NET UBIEP

Network for Using BIM to Increase the Energy Performance

INFORMATION MATERIAL

for Public Administration

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Co-funded by the Horizon 2020 programme of the European Union

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.

Public Administrations need to go through eight phases to achieve a good integration of BIM process in their authorization procedures.

The first step consists in a preparatory phase, where the Public Administration needs to rethink its own structure to manage the new authorization process. For example, in the Italian law DM 560/2017 these requirements are defined as:

- ✓ Training for the technical officers to be ready to the digitalization of the building sector
- ✓ Installing hardware to manage the digital process
- ✓ Defining and installing software needed to manage the digital authorization process
- ✓ Defining the procedures for the e-permit comprehensive of the extension and the size of the files to be managed

In this first phase it's also important to identify indicators which are also strictly related to the Regional/Local current policy instruments such as:

- Sustainable Energy Action Plan (SEAP) or Sustainable Energy and Climate Action Plan (SECAP)
- Thermal Plant cadaster
- Energy performance certification cadaster
- Green products comprehensive of energy carriers compulsory according to the green public procurement

The majority of Public Administration are not at all ready for this "digital revolution" and they need to acquire the right competences to put in place and manage the digital environment necessary for all the authorization necessary along the life of a building starting with the preliminary design and lasting till the end of life cycle of the building.

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The role of Public Administration

The Public Administration is the authority who disciplines, supervises and approves the main activities of the Building Life Cycle, controlling the respect of national regulatory and legislative requirements and supervising contracts between privates. If the commitment is public, the authority quantifies and identifies needs at the beginning and stipulates contracts with professionals and technicians after the public tender. In the end of the cycle it supervises recycling and disposal of the waste.

Focusing on the energy aspects, the Public Administration is the entity, which provides rules for NZEB both in the case of new buildings as well as for the refurbishment of the existing one. Regional and Local technical officers are responsible for controlling the respect of national regulatory and legislative requirements in the field of energy performances for the constructions and the materials used.

Preliminary phase

Tasks:

1. Develop a training plan for the technical officers at Regional and Local Level to use BIM for energy performance evaluation and control
2. Provide requirements for CDE (Common Data Environment) both software and hardware
3. To be aware of the objectives to be achieved and the project criteria to be respected
4. Provide energy performance requirements for e-permit both for public tender as well as for authorization procedures for privates
5. Provide the list of indicators necessary for SEAP (or SECAP) (Sustainable Energy and Climate Action Plan)

Strategic definition

Tasks:

1. Digitalize geo-referenced territorial maps, seismic maps, climatic maps
2. Provide SECAP (Sustainable Energy and Climate Action Plan) indicators lists
3. Identify the indicators that can be checked through code checking
4. Identify the requirements according to minimum environmental criteria to define the building sustainability (as energy and water consumption, …) during the life cycle of the building
5. Define the requirements for the CDE and eventually prepare a public tender for its implementation
6. Verify that the Project Information Model (PIM) meets the Employer's Information Requirements (EIRs)

Preparation and brief

Tasks:

1. Define the minimum energy performance indicators for Nearly Zero Energy Building (NZEB) to be introduced in EIRs for any building construction contract
2. Define the minimum energy performance requirements to be introduced in the EIRs for public tender related to public building
3. Define the compulsory maintenance delivery plan to ensure the foreseen energy performance of the building
4. Define the professional requirements for BIM and energy competences to properly work for NZEB
5. Define the requirements for supply chain data management for public tender
6. Review the preliminary BIM Execution Plan (BEP)

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7. Representation of informatic maturity level of the model according to predefined Level of Information / Level of Detail or Development (LOI/LOD) indicators

Concept design

Tasks:

1. Ensure that energy performance tasks are considered in the concept design
2. Review the BEP especially regarding the construction strategy to produce a NZEB or renewed buildings
3. Review the building service design to ensure the maximum energy performance
4. Consider post-occupancy and operational issues along with the consideration of buildability
5. Consider the presence of technologies like RES installations, building automation systems, HVAC systems, etc.
6. Ensure the presence of domotic systems, management and integrated control of systems (BACS - Building Automation and Control Systems)
7. Ensure the presence of devices for the reduction of water consumption
8. Ensuring the "dynamic" behavior of the building envelope, preferably adopting solutions with movable elements (shielding, sliding panels, etc.)
9. Representation of the level of information maturity of the models according to predefined LOD/LOI indicators for each model object in relation to the detail required by the definitive design

Developed and Technical design

Tasks:

1. Review the sustainability requirements for energy performance contained in the developed design
2. Review the handover strategy to ensure correct maintenance and operational instructions
3. Review the BEP, if changed
4. Review the project strategies in relation to the supply chain
5. Control the accomplishment of all the required regulation for NZEB or for the refurbishment of existing building
6. Verify that the continuity of insulation has been considered
7. Verify the existence of a non-technical guide for the energy performance control in a format that is readable for the end user
8. Verify the content of the sustainability impact assessment
9. Verify that all the requirements have been accomplished
10. Representation of the level of information maturity of the models according to predefined LOD/LOI indicators for each model object in relation to the detail required by the definitive design

Construction

Tasks:

1. Ensure that the information requirements are properly transferred to supplier
2. Ensure that all the information required for maintenance and use to maintain energy performance requirements are defined in the handover strategy
3. Ensure the storage of models for future routine and extraordinary maintenance

Handover and close out

Tasks:

1. Ensure that all the activities foreseen in the handover strategy are correctly performed
2. Ensure that a fine-tuning of the building services is performed to ensure the best energy performance.
3. Ask for project review if necessary
4. Ensure the storage of models for future uses
5. Guarantee the handover of final model to the cadaster or to the owner

In use and recycling

Tasks:

1. Check the in-use energy performance
2. Ensure that the maintenance manual is provided
3. Ensure the continuous alignment of storage model with the real situation

Learning outcomes of Public Administration

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.

E-learning platforms are available in different languages at: http://www.net-ubiep.eu/e-learning/

Contents

0. Introductory Module – Basic BIM knowledge and skills

0.1 Introduction: what is BIM?

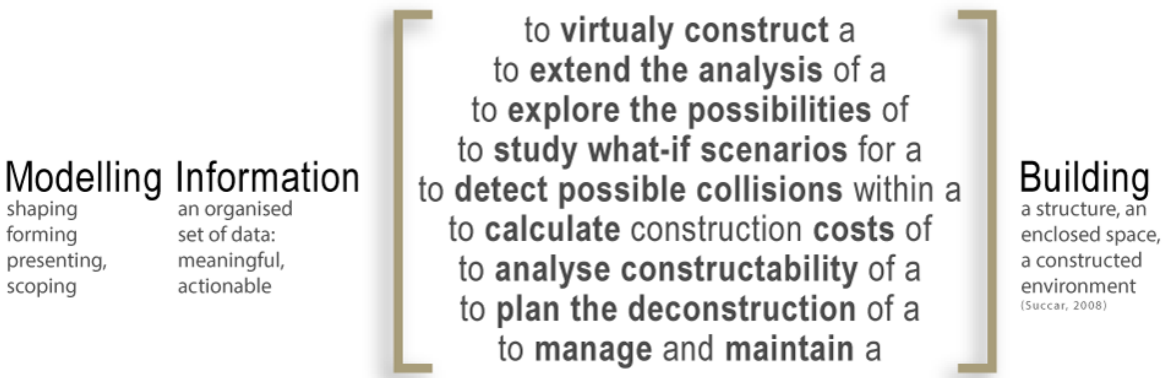
The boundaries of Building Information Modelling as a term-definition, set of technologies and group of processes is fast changing even before being widely adopted by the industry (https://www.bimthinkspace.com/2005/12/bim_episode_1_i.html). As a term, BIM seems to have somehow stabilized now but as 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 industry stakeholders (like designers, engineers, clients, construction companies, facility managers, governments...) BIM is 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:



Source: https://www.bimthinkspace.com/2005/12/bim_episode_1_i.html

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

(http://www.diccionariodelaconstruccion.com/en/search/planning-and-project-management)

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.

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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.

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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.

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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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N

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.

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.

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.

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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 (https://www.autodesk.com/redshift/building-information-modeling-top-11-benefits-of-bim/).

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 autosave 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. 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:** Another 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-throughs 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 the cloud, as with Autodesk BIM 360 Build software, 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 (https://www.bimthinkspace.com/2015/09/index.html), 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 .

SOURCE: https://www.bimthinkspace.com/2015/09/index.html

According to the defined glossary (Page 9), 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 8geographical Information System), PLM (Product Lifecycle Management) and ERP (Enterprise Resources Planning) - and help bridge the semantic gap between interdependent industries (e.g. Geospatial, Construction, and Manufacturing).

According to buildingSMART (https://www.bimthinkspace.com/), 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.

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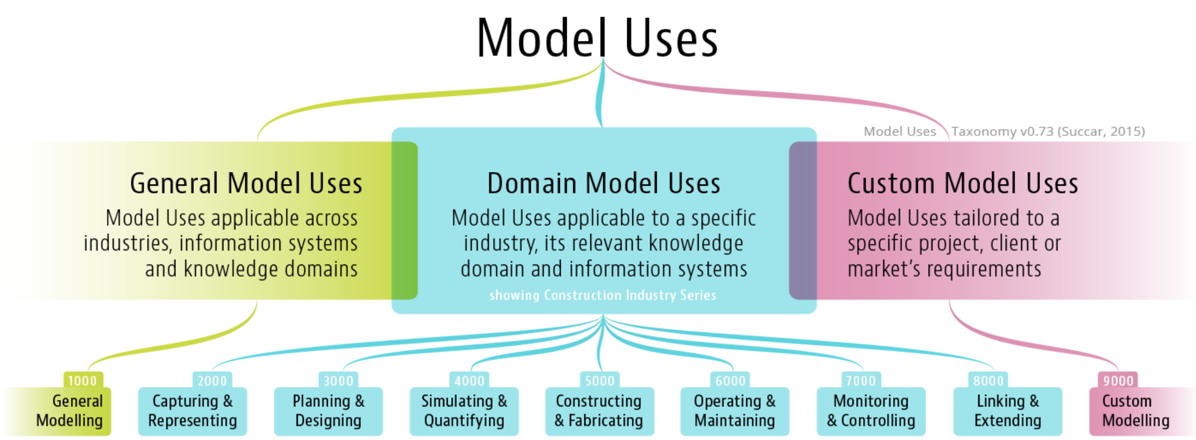
With respect to flexibility of use, and to allow the application of Model Uses across varied contexts, Model Use definitions must exclude unnecessary qualifications that vary from user to user, and from one market to another. To this end, Model Uses are defined independently from their user, industry,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



Source: https://www.bimthinkspace.com/2015/09/index.html

- ✓ 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" (https://www.graphisoft.com/ARCHICAD/open_bim/) 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.

