the designers can hold their own in client meetings) or moderate proficiency (so your designers can comfortably navigate a model and do basic modeling and annotation).
- Choose your topics wisely. One of the hardest challenges to deal with is that there is a lot of ground to cover and company have not much time to spend topics especially relevant for project managers such as contracts, deliverables, and BIM-execution plans. The company needs to decide which are the critical topics and which can be covered in passing, with an invitation to learn more in follow-up sessions.
- Plan your schedule: it is necessary to decide when to hold training sessions, for how long and of which type (courses, e-learning courses, workshop, meeting with round table...).
- Remember that an entire series of straight-up lectures probably won't have the wanted effect (people need more involvement to do their best learning). Therefore, it is advised to mix lectures, discussions and hands-on sessions and labs to give to designers practical experience with BIM programs.
- Get Everyone Involved: Invite Class Participation. Inviting your class to provide input on curriculum content, engaging individuals during group discussions, and encouraging everyone to ask questions will give them a sense of ownership of the training and increase its effectiveness. It also helps to remind people why they're here.
- Plan for some participants to have prior knowledge. It's likely that there will be people in training sessions coming from a variety of starting points. It could be best to divide up experts and non-experts so the first one isn't bored. If it needs to train everybody together, it's possible to tailor the agenda to accommodate them, but it will probably need to acknowledge to your power users that some topics may be review for them. It is possible to use power users as assistants, to help other people with less experience.
- Make the program on-demand. Putting together a BIM training program involves a lot of up-front work, but fortunately that effort quickly pays off: once you have a material set up, repeating it is easy. For larger offices, it will likely make sense to split up into groups to keep the size of the classes manageable and even if it is necessary only one group, at least one person will have a standing meeting that conflicts with training sessions. By making BIM training a continuing effort, it is possible to maximize the opportunity for all designers to attend.

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- Promote continuing education because without constant exposure, skills can atrophy. The same goes for BIM (like for a foreign language): if you don't speak it for a while, you start to lose your vocabulary and fluency.
- After the formal BIM training is over, keep even casual users engaged by encouraging them to attend in-house user-group meetings. Keep the agenda well-balanced between basic and advanced topics and make it worth their while to be there. If there's a local user group in the area, encourage them to attend those events as well.

Providing BIM training for designers and project managers isn't a trivial undertaking, but with planning and effort, you can help your entire office understand the benefits of BIM.

For the technicians is important to organize at least one hands-on session by letting the user to navigate a model, simulate a maintenance task and upgrading the information into the model. The session should follow the proficiency test on a basic course on BIM related to the common language and the use of BIM for maintenance, to be used by any expert as well as non-expert user.

3.3 The identification and collaboration among stakeholders

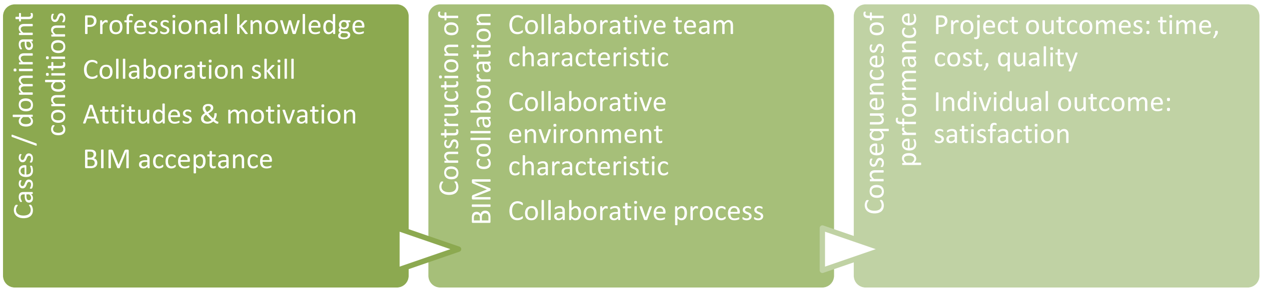
BIM is a collaborative approach to construction that involves integrating the various disciplines to build a structure in a virtual and visual environment. The essence of BIM implementation is collaborative working process in construction work. Therefore, project participants could generate the maximum benefit of collaborative arrangements increasing efficiency and effectiveness. The process allows project team to work effectively, particularly when identifying potential problems before they start to build on site. Maintenance service companies could be involved to review the design and verify the respect of maintenance requirements (accessibility to the HVAC plants, for instance).

The BIM serves as a collaborative platform for all stakeholders to share their knowledge resource and information. Sufficient information increases communication effectiveness. Effective communication allows stakeholders to exchange accurate, update and clarified information for decision makers to form a reliable decision. Being that, BIM is a shared digital representation founded on open standards for interoperability it demands collaboration in order to unleash the utility of BIM implementation and maximize stakeholders' return on investment. It is important to know that BIM project requires a specific process of activities, which involves high level of transactions on data, information and knowledge. A successful BIM project highly relies on effective collaboration among project participants including owners and maintenance services companies.

BIM becomes one way to cope with the cooperation, integration and coordination challenges faced in construction. Many study recommend construction industry to move toward Integrated Project Delivery (IPD), but few identify that IPD as the ultimate objective of construction project delivery method strongly demands closer collaboration and more effective communication. BIM has been proved that enhance collaboration and information sharing comparing those traditional construction processes. BIM is linked to higher level of efficiency in terms of communication and collaboration and a multi-disciplinary collaboration can be achieved through optimal use of BIM, but changing roles of key parties, new contractual relationships and re-engineered processes challenges need to be overcome.

