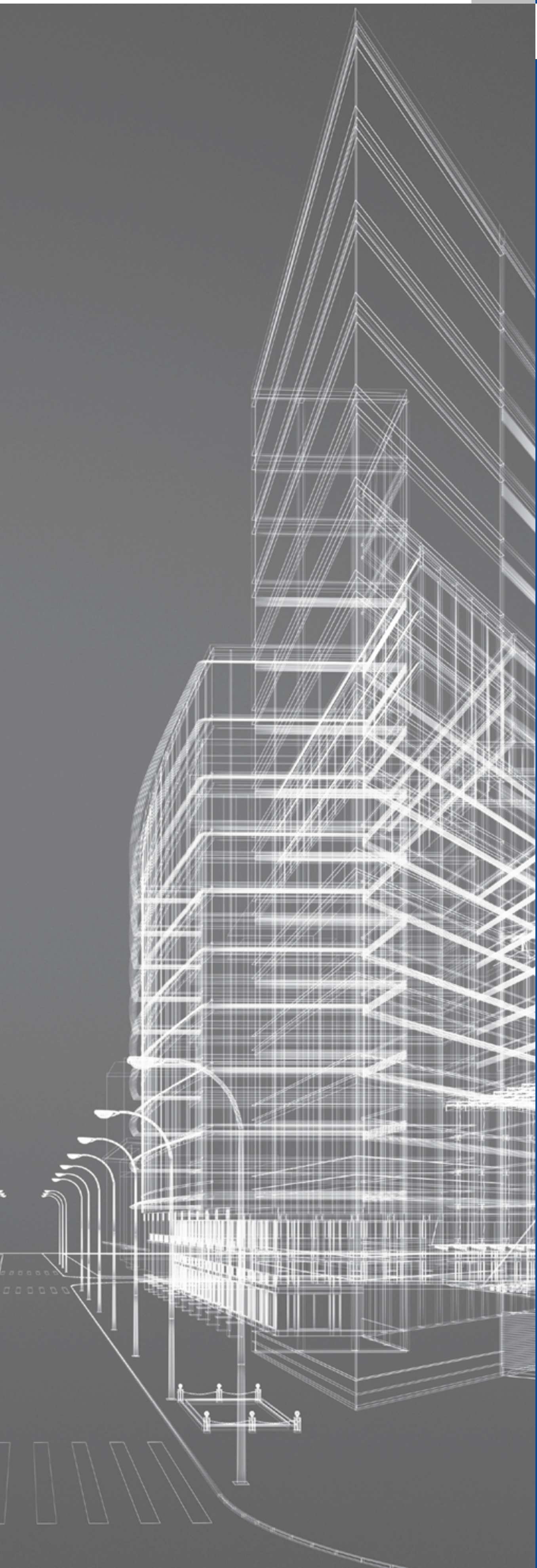

European Commission

Calculating Costs and Benefits for the use of Building Information Modelling in Public Tenders

Methodology Handbook

RINA, B1P Group
May 2021

EUROPEAN COMMISSION

European Innovation Council and SMEs Executive Agency (EISMEA)
Unit I-02 - SMP / COSME Pillar

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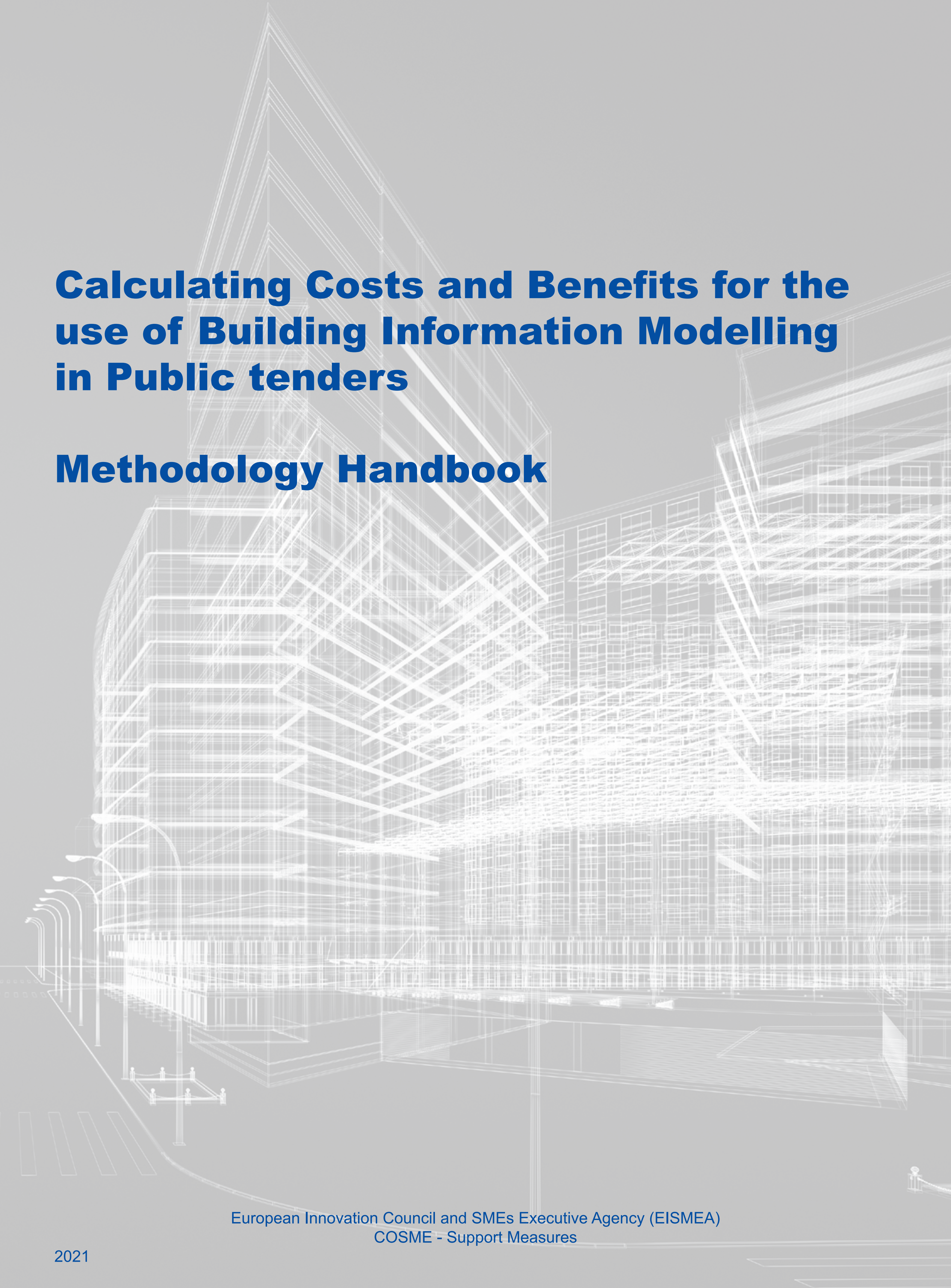