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 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.

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.

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 15643-1: 2010 – 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).

EN 15643-2:2011 - 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;
- 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 15978:2011 - 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;

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- 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: 2014 – 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 - Environmental Product Declaration:

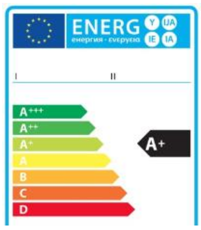
- provides the Product Category Rules (PCR) for developing Environmental Product Declaration (EPD);
- apply to any construction products and construction service;
- EPD is expressed in information modules, which allow easy organization and expression of data packages throughout the life cycle of the 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: 2011 – 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: 2010 - 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.



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.

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 devices (Computer, Tablet or Smartphone) from which it is possible to manage unambiguously and structured information for project management. The CDE allows to distribute information and create value for the whole chain of operators involved in the process facilitating collaboration among them (https://www.buildingincloud.net/en/cde-common-data-environment-strategic-bim-process-tool/).

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

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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 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 (dutch: isso iob : BIM protocol samenwerking = collaboration, bijlage = appendix) federated BIM models must also be guaranteed.

0.6 The BEP (BIM Execution Plan)

Publicly Available Specifications (PAS) are fast-track standards, specifications, codes of practice or guidelines developed by sponsoring organisations to meet an immediate market need following guidelines set out by BSI (British Standards Institution). Within 2 years they are reviewed to assess whether they should be revised, withdrawn, or become formal British Standards or international standards (https://www.designingbuildings.co.uk/wiki/PAS_1192-2).

PAS 1192-2:2013 is the Specification for information management for the capital/delivery phase of construction projects using building information modelling. It is sponsored by the Construction Industry Council (CIC) and published by The

British Standards Institution. It came into effect on 28 February 2013. It specifies the requirements for achieving building information modelling (BIM) Level 2.

PAS 1192-2:2013 proposes the creation of a BIM Execution Plan (BEP sometimes abbreviated as BxP) for managing delivery of the project:

1. A pre-contract BEP is prepared by prospective suppliers, setting out their proposed approach, capability, capacity and competence to meet the Employer's Information Requirements (EIR).

- PAS 1192-2:2013, proposes that the pre-contract BIM Execution Plan is a direct response to the **Employer's Information Requirements** (EIR). The EIR is a crucial document which sets out the information required by the employer aligned to key decision points or project stages. It may be considered to sit alongside the project brief. Whilst the project brief defines the nature of the built asset that the employer wishes to procure, the Employer's Information Requirements defines information about the built asset that the employer wishes to procure to ensure that the design is developed in accordance with their needs and that they are able to operate the completed development effectively and efficiently.
- The pre-contract BIM Execution Plan may include:
  - A Project Implementation Plan (PIP) setting out the capability, competence and experience of potential suppliers bidding for a project, along with quality documentation;
  - Goals for collaboration and information modelling;
  - Project milestones in line with the project programme;
  - Deliverable strategy.

2. A post-contract BEP: once the contract has been awarded, the successful supplier then submits a further BIM Execution Plan confirming the supply chain's capabilities and providing a **Master Information Delivery Plan** (MIDP). The MIDP is the primary plan setting out when project information is to be prepared, by whom, using what protocols and procedures, it is based on a series of individual Task Information Delivery Plans setting out responsibility for specific information tasks.
   The post contract-award BIM Execution Plan sets out how the information required in the Employer's Information Requirements will be provided:

   Management:
   - roles, responsibilities and authorities;
   - project milestones in line with the project programme;
   - deliverable strategy;
   - survey strategy;
   - existing legacy data use;
   - approval of information;
   - authorisation process.

   Planning and documentation:
   - revised project implementation plan (PIP) confirming the capability of the supply chain;
   - agreed processes for collaboration and modelling;
   - agreed matrix of responsibilities;
   - task Information Delivery Plan (TIDP) setting out responsibility for delivery of each supplier's information;
   - master Information Delivery Plan (MIDP) setting out when project information is to be prepared, by whom and using what protocols and procedures.

   Standard method and procedure:
   - volume strategy;
   - origin and orientation;
   - file naming convention;
   - layer naming convention;
   - construction tolerances;
   - drawing sheet templates;
   - annotation, dimensions, abbreviations and symbols;
   - attribute data.

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IT solutions:

- software versions;
- exchange formats;
- process and data management systems

Download free template of **post-contract** BEP produce by CPIC (Construction Project Information Committee).

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1. Module 1 – Diffuse BIM

1.1 Return of investments

The economic value of BIM technology is often weighed by measuring the ratio of return on investment, or ROI. Companies wishing to adopt BIM technology have always sought reliable factors for understanding how the technology and software transition will impact their company. After more than a decade of experience with BIM, the design and construction industry are now realizing BIM's value and financial impact. Calculating ROI has become a necessary evaluation step prior to many capital or labor-intensive business investments, such as BIM adoption. However, while some firms calculate a return-on-investment ratio to assess the economic benefits associated with process change, others find making this calculation too difficult or cumbersome (https://damassets.autodesk.net/content/dam/autodesk/www/solutions/pdf/Is-it-Time-for-BIM-Achieving-Strategic-ROI-in-Your-Firm%20_ebook_BIM_final_200.pdf).

The problem is that ROI analysis is often unable to represent intangible factors that are important to a project or a firm, such as avoided costs or improved safety. In addition, the systems and staffing required to measure and track ROI can be time-consuming and costly. Currently, no industry-standard method for BIM ROI calculation exists and many firms have not adopted any consistent measurement practices, although there is interest in doing so and belief in the potential value of ROI for BIM investment decision-making.

Defining the economic impact of BIM for the building design and construction industry is a challenge that has attracted significant academic research interest. This interest covers a breadth of inquiry into BIM ROI that spans the entire project lifecycle, examines various building types and considers varying levels of BIM experience while also looking at a range of calculation methods. There are three types of BIM investments:

1 Startup costs to ensure technology implementation is successful: although technology investment particularly in the startup phase is deemed a significant expense by over 50% of the survey respondents, it is considered unavoidable in the industry if the idea is to stay competitive and up to date. "BIM work requires more computing power and more networking power than traditional CAD work, and that power comes with a cost." Respondents cited direct labor expenses as the largest component of any project, whether it is a BIM or a traditional CAD project. "When we originally looked into BIM, we knew it was going to be a huge investment to train the staff, how to use it, and how to use it efficiently. There was going to be the whole ramp-up time, in which everyone would be slower than they were in CAD Architecture."
   - The costs of professional development, including initial training in the use of BIM products and further instruction in new work methods, must also be considered in the investment calculation.

2 Costs for tailoring BIM to a specific project: as BIM use on projects proliferates, 32% of survey respondents reported that additional labor investments are needed to tailor BIM to the processes of the firm, such as by adding a BIM manager or more IT support. One electrical contractor stated, "If there is one thing that as an industry we need to be aware of and attempt to change, then that is keeping the level of expertise proportional to the advances that are being made in the technology".

3 Longer-term outlays for strategic business changes, such as investing in standards development or customization: are part of the calculation, however, such costs can be difficult to quantify. Changes to internal processes – for instance, integrating data and information in the model earlier in the design development process or incorporating modeling during preconstruction – also have to be considered to build a complete investment calculation.

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- During adoption and early implementation, companies also find it challenging to measure costs such as workflow disruptions and inefficiencies.
- Virtually all BIM customers interviewed about ROI agreed that BIM represents an improvement in the way buildings are designed and promises a host of benefits to project contributors and to the owner over the project's lifetime. "It wasn't really a financial decision… this is where everything is going. If we're going to keep up and remain competitive, we're going to have to go there." "For owners, it's all about getting the building built sooner. The sooner the hospital is operating, the sooner the revenue starts. Nobody builds a building just for fun."
- Of course, calculating BIM ROI goes beyond these three types of investment. A nuanced view of return on investment for BIM considers three dimensions:
- ORGANIZATION DIMENSION are benefits measured at the project level or the firm level?
- STAKEHOLDER DIMENSION what specific role does the company occupy in the project ecosystem?
- MATURITY DIMENSION how much depth of BIM experience does the team and the company have?

By considering BIM adoption and ROI assessment across these three dimensions, firms may be better able to understand how measurement and technology innovation can be combined strategically to inform progress toward future levels of BIM maturity. "BIM has allowed us to remain where we want to be in the marketplace, and as other firms embrace BIM, we want to make sure that we remain a player. I think that we have strengthened our position in terms of market share and simply being ready to do the kinds of projects we know how to do."

1.1.1 Organization dimension of BIM ROI

When companies make the decision to move to BIM, the drivers for adoption establish important objectives that impact the way returns are pursued and achieved. In some cases, customers interviewed about BIM ROI stated that adoption was driven by a client requirement on a project. In this case, a firm is likely to seek returns resulting from the success and profitability of that completed BIM-enabled project.

Autodesk customers reported that BIM provided tangible, quantifiable benefits at the project level – such as fewer RFIs (Request for Information) – along with intangible benefits, which are more difficult to quantify. These present an opportunity to efficiently pursue and analyze additional design options and increase project value through parametric design improvements:

- ✓ **reduction in waste and risk** (for examples significant savings stemming from the design, construction, and erection of structural steel packages designed using BIM);
- ✓ improved design quality;
- ✓ **reduction in errors**, being able to contain labor costs more and complete projects faster with fewer errors. As the profession matures, BIM adoption will set us up for working on integrated project delivery projects because the company will absorb the software learning curve as well as the mental learning curve of working on a different risk model. The long-term benefit is that it sets us up to do the kind of work that company want to do economically;
- ✓ **increased client, design, and construction team understanding and communication** due to a simple showing of an animation generated straight out of the software;
- ✓ accelerated regulatory approval and permitting, and reduction of risk for the owner;
- ✓ improved project delivery through efficient use of resources, improved safety and accurate timelines, with a consequent reduction of litigation and claims.

As firms expand their application of BIM to multiple projects or widen use of BIM as a business strategy, the notion of ROI must expand to incorporate benefits at a firm level, such as opportunities for work with new clients. Other benefits

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included staffing competency and retention. Opportunities for business model expansion or new services, such as quality assurance or model development, are also benefits at the firm level.

Data-rich models provide opportunities for companies to offer ongoing services to clients as data is more seamlessly integrated into facility operations and maintenance.