Further, studies identify that coordination defects are the second largest negative impact to project performance after software issue in 35 construction BIM enabled projects. Collaboration issue cannot be demonstrated by any single contract theory or economic theory. Few studies expose the complexities of collaboration in BIM implementation. All the project participants need to be aligned with self-interest, mother company's requirement and project objective. So, this is not an issue of individual collaboration in a team or an organizational collaboration issue in a joint venture. Collaborative process is one of the key factors for BIM to be successful. The full potential of BIM can be realized by considering knowledge, technology and relationship. Many researches focus on the discussion of BIM technology. Few research address the importance of collaborative process of BIM implementation.

Based collaboration framework, the model below suggests that each of the determinants of BIM collaboration has sub-categorized factors.



First, four preconditions of collaborative team characteristics are identified, they are professional knowledge, collaboration skill, attitudes and motivation and BIM acceptance. The most important features of professional knowledge in BIM project appear to be their professional experience and the understanding knowledge of BIM (BIM acceptance). Organizations change their approach to collaboration according their experiences with past partners. Complementarity of professional knowledge contribution across disciplines assure the proceeding of construction project and inter-organizational collaboration. Their BIM acceptance is the perception how they contribute to the utilization of BIM and motivate to collaborate with other professionals within BIM context. Collaboration skill refers to experience of collaboration with others and individual social skills with other team members in a project organization. When project adopts innovative technology such as BIM and use this technology, adoption triggers new challenges of organization including structures and power relations. BIM acceptance is important that participants have mutual perception of BIM implementation in a project. To what extend participant's BIM acceptance can influence the effectiveness of BIM collaboration. Attitudes and motivation appear to be individual intestate in learning BIM and incentive of using BIM. Regarding attitudes, trust is found to be the most important determinants paired with mutual respect and common understanding that determine the appropriate team members. Little attention given to cultural issues, cultural differences do exist but it doesn't impact the formation of collaborative project organization. Because Hong Kong, as an international city, has a well-developed history and achieves certain norm among professionals no matter they are foreigners or new comers in construction industry. They all can find their role and interact with other team members in a brief period. In other words, the appropriate person, due to highly competitive and open market, can automatically fill the vacancy. So, professionals in construction industry work together as a temporary organization to deliver construction projects, they have enough experience to break the cultural barriers and build up a common agreement with each other. However, cultural issue may become important when dealing with other collaboration parties and industries. Second, actions of individuals may impact cooperative inter-organizational relationships.

Environmental conditions also influence the success of inter-organizational collaboration. Few scholars identify the importance of collaboration environment characteristics, despite a collaborative context is more likely to success. In a framework of inter-organizational collaboration, organizations create macro-environmental forces and organizational forces impact the extent of collaboration achieved. The degree of institutional support that individuals receive from their home institutions can determine their willingness to contribute with their time and resources to the project.

In BIM enabled projects, BIM maturity varies from projects and organizations. Sometimes, BIM maturity is also constrained by technology itself. Contract strategy is an important moderating variable in BIM collaboration. This will directly lead the success of BIM implementation as a whole. Practically, we find people adopt BIM under traditional procurement strategy such as design-bid-build which eliminate BIM as a visualization tool at earlier tendering stage. Some other cases we encountered that adversarial contract bind the motivation of individuals to collaborate with other company representatives due to economic consideration and provide minimum contribution according contract responsibility. However, the situation changes significantly in a relational contract environment. Professionals work together as a team and more willing to communicate and solve problem together and creatively. Therefore, we investigated specific contract strategy as a contextual characteristic for our research. Last, an operational platform with appropriate technology is likely to facilitate professionals to communicate and collaborate.

Another process model of collaboration: problem setting, direction setting and structuring. In this model, specific goals are set, clear roles and tasks are assigned to participants. Collaboration can be enhanced in this sustainable long-term activity, identifying the importance of process development in an inter-organizational collaboration. Furthermore, this process is dynamic and evolving over time. BIM collaboration is mainly utilized through its process. These results high demand of software interoperability and clear role and responsibility for each party. Although it is difficult, inter-organizational collaboration depends on specific input and effort contributed by individual members to have a mutual understanding of roles and responsibilities in different organizations. There is a link between communication and collaborative working and, based on these two sub-conditions, process could be fluently developed through a well communication context.

Both formal and informal communications are crucial to the success of project delivery, demonstrating a framework of collaboration model: collaborative decision making involve both formal structured judgment and informal alternative exploration. Decision-making strongly relies on collaborative process and experience of participants and it can increase the individual satisfaction and commitment. Being that uncertainty and conflicts emerge in construction process, decision-making in collaborative process is important. When project has prominent levels of collaborative relationship and participants are willing to share information and communicate, conflict decreases.

BIM execution plan (BEP) is reported as a priority before BIM implementation; a well-defined BEP can assure the compliance of project objectives and requests, can reduce the uncertainty and clarify the role and responsibility in most of BIM enabled projects. Further, BEP is identified as the key to the information management because it sets out protocols for interoperability, project delivery milestones, dimensional accuracy and other details. BEP specifies roles and responsibilities for team members and makes BIM collaboration successful. It is clear that there are correlated relationships between BEP and BIM collaboration success. In terms of consequence of collaboration there is a relationship among overall project performance, inter-organizational teamwork and participants' job satisfaction.