It can be challenging to attribute returns at the firm level solely to BIM adoption. If companies continue to track business health in terms of traditional metrics such as profitability, risk factors, volume of claims/litigation, projects won or lost, or repeat business with key clients, the actual impact of BIM on these measures can be difficult to separate from other factors.

1.1.2 Stakeholder dimension of BIM ROI

Interview respondents revealed that they assess the returns of BIM differently depending on their role in a project – whether one employs BIM as a tool in design, construction, or operations affects perspective. For example, owners tend to recognize multiparty communication and improved project process and outcomes as top benefits. Contractors list productivity and lower project cost as their top BIM benefits. Owners appear to be much more interested in ROI calculations and, like owners, designers are interested in ROI as a means to gain deeper insights into opportunities. Many design firms were early to adopt BIM based on the perception that their firms would be better positioned to work with public entities which adopted BIM mandates.

	Professional	Technician	Owner
BIM adoption	Widespread	Emerging, and increasingly appreciated	Many specify BIM, but few actively use or completely understand it
Key benefits	Improved collaboration with project contributors Less rework, fewer change orders	Minimizes/eliminates a significant number of changes Improves construction management Great for quantitates and materials estimating	Can shorten time to completion of project overall Enables more effective management, operations and upgrades
Associated costs	Requires more time to fully populate the model Designers can eat up more time exploring design alternatives	Requires a change in business process and accompanying technology investment to fully realize	Uncertain at present, other than investment in the software
Interest in ROI	Not particularly helpful if tied to a decision to use BIM or not Interested in understanding hidden costs as well as possible revenue opportunities	Not directly relevant as the BIM decision is typically not theirs to make	Interested and in need of education on getting the most benefit out of BIM-designed assets
Outlook on BIM	Here to stay. Makes work more complex but represents the "right thing to do."	Welcome improvement that should be applied to all projects	Significant potential and increasingly a standard requirement imposed upon project contributors

1.1.3 Maturity dimension of BIM ROI

When moving from 2D to initial BIM implementation, firms calculate ROI to determine whether the technology investment will be worthwhile. However, once firms have moved past the initial stage of BIM adoption, ROI calculation shifts to a more nuanced tool to assess specific initiatives linked to firm strategy. Recent research notes a correlation between different levels of BIM experience and ROI. High ROI is reported by a majority of high maturity BIM users, yet only by 20% of the low maturity BIM users. "The huge cost shifter with BIM is the way we use it to put great tools in the hands of experienced designers. Once trained, these very experienced people can do more in the same amount of time."

Many customers with significant BIM experience report having internal practices to measure experience, assess company competency, and provide incentive to employees to develop necessary skills. In regions where governments have enacted policies to encourage BIM adoption, such as in the United Kingdom, experience or maturity levels are often officially defined to provide clarity and to drive practitioners to increasing levels of sophistication.

To assess progress and ROI, companies can apply a number of measures associated with potential benefit targets. Cost savings or reduction of effort targets lend themselves to measurement. For example, in seeking a project outcome of "efficient use of resources" due to improved "team size and focus" during the construction phase, the firm might agree to increase the specialization of the BIM team. This would allow the firm to track the time invested in specific tasks by phase and compare the metrics to benchmarks for comparable projects in order to provide feedback on the effectiveness of the strategy. Alternatively, a team might target the BIM benefit of "fewer, earlier, and leaner RFIs" under the Scope Control category. A process change to define responsibility and level of development for models could be combined with a measurement strategy of tracking RFIs and hours invested in responding to them. Qualitative factors such as "project design scope understanding" or "owner comfort level" can be tracked by a score that is evaluated through a predetermined method, such as a questionnaire administered to staff and managers at key points in the project schedule.

This examination of BIM ROI suggests that firms that have deployed BIM find that, despite challenges in making an accurate calculation, measuring the return on their BIM investment is an important practice that can have relevance beyond determining whether or not to adopt a technology innovation. Of the customers who participated in the research effort, 75% responded that their firms were quantitatively assessing the impact of BIM. However, only 21% were literally measuring ROI. The rest were measuring other factors, such as the ability to complete projects with smaller teams or shorter schedules.

There remains a strong interest in applying ROI to assess specific BIM advances once firms have achieved the first level of maturity. Interestingly, 7% of the firms mentioned moving beyond the need to calculate ROI for BIM after evolving to a higher level of BIM maturity, echoing the observation that technology becomes invisible once it becomes ubiquitous. The practice of targeting benefits, tracking investments over time, and measuring returns helps firms select judiciously from a portfolio of technology/process initiatives, and to plan for strategic business change. In addition, firms agree that ROI can be a strategic tool for internal stakeholders in advocating for process change or to demonstrate the potential value of a new method to internal teams, managers, or employee groups.

Who benefits? Firms with extensive BIM experience observe that a nuanced and sophisticated application of ROI is becoming a factor in working successfully with building owners as that influential group becomes increasingly aware of BIM, realizes the benefits of BIM-enabled project delivery, and grasps the potential for process change in building operations and maintenance. Service providers understand that strategic applications of ROI can serve to demonstrate competency to clients, to increase value through data-driven decision making, and to provide competitive differentiation. Firm leaders can create their own roadmap for process change by developing a strategic BIM ROI practice – a commitment to measurement, benchmarking, retaining information in accessible formats for comparison purposes, and conducting ongoing evaluations of key performance indicators. As opposed to merely being a mechanism for go/no-go decisions, a strategic ROI discipline can support the prioritization and internal socialization of process change initiatives and improved business performance.

By employing ROI to assess BIM initiatives aimed at improving the performance of individuals and teams, firms can prioritize investments for organizational effectiveness to support sustained business improvement or implement

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models to assess BIM maturity and increase competency levels. Establishing the firm's orientation within the three dimensions of BIM, ROI suggests a set of promising measures for initial implementation and a potential road map for future development. Important strategic factors for firms include:

- the competency of employees
- collaborative culture,
- capability of teams.

For business leaders who want to find out even more, academic research provides recommendations and frameworks to devise optimization strategies stretching from initial BIM adoption to more sophisticated maturity levels.

1.2 Strategies for a BIM diffusion

When discussing BIM diffusion within an organization (micro) or across a whole market (macro), two terms typically pop-up: top-down and bottom up (https://www.bimthinkspace.com/2014/07/episode-19-top-down-bottom-up-and-middle-out-bim-diffusion.html):

- **Top-Down diffusion** is a push by an authority to mandate the adoption of a specific solution it perceives as favourable. A good example of a macro top-down BIM dynamic is UK's BIM Level 2. At the micro level, top-down diffusion occurs when senior management within an organization (irrespective of its size and location within the supply chain) mandates specific solutions to adopt. Through these, sometimes coercive, pressures, solutions start diffusing down the authority chain and, if coupled with education and incentives, are adopted.
- **Bottom-Up diffusion** refers to the grass-root adoption of technologies, processes or policies without a coercive mandate. At the macro level, this occurs when small organizations or those near the bottom end of the authority/supply chain adopt an innovative solution or concept; the solution slowly becomes a common practice; and gradually diffuses up the supply/authority chain (as is the case in Australia). Similarly, at the micro level, bottom-up diffusion occurs when employees near the bottom end of the authority chain introduce an innovative solution and – over time – this solution is acknowledged and then adopted by middle and senior management.

Although these two dynamics are easily noticeable, a third dynamic lies hiding in plain sight: the MIDDLE-OUT diffusion pattern:

- **Middle-out diffusion** applies to all those organizations and individuals occupying the median space separating the 'bottom' from the 'top'. At the micro organizational level, team managers, department heads and line managers push what they've personally adopted up and down the authority chain. At the macro market level, middle-out dynamic applies when mid-sized organizations (relative to the market – e.g. large contractors in the US) influence the adoption of smaller organizations down the supply chain. They also influence or actively encourage larger organizations, associations and authorities up the supply/authority chain to adopt and eventually standardize their solution.

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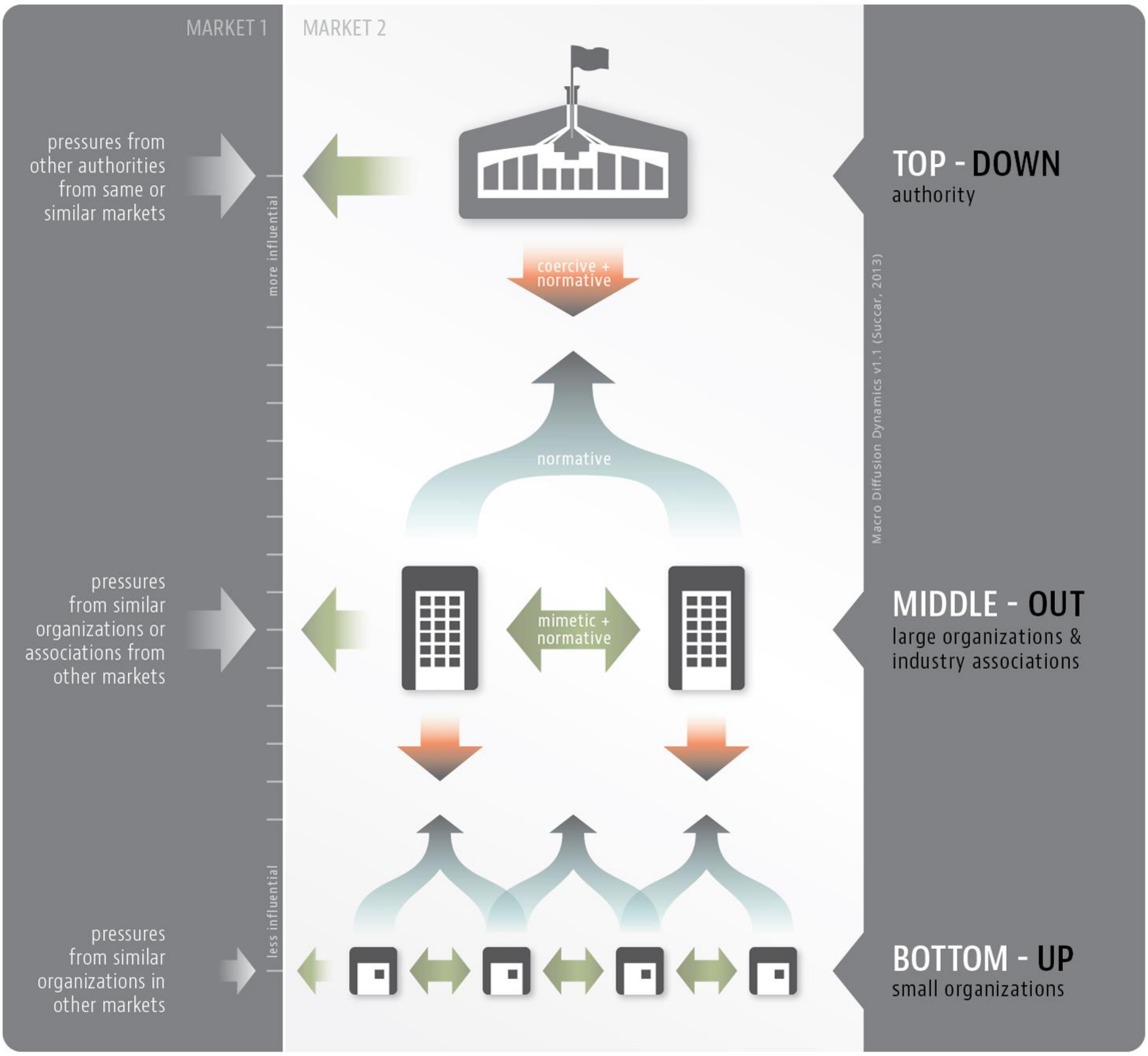

https://www.bimthinkspace.com/2014/07/episode-19-top-down-bottom-up-and-middle-out-bim-diffusion.html

Different organizations and markets display one dynamic more than the other due to a variety of market-driven and social variables. However, top-down, bottom-up and middle-out diffusion dynamics are complementary and even mutually inclusive. It is a misconception that one dynamic can be better than the others. While there is some evidence that a top-down dynamic encourages faster adoption rates across an organization or a market, there's no that it leads to sustained infusion5 of BIM workflows and deliverables.

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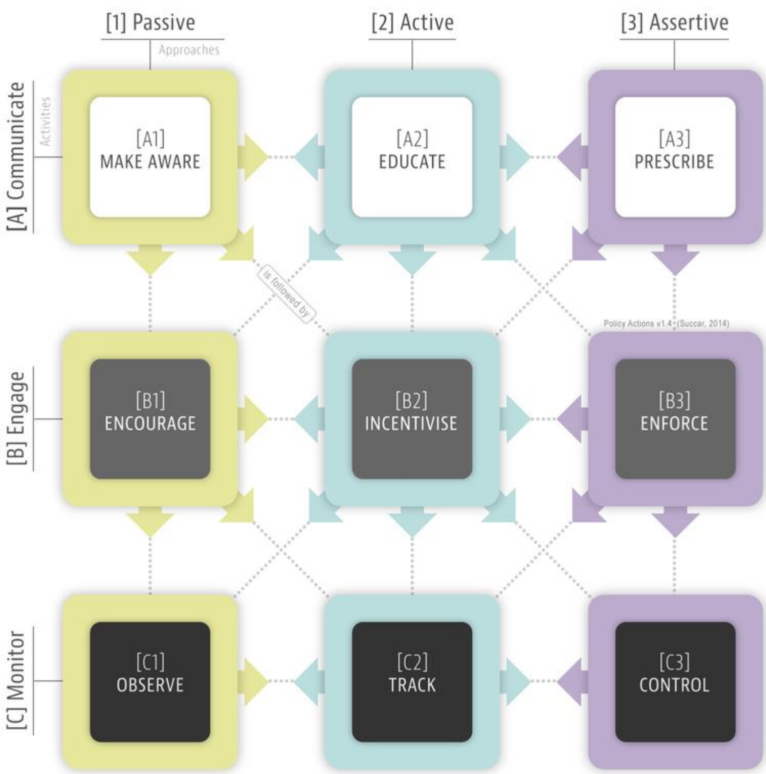

Source: https://www.bimthinkspace.com/2015/01/index.html

One of diffusion models is the **Policy Actions Model** which identifies three implementation activities (communicate, engage, monitor) mapped against three implementation approaches (passive, active and assertive) to generate nine policy actions:

The three activities are consistently witnessed in markets where there's an intentional top-down push to diffuse BIM tools and workflows. What varies is the intensity these activities are conducted and the mix of player types (e.g. government, industry associations and communities of practice) undertaking the policy development effort[ii]. That is, each of the three activities (communicate, engage and monitor) can be approached at three levels of intensity (passive, active, and assertive) accounting for the differences in cultural attitudes and power dynamics across different markets. Practitioners in one country (e.g. an SE Asian nation) may call upon their government to take an assertive approach, practitioners in another country (e.g. US or Australia) may prefer an active or even a more passive approach.

	Passive [1]	Active [2]	Assertive [3]
Communicate [A]	**Make aware**: the policy player informs stakeholders of the importance, benefits and challenges of a system/process through formal and informal communications	**Educate**: the policy player generates informative guides to educate stakeholders of the specific deliverables, requirements and workflows of the system/process	**Prescribe**: the policy player details the exact system/process to be adopted by stakeholders
Engage [B]	**Encourage**: the policy player conducts workshops and networking events to encourage stakeholders to adopt the system/process	**Incentivize**: the policy player provides rewards, financial incentives and preferential treatment to stakeholders adopting the system/process	**Enforce**: the policy player includes (favours) or excludes (penalises) stakeholders based on their respective adoption of the system/process
Monitor [C]	**Observe**: the policy player observes as (or if) stakeholders have adopted the system/process	**Track**: the policy player surveys, tracks and scrutinizes how/if the system/process is adopted by stakeholders	**Control**: the policy player establishes financial triggers, compliance gates and mandatory standards for the prescribed system/process

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As depicted in the table, the three policy approaches signify an intensification of policy maker's involvement in facilitating BIM adoption: from a passive observer to a more assertive controller. These policy actions are discussed here at low detail. Needless to say, each of the nine actions can be further divided into smaller policy tasks. For example, the incentivise action [B2] can be subdivided into multiple incentivise tasks: e.g. [B2.1] make tax regime favourable for BIM adoption, [B2.2] develop a BIM procurement policy, and [B2.3] introduce a BIM-focused innovation fund.

The Policy Actions Model reflect a variety of actions that policy makers take (or can take) in each market to facilitate BIM adoption. It is important to understand that all approaches are equally valid. However, it is critical for policy makers to select the combination of policy actions which best fulfil the unique requirements of their market.

The Policy Action Patterns sample chart provides a quick comparison of diffusion actions undertaken by policy makers in different markets. Each pattern represents the policy actions taken (or can be taken) by policy players. For example, the top-left pattern represents a wholly passive approach (Make Aware + Encourage + Observe), while the bottom-right pattern represents a mixture of assertive and active approaches (Prescribe + Incentivise + Track).

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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 (https://www.thenbs.com/knowledge/what-is-the-common-data-environment-cde). 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 being 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 (https://www.bimthinkspace.com/2005/12/the_bim_episode.html).

This non-declared denominator is a set of technological and procedural attributes of BIM Models (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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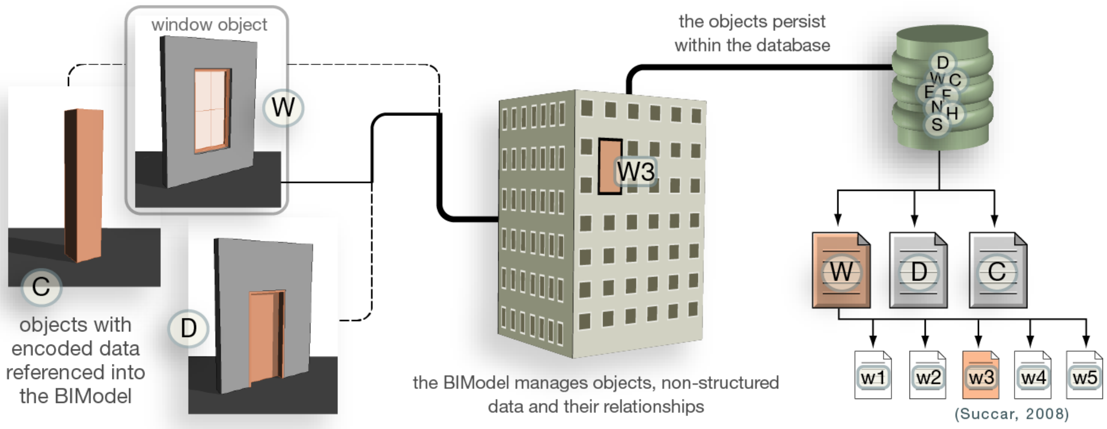

Source: https://www.bimthinkspace.com/2005/week51/

BIM modellers do not depict nor encode he 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 (https://www.bimthinkspace.com/2005/week51/):

- 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 BIM Modelers as Knowledge-Based. As per the definitions above and if we assume Goals to be synonymous to encoded Rules, BIM Models can include Knowledge-Based Models and Models based on Systems Thinking.

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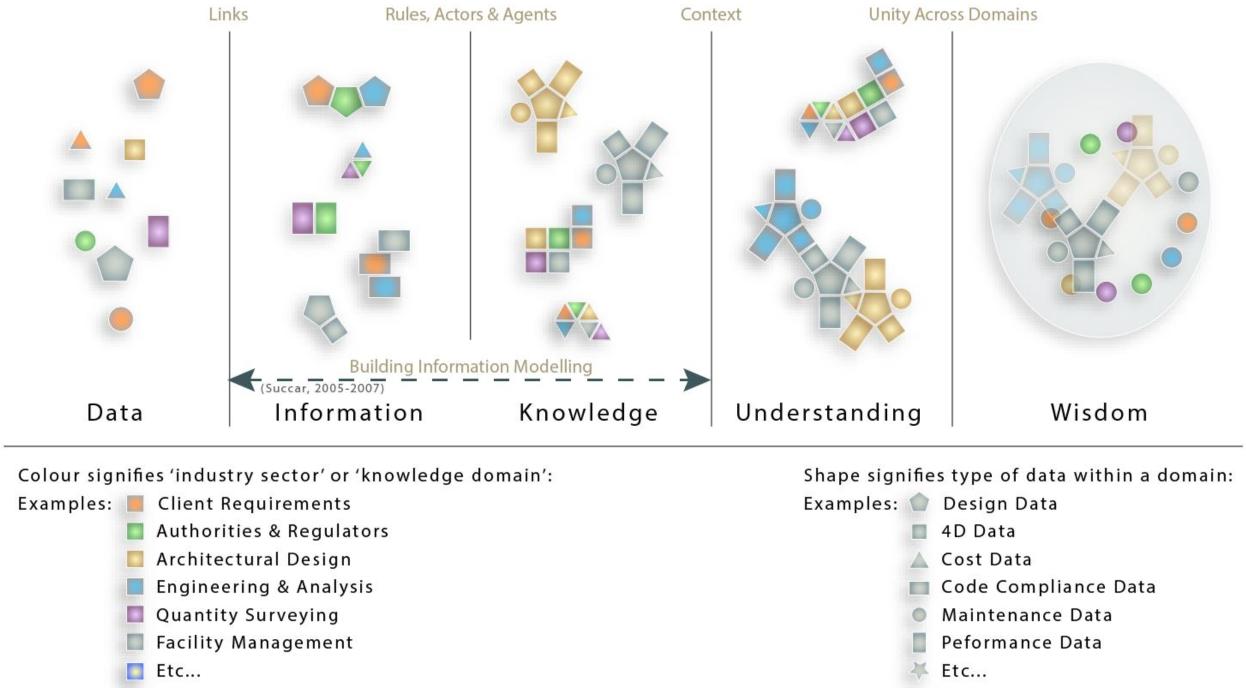

Source: https://www.bimthinkspace.com/2005/week51/

BIM Modellers can share little or much information available across desperate 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 (https://www.bimthinkspace.com/2006/02/the_bim_episode.html):

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: BIM Modeller$_1$ produces an IModel (Interoperable Model) that gets imported into BIM Modeller$_2$ where its worked-on then exported into IModel v.2 (version 2) that gets imported into BIM Modeller$_3$ 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.