Many researchers measure time, cost and quality as the measurements of project performance and they test different degrees of collaborative working relative to project performance and identify that higher level of collaborative working is more likely to produce higher levels of project performance. Other researchers also address that working relationships have positive impact on project performance in terms of project time cost and quality. This research conceptualizes the formalization of how to collaboration in BIM enabled projects. If participants are able to collaborate through construction project, they can perform more productively and project is more successful. In certain way, company will transmit those benefits to individual benefit such as incentives and more investments in technology and training. This demonstrates us how it can align individual satisfaction to the project success.

4. Module 4 – Use BIM technology

4.1 Sustainable construction sector

Construction activities and buildings have negative impacts on the environment because of the land use, the consumption of raw materials, water, the production of energy and waste and the consequent air emissions. Globally buildings are responsible for:

- 40 % of annual energy consumption;
- Extracted materials and minerals quarries 30 %;
- 30 % - 40 % of CO_2 emissions. Households and services are the first emitter of CO_2 emissions in EU-15 if the electricity is included in final sectors.;
- 12% of consumption of water;
- RC& D: 40 % total waste produced (92% demolition and 8% construction);
- 42% energy consumption - heating and lighting of buildings accounts for the largest single share of energy use (which 70% is for heating);
- 22% construction and demolition waste (by weight);
- 35% greenhouse gas emissions;
- 50% extracted materials (by weight);
- Buildings occupy 10% of the space.

Currently 80% of the European population live in urban areas and people spend more of 90% of their lives within the built environment (considering the home, workplace, school and leisure time). This environment, therefore construction activities, largely affects the wellbeing and comfort of the people and buildings also have impacts in human health.

The Sustainable Development is operated during the whole life cycle of the building and should:

- ✓ Reduce consumption of resources (save water and energy);
- ✓ Reuse of resources during the refurbishment or disposal of existing buildings or use of recyclable resources of new buildings. The wrong environmental management of the site encourages the generation of waste that could have been avoided;
- ✓ Eliminate toxics and ensure the healthiness of buildings, applying nature protection (climate change mitigation, biodiversity, ecosystem services);
- ✓ Put emphasis on the quality of the buildings, maximising the durability because, in general, it is more sustainable renovate existing buildings than to demolish and build new;
- ✓ Use eco-efficient materials (without processing) and local materials;
- ✓ Increase the comfort of life (increase the quality of outdoor areas and indoor air).

It is widely known that the construction sector is a key sector for achieving sustainable development. Because of that, systems for description, quantification, assessment and certification of sustainable buildings have been developed at international level and in Europe. CEN/TC350 "Sustainability of Construction Works" – has the task to establish the European set of rules for sustainability of construction works.

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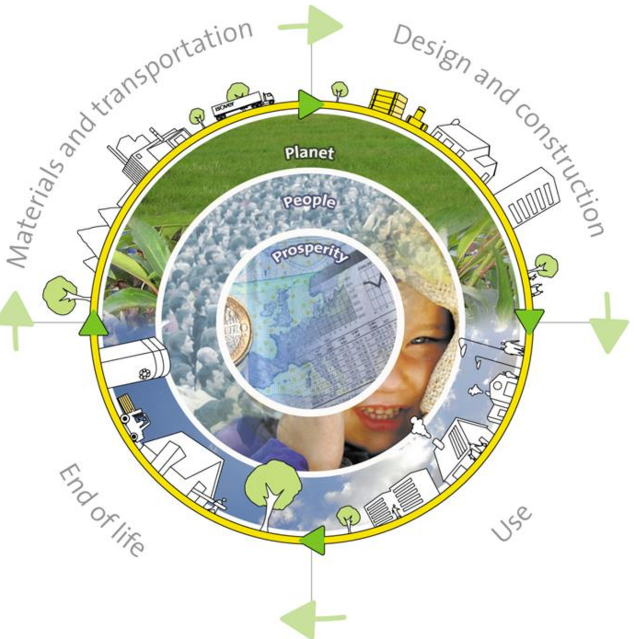
The choice of a building technique, component and construction material is generally based on criteria such as functionality, technical performance, architectural esthetics, economic costs, durability and maintenance. Nevertheless, this choice doesn't have into account the impacts of environment and human healthy. Build sustainably ensure that the social, economic and environmental aspects were taken into account throughout a building's life-cycle: from extraction of raw materials to design, construction, use, maintenance, renovation and demolition.



Refurbishment a housing inevitably leads to the generation of waste due to the demolition work and the construction itself; however, three major guidelines should be used to limit the quantity of waste taken to the landfill or incinerated:

- Prevention - limiting construction waste insofar as possible during the works and with regard to the future transformation or demolition of the building;
- Promoting recycling and reuse of demolition waste by sorting the waste on the construction site;
- When recycling is not possible, eliminating in two means: incineration with recovery of energy and taking the waste to the landfill.

Actions to be taken to limit the impacts on the environment and human health during construction and demolition waste are listed below:

- ✓ Prefer work with standard dimensions and prefabricated components in the construction process;
- ✓ Prefer mechanical fastening systems (using screws and nails) easy to disassemble and sort, and with a high rate of recycling – avoid fastening systems using glue, cement, welding, and other adhesives;
- ✓ Exclude materials or products from construction generating dangerous waste;
- ✓ Consider the re-use of certain in situ materials, without preliminary treatment;
- ✓ Carefully assess the quantity of waste produced on the construction site (construction and disassembly) per type of materials used, and the quantity of waste produced for the duration of the construction site.