../Images/Workshop%20IFC%20rail%20Roma.jpg

2.2 The "as built" BIM Model for improving the energy performance of buildings.

We can define the "as built" model as the editable copy that represents the final state of the building with the modifications that it has undergone throughout the construction process and that will serve to carry out future constructive interventions in the real estate asset.

These potential interventions cannot be unaware of the energy behaviour of the building and, to this day, these actions involve all types of construction and all geographical areas; the integration of silicon photovoltaic panels in a skyscraper is as important as the improvement of insulation under the Arabic tile roofs of a historic complex of a small town. If one's own initiative is not enough, incentive policies, via grants, may act as a catalyst.

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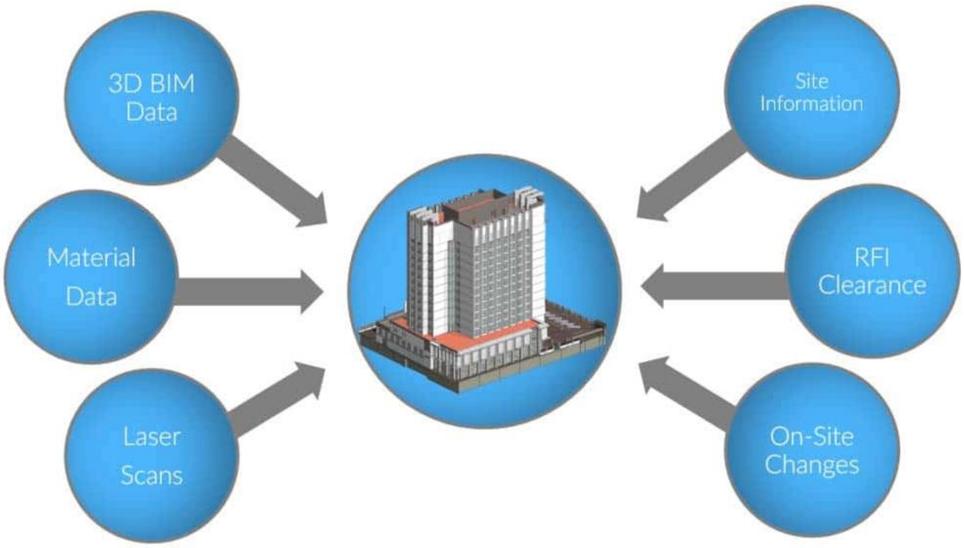
Therefore the original Model is not viable for the operations and maintenance stage till it is efficiently converted into an as-built model. An as-built model has various requirements: first of all it should be geometrically commensurate to actual site construction and secondly it should be having relevant basic information about all the building components which can be later enhanced at the 6D Levels.

There are a number of methods in which an existing structure can be produced accurately and as close to the raw survey data as possible. Essential BIM are experts at producing As-built BIM Ready models from all raw survey data types.

1. **BIM ready model from 3D Laser Scanned point cloud data**: it is now common practice for Architectural surveying companies to laser scan structures/buildings. This technique produces a point cloud consisting of billions of points representing real world coordinates that build up the environment from everything the scanner sees. These clouds have been used for years to produce accurate 2D CAD drawings which were then used to model 3D As-Built conditions. Essential BIM have worked with these methods since they have been available and have developed best practices to efficiently produce extremely accurate models.

- 3D laser scanners capture everything that the scan position can see, by overlapping many scan positions (or by



using recently available mobile scanners) it is possible to get close to 100% scan coverage of the environment. Due to this it is possible to model to any level of detail without further visit to site to collect more data, a client can request a basic level of detail initially and specify greater levels of details in areas as required without further disruption of the site, this was impossible with previous traditional methods of surveying.

2. **BIM ready model from 2D CAD drawings**: it is extremely likely that 2D drawings have already been completed for a building from previous years. It may be extremely cost effective to produce a 3D BIM ready model from this already worked up and finished data. This is generally the fastest way to produce a model as the majority of the analysis of the data has already been done. If these drawings have already been completed, then it is generally more cost effective than conducting another survey (assuming nothing has changed since they were drawn). The 3D BIM ready model is of course limited in detail to what is produced in the 2D CAD drawings
3. **BIM ready model from traditionally measured raw survey data**: as laser scanners are extremely expensive the majority of architectural surveying companies use traditional techniques to capture their data. this could involve creating CAD drawings on site using hand held PCs linked to laser measurers. All of which can be used

to create a 3D BIM Ready Model. Essential BIM have produced many models from such data with great success allowing for companies with a smaller budget for equipment to still compete with the larger Market leaders.

4. **BIM ready model from Architectural/structural Plans**: as most Buildings/structures are generally built from plans it is fairly likely that these may be available to produce a BIM ready As-Built (assuming that the building was built closely to the plans). These plans can be easily converted to a BIM ready Model. This can be a perfect solution for Facility Management (FM) as a BIM model can be used for the life time of a building for space planning, costing for materials, scheduling of elements etc. even for handing over to future Architects to use to design a proposed extension from.

If a building hasn't yet been built then a BIM ready Model can be created from such plans to create photo realistic visualizations or animations to help sell or market the property. The model can be used for early FM and even passed to interior designers, space planners, landscape designers etc. to develop the finished quality of the building, helping the end user visualize their space much easier than they could from 2D plans. The Contractor can even use the model to get a better idea of what needs to be built, the construction and structural details can even be modelled/embedded to aid the contractor with the build work.

Moreover energy performance certificates for buildings must necessarily incorporate so-called recommendations for improving energy performance. Compliance with this simple standard requires a simulation process that must produce results that detail not only the actions to be carried out and the tabulated efficiency improvement, but also the detailed study of the economic analysis of savings measures under real conditions based on historical consumption data of the building (according to Annex III of the official model for energy efficiency certificates for buildings, published by the Ministry for Ecological Transition of the Government of Spain).

The BIM work methodology has no competence in simulation processes; actually, it could be said that the BIM model "was born for simulation". A BIM model that incorporates information on the thermal characteristics of the enclosure, as well as 5D information based on the cost of the elements, will make it possible to obtain efficiency and cost reports practically immediately. The incorporation and/or substitution of alternative elements (which can be integrated into a single model) will suffice to obtain the efficiency/cost comparison of potential actions to be carried out on the model. These actions, which can be carried out almost immediately in the BIM model, would require tedious trial and error processes using more traditional methodologies (based on spreadsheets, databases and non-integrated models).

The example proposed for thermal envelope studies is analogous to that of any installation serving efficiency improvement; if the BIM model integrates the necessary systems, the simulation can be carried out without any limitation other than the information integrated in the model.

The versatility of the BIM model derives from its ability to collect modifications and forecast future scenarios. This versatility will allow its adaptation to the different phases of the life-cycle of the project, from its design to its demolition, and the energy side takes on special relevance in this life-cycle.

The BIM model "as built" will result in AIM (Asset Information Model); a single source of validated and approved information that relates to the built asset. This replica of the real model, much more manageable and in which mechanisms of augmented reality can operate, will serve to take conscience and knowledge of the asset, that is to say, of the own building or construction. Any potential improvement in the energy efficiency of the asset can be easily tested, simulated and verified in the model.

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3. Module 3 – Apply procurement management

3.1 Quality tender and contracts, guarantees and Change Management

All parties will behave in accordance with the following standards at all times:

- ✓ Honesty and fairness: parties will conduct all procurement and business relationships with honesty and fairness and avoid any practice which gives one party an improper advantage over another;
- ✓ Accountability and transparency: the process for awarding contracts will be open, clear and defensible and all parties must not engage in collusion, hidden commissions and other anti-competitive behavior.
- ✓ No conflict of interest: a party with a conflict of interest will declare and address that interest as soon as the conflict is known to that party.
- ✓ Rule of law: parties will comply with all legal obligations.
- ✓ No anti-competitive practices: parties shall not engage in practices that are anti-competitive.
- ✓ Intention to proceed: parties should not seek or submit tenders without a firm intention and capacity to proceed with a contract.
- ✓ Co-operation: parties will maintain business relationships based on open and effective communication, respect and trust, and adopt a non-adversarial approach to dispute resolution.

Download free best practice guide for tendering and contract management

In international construction projects, it is standard practice for the Employer to request guarantees to secure the performance of the Contractor. The most frequent guarantees are:

- The **Bid Bond** is granted in favor of the Employer to secure that the Contractor/tendered duly complies with its obligations either during the tender phase or afterwards. In particular the Bid Bond guarantees that (i) the Contractor does not withdraw from his tender before the end of the bid acceptance period set by the Employer or (ii) the Contractor fulfils the obligation to sign the contract -if awarded to him- or (iii) the Contractor does not fail to issue the bonds provided in the contract itself after the award of the contract (for instance, to provide the performance bond).
- The **Advance Payment Bond** is issued to secure that any sum paid in advance to the Contractor before the start of the works will be duly paid back to the Employer by the end of the works. The Employer, usually, pays to the Contractor (after the signature of the contract) an amount normally at around 10% of the contract price. The advance payment is used by the Contractor to start the procurement and/or the mobilization process.
- Usually, the mechanism is that the advance payment is repaid back to the Employer during the execution of the project by way of deductions on each interim payment made by the Employer. If the advance payment is not paid back (for instance because the contract is terminated in advance), then the Employer will obtain the repayment of the advance payment not yet repaid back by calling the advance payment bond.
- The **Performance Bond** is the guarantee which secures the Employer in case the Contractor will not complete (or not duly and/or timely complete) the scope of works under the contract. If the Contractor breaches any

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specific obligations, the Employer will be entitled to call the performance bond (in full or partially depending on various circumstances) if the breach is not remedied or is not capable of being remedied.

- The **Warranty Bond** secures the Employer from the failure of the Contractor to remedy any defects in the works which could occur during the warranty period of the works as provided under the contract.
- If the Contractor will not repair any defects during the warranty period or will not comply with its warranty obligations in a timely manner, then the Employer will be entitled to call the Warranty Bond.

There are mainly two major categories of bonds in construction contracts. They are (A) the default guarantee and (B) the on-demand guarantee. As the names imply, they operate quite differently:

- **default guarantee**: it is also known as the "conditional guarantee" and, very broadly, will be paid when the Employer has proven the actual Contractor's breach under the terms and conditions of the contract. The guarantor, in turn, may raise any objection that the Contractor could raise against the Employer on the basis of the construction contract;
- **on-demand bond**: on the other hand, the on-demand bond can be called on simple demand by the Employer who does not have to prove the default of the Contractor. Neither the Guarantor nor the contractor can raise any objection (on the basis of the underlying contract) to prevent the payment of the on-demand bond (despite there are certain cases in which the bond cannot be paid, for instance in the case of fraudulent calling from the Employer).

One of the tests you can run to understand if the requested guarantee is in the form of an on-demand bond is to analyze carefully the relation between the bond and the underlying contract. In all those circumstances where the bond is substantially independent of the contract, then likely you are requested to issue an on-demand bond.

The bid documents and the construction contract provide, generally, the type and amount of the bonds that the Contractor has to provide.

The wording used is crucial and it is strongly advisable that at least the contract provides details on the bonds, such as for instance in which circumstances and at which conditions each of the bonds can be called by the Employer. This can, in fact, avoid the majority of the disputes that usually occur in relation to the calling of the bonds by the Employer.

It is normally stated in the bond itself and it happens that the law governing the bond might be different from the law governing the construction contract. This happens especially in the case where the bond is provided by an international bank or surety company.

If there is no express reference to the law governing the bond, usually the guarantee is governed by the law of the country where the guarantor which has issued the guarantee has its location. It is, however, advisable to ascertain that the governing law is expressly indicated in the bond and to take advice from a local counsel.

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.

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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 like Revit day in and day out, who need to keep their skills sharp and stay on the cutting edge of technological developments. But what about the rest of the office.

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, the training used for BIM specialists is not the same needed for the training of casual user. Eight BIM tips for the training of employees are listed below:

- 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 need 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.
- 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.

3.3 The identification and collaboration among stakeholders

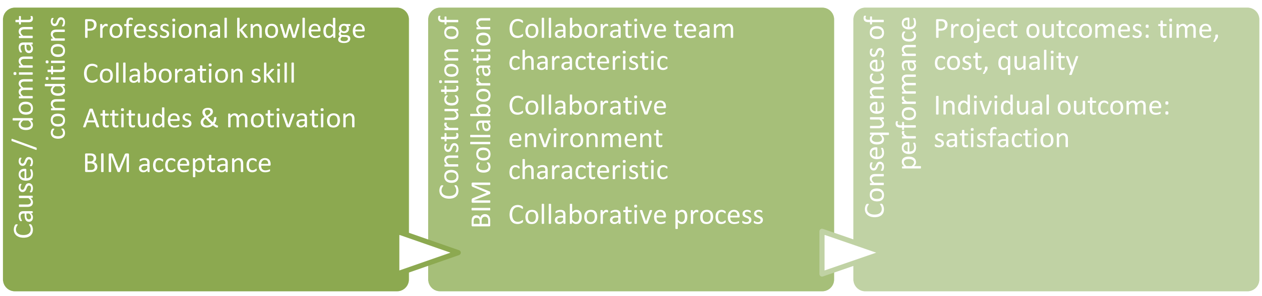
BIM is a collaborative approach to construction that involves integrating the various disciplines to build a structure in a virtual and visual environment. The essence of BIM implementation is collaborative working process in construction work. Therefore, project participants could generate the maximum 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.

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.

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 projects BIM enabled projects. Collaboration issue cannot be demonstrated by any single contract theory or economic theory. Few study 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 success. 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.



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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 disciplinaries 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 is 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 commers in construction industry in Hong Kong. They all can find their role and interact with other team members in a brief period. In other words, the vacancy can automatically be filled by the appropriate person due to highly competitive and open market. 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 interorganizational collaboration. Few scholars identify the importance of collaboration environment characteristics, despite a collaborative context is more likely to success. In a framework of interorganizational 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 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, interorganizational 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 judgement 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, interorganizational 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 in 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:

- X 40 % of annual energy consumption;
- X Extracted materials and minerals quarries 30 %;
- X 30 % - 40 % of CO2 emissions. Households and services are the first emitter of CO2 emissions in EU-15 if the electricity is included in final sectors.;
- X 12% of consumption of water;
- X RC& D: 40 % total waste produced (92% demolition and 8% construction);
- X 42% energy consumption - heating and lighting of buildings accounts for the largest single share of energy use (which 70% is for heating);
- X 22% construction and demolition waste (by weight);
- X 35% greenhouse gas emissions;
- X 50% extracted materials (by weight);
- X Buildings occupy 10% of the space.

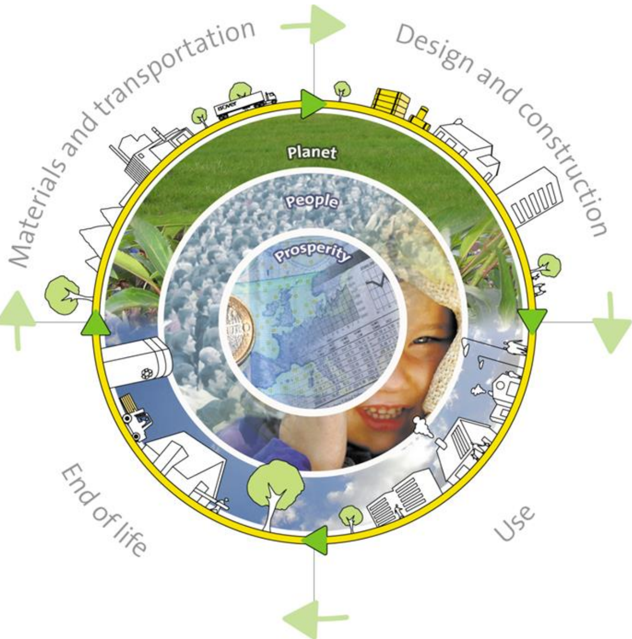
Currently 80% of the European population live in urban areas and people spend more of 90% of their lives within the built environment (considering the home, workplace, school and leisure time). The wellbeing and comfort of the people is largely affected by this environment, therefore construction activities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

The Sustainable Development operates during the whole life cycle of the building and would like to:

- ✓ 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.

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 of 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 de 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.

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**.

4.2 Automatic model checking

The "BIM oriented" design guarantees the interoperability of the models related to the various disciplines allowing simultaneous control with different purposes: controls of the convergence of the models of the single disciplines, checks the elements coexistence of the different disciplines and checks regulatory on the multidisciplinary model.

In general, the validation of the BIM model consists in the requirements and functionality verification carried out in a conceptually (not dissimilar) way from what is normally required in a traditional design approach. Operatively (and synthetically) this is carried out through the verification of adherence to the design and regulatory requirements (Code Checking) and the verification of the coherent design of what is expected (Clash Detection).

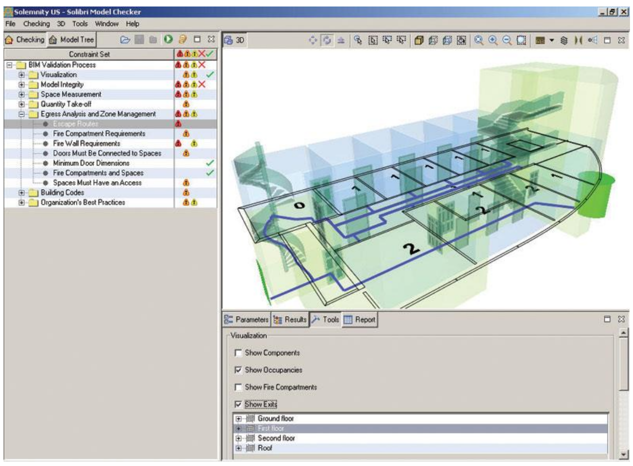
4.2.1 Code checking

Regarding the above-mentioned control, in specific Model Review tools, when the 3D IFC Model of the various design disciplines have been loaded, it is possible to verify compliance with specific needs and reference standards, which can be customized through the parameters of the verification rules. At the same time, the quality of the models of the individual disciplines is guaranteed without loss of information, as happens in the transfers of the same models through 2D formats to 3D formats. Thanks to the IFC file format, the correct transfer of geometry and attributes related to 3D models is guaranteed.

About a subsequent phase of regulatory checks and compliance checks, specific rules are available for the so-called Code Checking, for different reference standards that automatically highlight the differences between the models and the standard, classifying them according to the severity of the discrepancy. The ranges of values that identify problems of low, medium and high differences can be customized by the user, thus managing any limit situations.

Among the main controls (but not exhaustive list of all those available as standard), it is possible to highlight:

- Verification of compliance with hygiene regulations (minimum heights, volumes, services, etc.)
- Verification of the minimum areas of the premises and of the dwellings in relation to their function
- Verification of the air-illuminating relations of the premises
- Verification of the minimum dimensions of stairs and accesses
- Verification of accessibility to the premises (corridors, toilets, etc.) and the presence of architectural barriers



- Fire prevention checks (fire resistance of elements and compartments, escape routes, etc.)
- Control of the presence of fire prevention devices inside the premises or corridors
- Verification of free spaces around a specific element (fire extinguisher, hose reel, etc.)

All the differences from the regulations are automatically inserted into slides, which explain the discrepancy through an image accompanied by some technical notes both generic and specific in relation to the codes of the components that generate the problem.