The people who are most exposed to substances and emissions of these substances are:

- Workers producing the construction materials
- Workers using the construction materials
- Users of the building
- Workers doing demolition

The primary emissions from materials are high immediately after manufacture, they drop by 60 to 70% in the first six months and by and large disappear entirely one year after they have been incorporated or used (like biocides, fungicides, certain solvents, volatile organic compounds and certain additives). The secondary emissions can persist and even increase over time.

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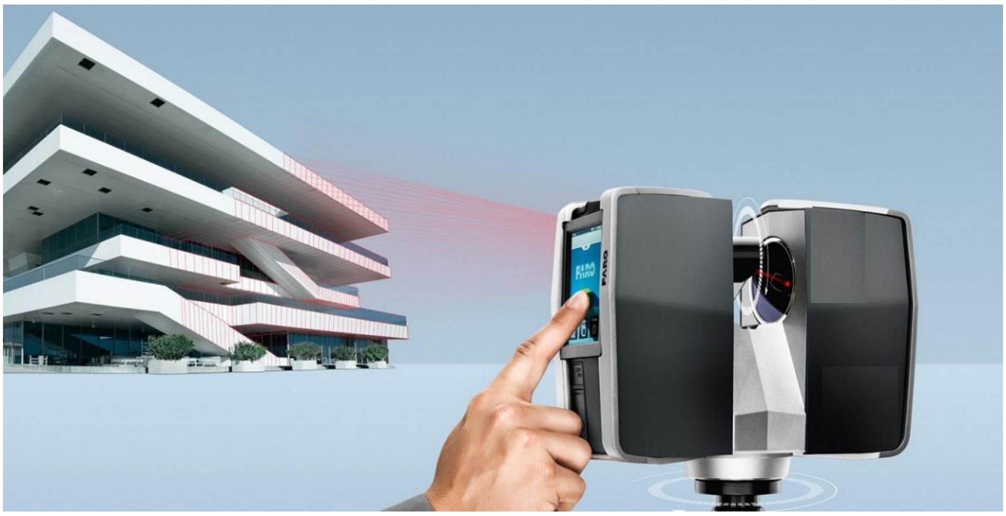
For an efficient use of the building it needs to build new nZEBs and refurbish existing buildings as "**passive houses**" improving thermal insulation, minimizing thermal bridges, improving airtightness, using excellent quality windows, ventilating with efficient heat recovery and efficient heat generation and using of renewable energy sources. The integration of sustainable development concept into housing and architecture in general is called **Sustainable Construction**.

The technicians should have a transversal knowledge of all the techniques to improve energy performance of a building in order to suggest the best solution when involved in refurbishment works.

4.3 Laser scanning technology

The application of laser scanning technology has been popular in the geospatial and survey industries for many years. However, recent advances in hardware technology and building information modeling (BIM) are helping to usher in a new level of scanning utilization for the building construction industry. Scanning for building construction is being applied most often to existing structures but is also seeing an advent of applications relating to new construction work. Scanning technology is becoming a critical function necessary to complete the integrated BIM cycle and provides a clear value-add for the integrated BIM workflow.



To understand how scanning technology can be applied to the integrated BIM workflow we must first take a moment to understand what laser scanning is and what basic functions it intends to serve. At the highest level, scanners are used to send out a high density of laser beams for the purpose of positional measurement. Laser beams project outward from the scanning hardware and are measured in time of flight or phase shifts as they return to the source. The hardware measures the return time of the laser and can tell how far away a physical element is. Current scanning technology has the ability to send out thousands of beams per second, resulting in a "point cloud" of data. Scanners can also identify the R,G,B color value for a more intuitive display of point cloud information. Resulting point clouds can include millions, even billions, of data that reflect the physical environment being scanned.

Point clouds resulting from scan data are immensely powerful for analysis on their own; however, the point clouds need to be converted to object-based BIM models. Converting scan data into BIM models is traditionally a three-step process:

1. First, multiple scans are captured from different scanning stations.

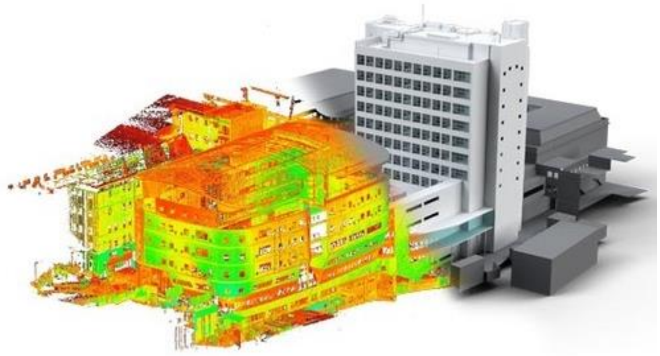
2. Second, data from multiple scanning stations is stitched together in what is commonly known as the post processing or registration stage.
3. Next, CAD or BIM software can be used to author object models while referencing the point cloud.

Some registration software has the capability to create content from within the point cloud by running algorithms across the data points and recognizing surfaces from it. Creating objects within the registration software offers the benefit of rapid creation but has some limitations surrounding the accuracy and metadata acceptance of modeled objects. Creation of object models using external authoring applications is slower and more manual but has the benefit of detailed object representation and increased metadata acceptance.

Scanning can be a time-consuming endeavor, resulting in very large and/or complex datasets, so it is recommended that any team wanting to apply scanning technology plan their effort very carefully. First, the desired outcome of the scanning application should be clearly identified. In many cases the desired outcome is to identify precise locational (X, Y, Z coordinate information) about physical work in place. Next, a team must consider what they will do with the knowledge that comes from the work in place information. For example, 3D information is often used in design validation. Further, element information can be leveraged to extract 4D time information and 5D cost information. Last but certainly not least; objects can be further populated with 6D facility management information.

A scan plan should be made after the project objectives have been clarified. A scan plan is a set of information that outlines the scope and approach that will be taken to capture the data on-site. Often, a scan plan starts with detailed analysis of precisely which elements need to be captured. If using scanning for new work most scanners will capture the position of each element that will be geo-referenced. In the case of renovation work, scanners will often have the specific objective to gather more information. Identifying the exact scope of elements to be scanned helps the on-site team to prioritize their efforts and mitigate time spent capturing unnecessary elements. With a clear scope in mind a document can be created that identifies the optimum equipment location necessary to capture the desired information.

At the same time, knowing which elements to capture, scanners can be set to gather the precise level of detail at which the information is needed. Many projects will recognize that there is only a significant need to capture elements of a certain size, such as 2° and above. Attempting to capture smaller elements is often impractical and unnecessary. With these tolerances in mind the scanning hardware can be dialed in to precise operational settings to regulate the fidelity of the laser beams, which is known as the resolution and quality settings.



The resolution of a scanner can reach half millimeter, which, for geometrical values, has a much higher resolution than any traditional metering system.

During the scanning process a series of targets will be used to assist in the post processing effort. Targets for scanning can be paper-based hatching patterns that are placed onto a flat surface or spherical objects that can be set onto a surface. The intent of targets is to provide a minimum of three common points of reference across scanning locations so that each reference can be joined with its previous scan presence. Increasing the number of common targets increases the accuracy of the final registered scan. Failing to have enough targets can greatly hinder the post processing effort and will result in a low-quality registration. Further, failing to have enough targets may require additional site visits and cost. Proper target placement is fundamental for successful scanning!

In order to know the dimension of a wall, for instance, the scanning will be performed both inside and outside the building. Each point will have precise Cartesian coordinates and merging the internal and external scanning the dimension of the wall will be defined within one millimeter.

Once on-site scanning is complete, and the multiple scans have been registered together, the object model creation process begins. Again, object creation can occur in the registration software or in external modeling applications. The choice of which tool to be used for modeling should depend upon the desired scope outcome. For detailed scopes, such as complex structures, specific authoring applications (less detailed scopes can be very quickly represented using simple authoring applications). Using external authoring applications requires a methodical approach to model creation whereby elements are created systematically and in order of importance pertaining to the scope. Attempting to recreate every single element in a single area can lead to loss of focus and failure to meet the broader objective. In many projects the structures are modeled first; while architectural features are modeled second, and finally mechanical systems. In the case of renovation work, modelers will be well advised to include some kind of "existing to remain" delineation so that those model elements can be viewed separately throughout the BIM use cycle.

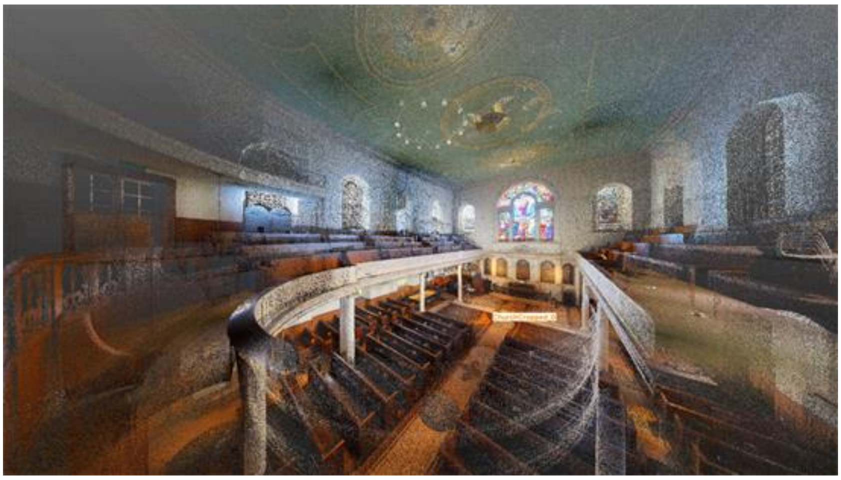
Of special importance for design validation efforts is the support of the coordination process. Oftentimes renovation projects include a mixture of existing to remain elements with newly placed elements. The scan and model data is capable of providing detailed information about points of connection that may exist between these two work scopes. Having exact points of connection between the two work scopes allows for a more accurate coordination process.

Stemming from accurate coordination is the ability to prefabricate. Many project subcontractors are very sophisticated in their ability to create physical work assemblies in off-site locations and then bring them on-site in large clusters for rapid installation. Prefabrication offers many benefits, including safer working conditions, controlled environments, and automated machine usage. However, prefabrication can only be successful when used in conjunction with accurate information about the destination of the final installation, which laser scanning provides.

Having an accurate 3D representation of elements from scanned data allows for further use of the data when considering the 4D time aspect associated with each construction element. Specifically, the quantity and position of each element can be leveraged to create detailed location-based schedules. Location-based schedules have a significant advantage over traditional schedules in that in they use detailed quantity and position information to represent the true work volume and position to take place during construction. Location-based scheduling is a concept that further extends into the ability to perform production control on-site and make teams proactive when managing a project schedule. The combined pro-activeness of scanning information and production control is a key component to mitigating schedule delays on renovation projects.