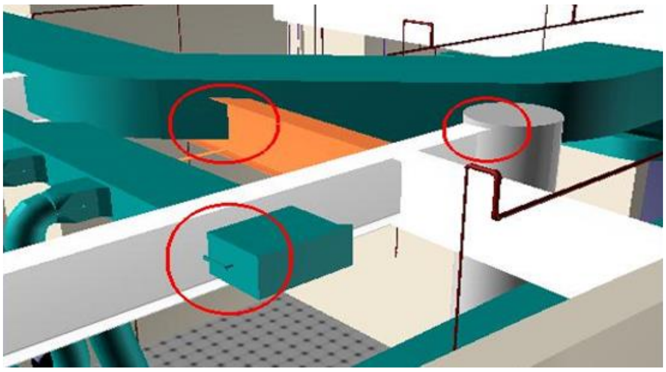
Through reports included in the software, it is then possible to communicate the differences to the various designers and request their correction in the authoring software that generated the controlled model. These reports can be exported either as a table or text file (excel file or rtf, pdf).

However, in addition, they can be generated as three-dimensional reports: the BIM Collaboration Format allows, in the authoring software, through a suitable plugin, to read the notes related to the highlighted criticality, orientate the 3D model and automatically highlight the elements that generate the problem to be corrected making it easier to identify them. The latter method of export is more effective for communication and then the identification of the problem within all the software participating in the BIM process, effectively completing the interoperability between the different disciplines.

4.2.2 Clash detection

One of the key benefits of BIM is the ability to spot “clashes” at an early stage in your project where they should be much easier, cheaper and less time consuming to rectify. In design terms a clash occurs when components that make up a built asset are not spatially coordinated and, therefore, they conflict. In a BIM process these clashes can be spotted more easily during the design phase of a project ahead of work starting on site.

A range of disciplines comes together to work on various aspects of construction projects. Using the architect's model as a starting point, a structural engineer, environmental engineer, mechanical and electrical engineer (and potentially many others) will produce their own model. Each 'model' will consist of a range of model files, documents and structured data files containing non-geometric information about what it will be built. All these assets come together as a digital replica. This will, at first, show what has been designed and will eventually show what has been built and installed. In a Level 2 BIM process the federated models produced by individual teams are integrated (at pre-determined intervals) into a master model that sits inside of the Common Data Environment (CDE). With data from a multitude of models coming together to form a master model it is inevitable that there will be clashes that need to be resolved.



When we imagine clashes we commonly think of two components occupying the same space. These are often referred to as a “**hard clash**” - a column running through a wall or pipework through a steel beam, for example. These kinds of clashes can be time consuming and costly to put right if only discovered onsite. A “**soft clash**” occurs when an element isn't given the spatial or geometric tolerances it requires, or its buffer zone is breached. For example, an air conditioning unit may require certain clearances to allow for maintenance, access or safety that a steel beam would negate. Given sufficient object data, software can even be used to check adherence to relevant regulations and standards (Chapter

5.2.1). Other kinds of clash might involve the scheduling of contractors, the delivery of equipment and materials, and general timeline conflicts. These are often referred to as "**Workflow or 4D clashes**".

Clash avoidance is a key part of the design and construction process. Documenting a set of standard procedures in a BIM Execution Plan (BEP) and setting out procedures for co-ordination in Employer's Information Requirements (EIR) as part of a project's contract documentation are crucial. So too are the BIM Execution Plans authored by suppliers. During the design and construction process, design team interface managers should assess design decisions and clashes to see if they can resolve them internally, and where this cannot be done, separate models may be combined for review by a design lead.

The traditional design process would see specialists working on separate drawings with tracing papers produced during co-ordination checkpoints to check for compatibility. It wasn't that unusual for clashes to only be spotted on the construction site with the potential of huge costs and delays. In a Level 2 BIM process a range of federated models are produced and coordinated data drops used to inform a master model. BIM modelling software and BIM integration tools allow designers to check for clashes in their own models and when models are combined.

Clash detection software is becoming increasingly sophisticated, allowing the user to check for clashes within specific subsets (structural elements against walls, for example) and for these to be flagged on screen (often in vibrant colours).

Some geometric clashes will always be perfectly acceptable (think: recessed ceiling lights, pipes embedded within walls) and software rules that draw on embedded object data can stop these kinds of clashes being flagged. As you can imagine the level of detail in BIM modelling is, therefore, crucial when it comes to clash detection.

Running a clash detection scan or report will typically bring up many duplicate instances of the same issue. If a single run of pipework clashes with five beams, it will show as five clashes though, in reality, resolving one issue (the placement of the pipework) will solve all clashes. Reviewing and cancelling these clashes in the design is a key part of the BIM process. As with any automated process these kinds of scans should not be relied upon in isolation and should form part of wider design co-ordination processes.

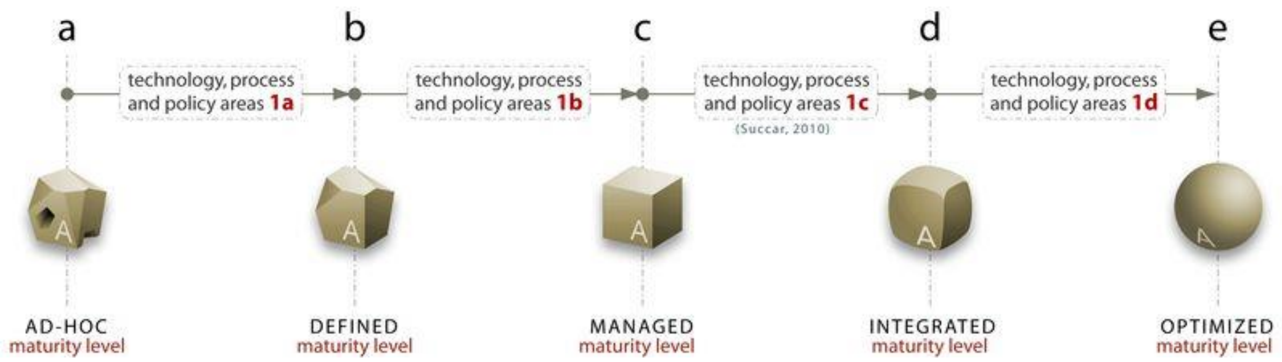
Software tools are likely to continue to become increasingly sophisticated as ever-richer data in standard formats are combined into models. The greatest potential for improvement however comes with Level 3 BIM. Working on one collaborative, coordinated building model (rather than the numerous federated models brought together to form a single complete model at key stages) should mean that the number of project clashes are dramatically reduced.

4.3 Information maturity index

The term 'BIM Maturity' refers to the quality, repeatability and degrees of excellence of BIM services. In other words, BIM Maturity is the more advanced ability to excel in performing a task or delivering a BIM service/ product. To address this issue, the BIM Maturity Index (BIMMI) has been developed by investigating and then integrating several maturity models from different industries. BIMMI has five distinct Maturity Levels: initial/ ad-hoc, defined, managed, integrated and optimized. In general, the progression from lower to higher levels of BIM Maturity indicates:

- ✓ Better control through minimizing variations between targets and actual results;
- ✓ better predictability and forecasting by lowering variability in competency, performance and costs;
- ✓ greater effectiveness in reaching defined goals and setting new more ambitious ones.

The figure below visually summarizes the five Maturity Levels or "evolutionary plateaux" followed by a brief description of each level (https://www.bimthinkspace.com/2009/12/episode-13-the-bim-maturity-index.html):



Maturity Level a (initial or ad-hoc): BIM implementation is characterized by the absence of an overall strategy and a significant shortage of defined processes and policies. BIM software tools are deployed in a non-systematic fashion and without adequate prior investigations and preparations. BIM adoption is partially achieved through the 'heroic' efforts of individual champions – a process that lacks the active and consistent support of middle and senior management. Collaboration capabilities (if achieved) are typically incompatible with those of project partners and occur with little or no pre-defined process guides, standards or interchange protocols. There is no formal resolution of stakeholders' roles and responsibilities.

Maturity Level b (defined): BIM implementation is driven by senior managers' overall vision. Most processes and policies are well documented, process innovations are recognized and business opportunities arising from BIM are identified but not yet exploited. BIM heroism starts to fade in importance as competency increases; staff productivity is still unpredictable. Basic BIM guidelines are available including training manuals, workflow guides and BIM delivery standards. Training requirements are well-defined and are typically provided only when needed. Collaboration with project partners shows signs of mutual trust/respect among project participants and follows predefined process guides, standards and interchange protocols. Responsibilities are distributed and risks are mitigated through contractual means.

Maturity Level c (managed): The vision to implement BIM is communicated and understood by most staff. BIM implementation strategy is coupled with detailed action plans and a monitoring regime. BIM is acknowledged as a series of technology, process and policy changes which need to be managed without hampering innovation. Business opportunities arising from BIM are acknowledged and used in marketing efforts. BIM roles are institutionalized and performance targets are achieved more consistently. Product/service specifications similar to AIA's Model Progression Specifications or BIPS' information levels are adopted. Modelling, 2D representation, quantification, specifications and analytical properties of 3D models are managed through detailed standards and quality plans. Collaboration responsibilities, risks and rewards are clear within temporary project alliances or longer-term partnerships.

Maturity Level d (integrated): BIM implementation, its requirements and process/ product innovation are integrated into organizational, strategic, managerial and communicative channels. Business opportunities arising from BIM are part of team, organization or project-team's competitive advantage and are used to attract and keep clients. Software selection and deployment follows strategic objectives, not just operational requirements. Modelling deliverables are well synchronized across projects and tightly integrated with business processes. Knowledge is integrated into organizational systems; stored knowledge is made accessible and easily retrievable. BIM roles and competency targets are imbedded within the organization. Productivity is now consistent and predictable. BIM standards and performance benchmarks are incorporated into quality management and performance improvement systems. Collaboration includes downstream players and is characterized by the involvement of key participants during projects' early lifecycle phases.

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Maturity Level e (optimized): Organizational and project stakeholders have internalized the BIM vision and are actively achieving it. BIM implementation strategy and its effects on organizational models are continuously revisited and realigned with other strategies. If alterations to processes or policies are needed, they are proactively implemented. Innovative product/process solutions and business opportunities are sought-after and followed-through relentlessly. Selection/use of software tools is continuously revisited to enhance productivity and align with strategic objectives. Modelling deliverables are cyclically revised/ optimized to benefit from new software functionalities and available extensions. Optimization of integrated data, process and communication channels is relentless. Collaborative responsibilities, risks and rewards are continuously revisited and realigned. Contractual models are modified to achieve best practices and highest value for all stakeholders. Benchmarks are repetitively revisited to insure highest possible quality in processes, products and services.

4.4 4D and 5D BIM technologies

BIM models are the result of the superposition of multiple layers of information, from simple geometry to information related to maintenance or asset management. Each of these "information layers" are usually known as the "BIM dimensions", so we can find references to BIM 4D, 5D, 6D, etc. models. In the particular case of BIM 4D models, the "protagonist" information layer in the model is that which is related to planning and time management, i.e., the data that allows us to temporarily locate a certain construction element during its commissioning.