Additional variances in schedule activities may be recognized when considering tasks such as connecting newly designed pipe systems to existing pipes. In the case of these tie-ins, it may be necessary to isolate, shut down, drain, and make safe the existing pipe system before a new connection can be made. Because pipe systems often stem from a central location or plant, the shutdown of a system for a new connection in one location can have a dramatic impact on downstream functionality of the pipe system. An additional challenge could exist when making these sorts of tie-in connections is the discovered that the existing to remain pipes are not of suitable quality and have to be replaced. Therefore, scanning and scheduling renovation work prior to commencement should offer the opportunity to put schedule buffers surrounding tasks that integrate new works with existing works.

The combination of scanning and scheduling has already demonstrated significant benefit in specific cases of phased renovations of occupied spaces, including renovations of healthcare and manufacturing facilities. Scanning of work allows for a macro view of the mechanical systems than is often not available when "poking around" in an occupied space before construction. The macro perspective of the system allows for a more insightful schedule plan, again because the system uptime and performance can be viewed as a whole and then accurately delineated into the individual work spaces using the location-based methodology of scheduling. Using integrated software for these purposes also allows the planner the ability to produce schedule simulations. Schedule simulations are a great way of communicating to owners how construction work will impact their facility. This offers significant value to building operators who must accommodate for shut downs by maintaining new paths of travel across the facility, or new locations for production equipment uptime.



Scanning of work before construction has also proven to be a value-add as the quantifiable information coming from 3D elements allows for more detailed cost planning, or 5D as it is called. Scanning of work produces the 3D models and allows for the accurate delineation of cost assemblies associated with new and existing work. Cost components relating to the two different phases of construction may include different unit rates, different crews and different cost buffers in order to arrive at a more accurate project estimate. Similar to the duct example above, different work activities will be performed on new vs. existing to remain scopes and so will have different unit rates tied to the quantity of work. A unique line item for the cleaning of duct would be necessary for existing to remain elements, yet there need not be a cost line item for the placement of hangers and sealing of such duct work. It could also be recognized that the production rate, which is ultimately multiplied by the unit cost, for insulating new vs. existing duct may be different because existing ducts can be more challenging to access and so will have lower productivity.

Savvy contractors have also found a way to be more precise when applying cost buffers to renovation work after scanning. All contractors recognize that there are many unknowns when doing renovation work and so put a buffer on the project cost to account for the unknown. Scanning and modeling the work before execution allows for the cost buffers to be tied to the actual quantity of work which is existing and/or new, and so may have a less dramatic impact on the overall estimate. Accurate vs. broad cost buffers tied to an estimate can be the difference between being awarded a project and losing a project.

A clear benefit to laser scanning can be identified when considering the final deliverables that will go to the owner at the end of a project. Owners are responsible for operating the facility throughout its lifecycle and so are very interested in having as much detail as possible about the as-built condition of the building. Laser scanning can be applied at various stages of work commencement to measure the final position of work installed. Final element position can then be cross-checked with the BIM to ensure that the handover model truly reflects the installed position. Understanding the installed position of elements from the model allows facilities operators to be much more calculated when addressing problems because investigation can be performed from within the facilities office, rather than up a ladder in an occupied space.

Scanning at the end of work phases may sometimes require multiple scans due to the limitations of site that occur as systems become layered atop one another. This can present some unique challenges to the team managing the data and creating the BIM, however cases such as this present the optimum need for data capture and handover to the facilities team. Consider that if multiple scans are needed to capture and reflect element positions there is likely to be a scenario where facilities managers would be required to get “up into a space” to investigate problematic equipment that is located above other elements. This can be very unsafe, as there is rarely proper support up inside mechanical spaces for a human to navigate and rest upon when performing maintenance. Using a BIM model to investigate the space beforehand allows the maintenance personnel to be more tactful when planning their approach to the physical space and problem correction.

Several sophisticated owners have also opted to use laser scanning for the purpose of creating a facilities BIM model even when construction operations are not ongoing. This is because the sophistication of facility management software allows for a more proactive building management plan instead of the traditional reactive approach. Being proactive when managing the building offsets the cost of scanning because maintenance is done in a pragmatic manner beforehand and is significantly more cost efficient than emergency responses that include downtime.

Similarly, scanning may be performed on buildings that are not under construction for the purpose of capturing and maintaining historically significant features. It may be the case that a facility does not immediately have the funding to repair decaying features but can capture their condition before things get any worse. In this case, the scans can be retained and provided to the repairing contractor when funds are available for fixes, and the contractor has the ability to reference the scan data prior to fixes being made.

The implementation of laser scanning brings an entirely new realm of possibilities to an already powerful integrated BIM workflow. The ability to capture detailed information about elements in their physical space allows for more precise use of data. Whether capturing 3D information for coordination and prefabrication, or leveraging the quantity information for estimating and scheduling, laser scanning is surely a necessary endeavor to increase the accuracy of project information. Decreasing hardware costs and increased software capabilities have made scanning a competitive advantage for contractors willing to invest the time and effort into this fully integrated BIM workflow.

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5. Module 5 – Analyse the BIM Model

5.1 Simulation techniques and energy and lighting analysis

It is very important to define the requirements for energy performances since the design phase for both new and existing buildings and to identify the data need for the correct simulation of the energy performance.

For any building the use for the different "zones" need to be identified to establish the foreseen temperature, the number of air exchange, etc. besides the thermal transmittance of each wall, ceiling, pavement, window, door, etc. need to be known. The more these data are reliable the better will be the simulation. Especially in the case of existing building, it is very important to know the habit of the tenants so that the simulation can be performed in the correct way.

In order to have an accurate energy analysis of the building, a 3D geometric model created is converted into an analytical model. First, it is needed to convert all the spaces into rooms. In the BIM tool, rooms are considered to be the equivalent of zones that need to be defined. A thermal zone is a completely enclosed space bounded by its floors, walls and roof and is the basic unit for which the heat loads are calculated. The extent of a "room" is defined by its bounding elements such as walls, floors and roofs. Once a "room" is defined for the purpose of analysing the building's energy, these bounding elements are converted to 2D surfaces representing their actual geometry. However, overhangs and balconies, which do not have a room, are considered as shading surfaces. In order to determine whether a room is an interior or an exterior one it is important to define its adjacent in the analytical model. By using the developed plug-in that is loaded in the BIM tool, designers will directly transfer the created model of the building to the energy simulation and analysis tool using both the gbXML and IFC formats.

In order to test what type of data was included in each of those file formats, a careful comparison will be necessary. The created case building model is tested for building materials, thickness, geometry (area and volume), building services, location, and building type. All the input variables are kept constant in the base case while the testing is done with one alteration at a time.

The platform provides a suitable environment to establish a Decision Support System (DSS) to help the design team decide on the selection of the best type of sustainable building components and families for proposed projects based on defined criteria (i.e. Energy consumption, Environmental impacts and Economic properties) in an attempt to identify the influence of the design variations on the sustainable performance of the whole building. The final design will be influenced by the results of the energy and lighting analysis, the LCA and Environmental Impact and embodied energy results, and the sustainability evaluation of every building component based on the LEED rating system, as well as the initial costs of these components. The LEED (Leadership in Energy and Environmental Design) is one of the most popular green building certification programs used worldwide. Developed by the non-profit U.S. Green Building Council (USGBC) it includes a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods that aims to help building owners and operators be environmentally responsible and use resources efficiently.

- **Energy Models**: These building information-modelling models deal with all the big questions. You'll often use an energy model at the earliest stages of your analysis. The energy model helps you to interpret the basic information. You'll figure out what you need to know about your structure's form and orientation at this stage.

Often, you'll only use basic geometry to build your models. More realistic and defined specifications come with later energy models.

- **Lighting Models**: These are all about the presentation because the lighting model handles the visual aspect. They tend to contain much more detail than energy models. You'll touch up your geometry and use this model to define the properties of your materials. This is the model that helps you to figure out exactly what you need, as well as how everything should fit together. Generally, your finished lighting model is similar to the one you'll present to clients.

When imported into the energy simulation tool, the model would assume the default values for the location given when creating the digital model. In order to discern that the information related to the selected material used in the model has been completely transmitted over to the energy simulation and analysis tools, a new material could be assigned to the 3D model of the building.

The basic requirements for lighting analysis and design are highlighted in the box below:

- Spatial geometry;
- Surface reflectance;
- Luminaire photometry and associated factors;
- Luminaire position and aiming.

The newest feature is the ability to calculate light levels in a space from the sunlight and skylight at a given day and time. All-Weather Sky method, uses historical weather data to better approximate the sky conditions for the selected day and time.

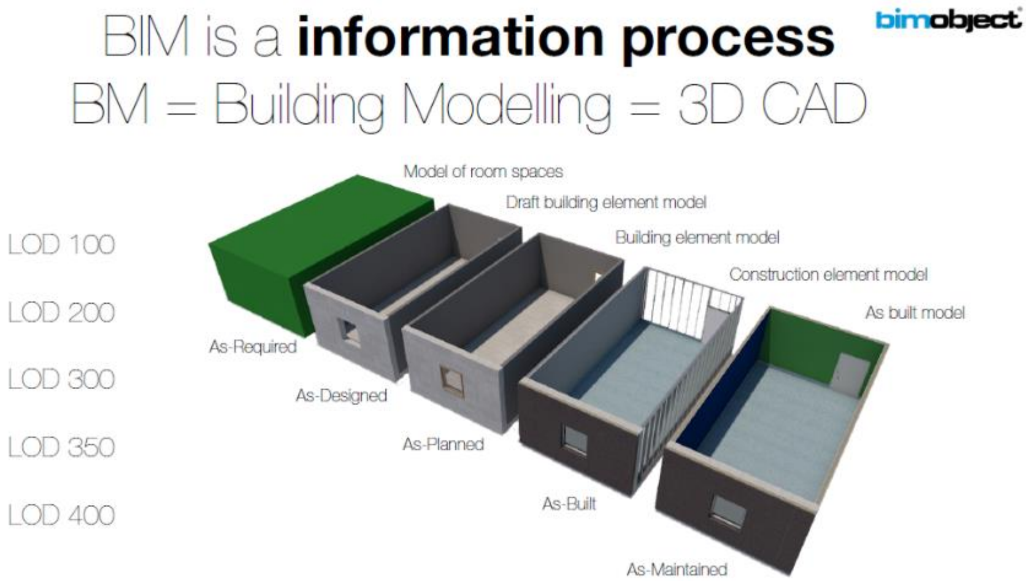
5.2 BIM for handover and maintenance

Design and construction teams are typically contracted to deliver a structured information handover package to support a client's asset operations and maintenance at a project's end. However, not often this handover information is checked for completeness, accuracy and appropriateness at the point of receipt. This goes some way to explaining why asset owners and facilities managers can often struggle to ensure an asset delivers against its expectations (cost or scope) in the early years. So, there's a case to be made that facilities managers can be more upfront to clarify all preferences and expectations of the information they need on day one. BIM and a collaborative approach to building design, construction and handover can play a crucial role in taking us even further along the path towards better executed built assets and less headaches for all.