4.4.1 4D Phase Planning

Gantt charts (www.etc-cc.com/etc/download/bmi/BIM_project_planning_EN) have long been a staple of project planning, but they leave something to be desired when it comes to visualizing a project schedule. Most builders invested in their first project planning system more than a decade ago and they've become a vital tool for project management services. BIM solutions on the other hand are relatively new. Rich with information, building information models provide architects a wealth of design-centric tasks, energy analysis, sun studies, and specification management, to name a few. Given the success of BIM in the design realm, building firms are now turning to building information models for their own uses, constructability analysis, trade coordination, quantification, cost estimating, and so on. One of the most obvious building applications for BIM is where design and construction first come together: construction planning .

4D Construction planning is an ongoing effort to manage the progress of a construction project and react accordingly – dynamically adjusting to the "situation on the ground." Of course, a building's design is at the core of its project plan, and by adding schedule data to a 3D building information model (i.e., the building design) you can create a 4D building information model, where time is the 4th dimension. 4D models include planning data such as the start and end date of a component and their criticality or slack.

Therefore, a 4D BIM model can be defined as the result of the integration of two layers of information, geometry of constructive elements and list of tasks or activities (with their corresponding durations and links), through the use of a software tool that allows to interrelate them. The result is an integrated model that, from the point of view of sustainability (understood as a reduction in the environmental impact of construction, very in line with the concepts that consider certifications such as BREEAM, LEED or GREEN) can be used in two main areas: the planning of the construction process of the project and the planning of the site itself and the impact on its immediate environment.

Focusing on the first of these, the construction sequence of the project, the use of tools and methodologies based on BIM 4D models provides a holistic view of the building to the technicians in charge of managing and planning the

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execution process of each and every one of the elements of the project. Access to all this information and, above all, the ability to simulate different construction scenarios, make BIM 4D planning an integral tool for improving construction times, reducing interference between construction systems and optimizing the purchase, delivery and commissioning of different materials, especially those that, due to their particular impact on the energy performance of buildings, it is critical to control and verify their correct execution.

As a result, a 4D building information model provides an intuitive interface for project team and other stakeholders to easily visualize the assembling of a building over time. It enables 4D construction simulation, a key planning tool during preconstruction to evaluate various options. 4D storyboards and animations make BIM a powerful communication tool – giving architects, builders, and their clients a shared understanding of project status, milestones, responsibilities, and construction plans. Teams usually start out developing 4D models by manually mapping the schedule dates from the project plan to the model components. That effort helps them improve the plan and improve how they communicate the plan to the whole team. Later, as they advance their skills, they programmatically link the schedule to the model, to save time and increase their ability to evaluate various construction sequence options.

As a complement to this detailed planning of the construction sequence, we find the planning of the immediate surroundings of the work, where simulation and control tools based on BIM 4D models allow us to precisely control and simulate three key aspects in the environmental impact of our building: the stockpiles and work zones, safety and health on the work site (routes, risk zones, etc.) and construction waste management (studying quantities, types, locations and, above all, their evolution throughout the construction process).

It is possible to use several approaches for linking a building information model to a project plan, exporting from BIM software to Project Management software in a specialized 3D/4D visualization environment linked to a project plan.

In summary, the use of BIM 4D models allows us to understand and visualize planning beyond the Gantt diagram, showing constructive sequences, relationships between elements, alternatives and anticipating interferences and conflicts during commissioning; in short, it is a question of better planning to build in a more efficient and sustainable manner.

4.4.2 5D Cost Estimation

Cost estimating (http://images.autodesk.com/apac_grtrchina_main/files/aec_customer_story_en_v9.pdf) is yet another aspect of the building process that can benefit from computable building information. Designing a building is the responsibility of architects, whereas assessing the cost to build it is the domain of estimators. In general, the architect's scope of work doesn't extend to material takeoffs or cost information. That's left to the estimator.

When preparing their cost estimates, estimators typically begin by digitizing the architect's paper drawings, or importing their CAD drawings into a cost estimating package or doing manual takeoffs from their drawings. All of these methods introduce the potential for human error and propagate any inaccuracies there may be in the original drawings.

5D is that dimension of the application of the BIM methodology that explicitly corresponds to the estimation of costs. In the three-dimensional model, the economic variable is introduced for the valuation of the costs of the project in order to control them and estimate expenses (assigning the price to the different objects or modelled elements as the value of a parameter).

By using a building information model instead of drawings, the takeoffs, counts, and measurements can be generated directly from the underlying model. Therefore, the information is always consistent with the design. And when a change is made in the design – a smaller window size, for example – the change automatically ripples to all related construction documentation and schedules, as well as all the takeoffs, counts, and measurements that are used by the estimator.

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The time spent by the estimator on quantification varies by project, but perhaps 50-80% of the time needed to create a cost estimate is spent just on quantification. Given those numbers, one can instantly appreciate the huge advantage of using a building information model for cost estimating. When you do not require manual takeoffs, you can save time, cost, and reduce the potential for human error. In fact, a common complaint from estimating firms is how much they hate paying estimators to simply count or quantify when they bring so much more expertise and experience to the table.

By automating the tedious task of quantifying, BIM allows estimators to use that time instead to focus on higher value project-specific factors - identifying construction assemblies, generating pricing, factoring risks, and so forth - that are essential for high-quality estimates. For example, consider a commercial project slated for construction in northern Minnesota in the winter. The estimator will realize that winter heating and dewatering will be needed for a portion of the concrete substructure. This is the sort of specialized knowledge only professional estimators can factor in to the cost estimate accurately. This construction wisdom, not "counting," is the real value professional estimators bring to the cost estimating process.

If thanks to BIM modeling tools applied to the design and virtual modeling of a building, it is possible to increase the efficiency of the construction process from its conception and throughout its entire life cycle, by managing the cost that BIM 5D allows, it will be possible to estimate these costs from a very early stage, which will allow, at the same time as analysing the different design proposals and exploring and simulating the different alternatives in terms of efficiency (by means of conceptual analysis of energy flows, evaluations of thermal performance, analysis of solar control, evaluations of energy efficiency, analysis of lighting, etc.) to evaluate and study the economic impact of each of the proposed solutions. The changes in the design reflected in the BIM model will have a quick response in the budget generated from it, being able to be updated immediately.

There are a variety of ways of getting quantities and material definitions out of a building information model into a cost estimating system. Broad categories of integration approaches include:

- **Application Programming Interface (API)** to commercially available estimating programs from vendors with a direct link between the costing system and BIM Modelling software. From the BIM-strategy software a user exports the building model using the costing program’s data format and sends it to the estimator, who then opens it with the costing solution to begin the costing process.
- **ODBC connection (Open Data Base Connectivity)** to estimating programs, useful for integrating data-centric applications like specification management and cost estimating with building information modeling. This approach typically uses the ODBC database to access the attribute information in the building model, and then uses exported 2D or 3D CAD files to access the dimensional data. Part of the integration includes a reconstitution of the building data within the costing solution linking cost geometry, attributes, and pricing.
- **Output to Excel**. In comparison to the approaches outlined above, quantity takeoffs done and output to a Microsoft® Excel® program may seem lackluster, but the simplicity and control is perfectly suited to some costing workflows. For instance, many firms just create material takeoffs, output the data to a spreadsheet, and then hand it off to the cost estimator.

There are no right or wrong approaches – each integration strategy is based on the estimating workflow used by a specific firm, the costing solutions they have in place, the pricing databases they use, and so on.

We must not forget that, although the energy efficiency of buildings pursues as its ultimate goal the saving of natural resources, the reduction of the carbon footprint and, ultimately, the preservation of the global balance of our planet, the truth is that the decisions to be taken in the constructive process, as business action that is (at least, in most cases) must also respond to criteria of business efficiency, ie reduction or, at least, compensation of costs. The BIM methodology in general, and the BIM 5D in particular, offers us the tools so that these decisions can be taken on the basis of reliable data that, in addition, can be obtained, as we said before, practically immediately. The reduction of uncertainties is one of the greatest achievements of the BIM methodology; this allows the best possible decisions to be taken at the most appropriate moments of the construction process.

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5. Module 5 – Analyse the BIM Model

5.1 BIM for quality management

Most managers in existing buildings (https://www.hindawi.com/journals/jcen/2014/672896/) need to manage the influences of daily activities as they oversee the maintenance and operations of these facilities. Typically, their top concern is managing thermal comfort. Managers also must manage the quality of the indoor environment — humidity, lighting, sound, etc. — as well as the quality of services provided, building operating costs, energy use, water use, recycling, and waste reduction. With the rise of reporting mandates, measuring building performance is more important than ever.

Most managers already work with several technologies as they manage facilities. A building automation system (BAS) or building management system (BMS) most often handles the operating of building mechanical and lighting systems. An energy management system, which might be part of the BAS or BMS, handles the energy. In many facilities, integrated work management systems (IWMS) or computerized maintenance management systems (CMMS) support facility management – maintenance activities, work orders, space management, capital planning, personnel, etc.

All of these systems are data-intensive. Anyone who has been involved in implementing them in an existing facility knows that to be truly valuable, they take careful planning, understanding of expected outcomes, detailed data collection, testing, vetting, and training.

While the need for planning and training will never go away, BIM technology and the standards developed around it might offer a way to knit these various systems together. In the standard way of operating, managers have many documents that provide information about facilities: generations of drawings, specification books, operations and maintenance manuals, warranties, system test reports, and other project records.

Seldom are these information sources linked electronically. In all of my years of practice as an engineer, the best and only example I have seen of maintaining design and operations data is one company that maintained master drawings for each of its buildings, as well as each of the major systems within those buildings. The organization also maintained binders for specific systems denoting specific parameters and procedures. Depending on the activities in a given month, it was a part-time to full-time job keeping up with the information. Accessing the information was another matter because it was not always up to date.

Managers certainly understand the need for consistent, accurate, and easily updatable information to help manage facilities, but the technology hasn't always been available to support it in an easy fashion. Managers need a better way to connect the information they have to the management tools they use.

5.2 BIM for handover and maintenance

Design and construction teams are typically (https://www.ukconstructionmedia.co.uk/news/bim-handover-maintenance/) 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.

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 labour 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 organised 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 lets 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 realise 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, 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. 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.

Some deliverables could also be translated in partners national languages and could be find in the respective national web pages. Click on the flags to open the correspondence pages:

International web page

Italian web page

Croatian web page

Slovak web page

Spanish web page

Dutch web page

Estonian web page

Lithuanian web page

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