When they are handed the keys at the end of a construction project, what a facilities manager (FM) will be typically given is a box, be it virtual or physical, filled with information and data. That box should contain explanations on building maintenance, equipment warranties, security operating instructions and asset lists among other things. This information may be in all kinds of formats, including paper and digital media like CDs and USB keys.

A diffuse use of the so-called "BIM object" will facilitate the handover. A BIM object is an element of the building both belonging to the structure and to the Heating, Ventilation and Air Conditioning (HVAC) plants and can even include piece of furniture and domestic appliances. The BIM object can contain any information like geometry, connection to the plants, instruction for maintenance, warranties, etc. Many producers are now converting their traditional catalogues into BIM objects catalogues so that designers can just take the object and insert into the model. The "plug and play" can be done with different "Level Of Definition" (LOD) in the different phases of the life cycle of the building.

During the preliminary design phase, for instance, only the geometry is needed while for the technical design all the information about connections to central plants would be provided and finally, during the handover and close out, any other information will be provided. In the picture an example of different LOD for the same object.



To complicate matters further, vital building-related information risks being lost during the handover of that box. When the facilities manager notices that there is information missing, they will need to spend unwanted time tracking down historical project information. This is a waste of efforts, not least because of the labor involved. The information that is resurrected after the ordeal often might be inaccurate or incomplete. In the worst-case scenario, that data can't be recovered and the FM then must undertake a fresh survey of the building or part to capture its as-built condition. The result of this is a cost paid twice over by the building owner for a survey (and for the maintenance contractor), which should only have to happen once.

On the other hand, assume that every piece of data handed-over was proper, complete and future friendly. Not only that, but it was relevant with all immaterial information either filtered out already or organized so that it could be easily sorted and made usable for the next twenty years. Then, the information could contribute to the improved ongoing operation of the building, not just now, but for years after the handover.

What's all of this got to do with building information modelling (BIM)? BIM allows information flow seamlessly from the start of a construction project all the way through to facilities management. It articulates to the client everything from floor plans and layouts to materials used, asset shelf-life and required maintenance schedules – essentially, it depicts what products are in the building, where they are, how they work, and how they all fit together. It relates objects in a model and links them to each other for the greater understanding of all parties involved in the design, construction, operations and ongoing upkeep of the structure.

What this means in the long term is enhanced predictability and the opportunity to take early steps towards proactive FM action; they can realize the full value of their asset over its useful life through cost-, sustainability- and time-effective operation and maintenance. With BIM, facility managers can visualize facilities being created, helping them to understand project intent. BIM lets them see into the future – it lets them see the effect individual design features will have in the immediate future, that very evening and in the days following.

BIM can also act as a bridge between different stages of the handover process. Where teams implement Common Data Environments, such as Aconex, workflows can be automated on a shared, neutral platform, whilst providing a comprehensive information resource accessible by interested parties and shared during or after the project. In this way, the risk of losing asset information created earlier on in the project is lessened. Accurate information should have been recorded, verified, and submitted in a timely fashion throughout the process, not just collected at the end.

It is common for FMs to be concerned that they haven't been involved in contributing to the design of the building and that this makes their job harder. What BIM will mean for them is working not harder, but smarter. New working practices encourage, through embracing BIM, a need to involve asset owners and facilities managers to understand the information they require on handover. It will mean bringing people together. Facilities managers do not have to know everything about CAD technology or 3D modelling – but they can still have an important say during design, can impact the result, and can ensure the information handed over by the contractor fits their specific needs.

How do we achieve this collaborative way of working? By encouraging open conversation between all disciplines. The direction of travel in the industry will eventually lead to a point where facilities management experts can help and educate others within the design and construction stages on the long-term benefits of using BIM to aid the asset lifecycle. A specific role comes to the open BIM formats like IFC (Industry Foundation Classes). It's an international data standard for BIM which allows communication between parties during the project, irrespective of the software platforms they use, and makes sure that the data can still be read in ten years and more. It creates rules and foundations for collaboration to ensure that everybody is speaking the same language.

Without sophisticated digital handover tools, contractors are scrambling to retrospectively gather project information at practical completion to deliver to the owner, or risk penalties or late payments. Even then much of this information is inaccurate and/or incomplete. BIM gives owners a multidimensional model of the as-built asset, but more importantly, the opportunity to develop a structured digital information source of the asset so that the design can be modified and approved while testing its constructability. In the future, the facilities manager has the opportunity to influence the quality of the information they receive, including a complete digital representation, and a geospatial view, with all relevant project and handover information detail included.

Education affords many things. In our line of work, it opens doors and windows so that clients are fully conscious of the data they will need to make their lives easier. With more meaningful insights added every day, digital twins will emerge as the digital replica of physical buildings. Harnessing that sort of cutting-edge technology can elevate facilities management to a new space.

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The present deliverable will be update during the project in order to align the outcome to the market needs as well as to other BIM related projects realized within Horizon 2020 program.

The updated version of the deliverable will be only available in the website of the project www.net-ubiep.eu.

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