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Preface

The European construction ecosystem is at the centre of a difficult but also promising set of economic, environmental and societal challenges. As one of the 14 industrial ecosystems in the European Union[1], it is responsible for almost 9% of the EU GDP, 7% of employment, and it is composed by 3.1 million businesses, most of them being SMEs[2].

The European Union has set the green and digital transition as high priorities for the present and the years to come. The European Green Deal aims at transforming the European Union into a just and prosperous society with a modern, resource efficient and competitive economy. On the same time, the Commission is determined to make this a ''Digital Decade for Europe''[3], with a clear focus on data, technology, and infrastructure and strengthen EU's digital sovereignty.

The construction ecosystem is transforming, by seizing the opportunities offered by digital tools and technologies. Building Information Modelling (BIM) is one of the principal tools that transforms the construction ecosystem and the management and interventions to the built environment. The EU Public Procurement Directive of 2014[4] encourages public entities to use BIM when procuring for construction projects. On that basis, the European Commission has been collaborating with the EU BIM Task Group since 2016[5]. The ''EU handbook for the introduction of Building Information Modelling by the European public sector '' was published in 2017 as one important result of this collaboration. The handbook, translated from English to 20 more languages, has been downloaded more than 30 000 times.

Certainly, there is more to be done in order to make BIM the norm in public procurement for construction. The methodology for a cost benefit analysis for the use of BIM in public procurement is one of the first deliverables of the Renovation Wave Communication (2020)[7] and aims to build the case for the introduction of BIM in public procurement for individual public projects, by demonstrating costs and benefits from their perspective.

The methodology is based on so far used procedures and it is necessary to update it further according to the current development of the latest technical standards EN ISO 19650 series and EN 17412-1 developed by the standardisation organizations CEN and ISO.

The methodology was developed as part of the service contract GRO-SME-20-F-101, EASME/2020/MV/0001 with three main objectives:

1. The creation of a model that measures the costs and benefits for using BIM in public construction projects, also taking into account expenditures, revenues and non-monetary benefits
2. The validation of this model, demonstrating its relevance and practical applicability through 6 case studies, representative of different types of projects
3. The drafting of an informative and easy-to-consult handbook, addressed to public entities in the EU that want to learn more about this model

[1] European Industrial Strategy. European Commission (2021) https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en
[2] European Construction Sector Observatory https://ec.europa.eu/growth/sectors/construction/observatory/data-mapper_en
[3] Europe's digital decade. European Commission (2021) https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12900-Europe-s-digital-decade-2030-digital-targets_en
[4] https://ec.europa.eu/environment/gpp/eu_public_directives_en.htm
[5] http://www.eubim.eu/
[6] http://www.eubim.eu/handbook/
[7] Renovation Wave Communication. European Commission (2020) https://ec.europa.eu/energy/sites/ener/files/eu_renovation_wave_strategy.pdf

Abstract

This handbook represents the work carried out by RINA Consulting S.p.A. and its subcontractor, B1P Group S.r.l. in the framework of the service contract GRO-SME-F-101 'Methodology for cost-benefit analysis for the use of Building Information Modelling (BIM) in public tenders'. The document reflects the analysis performed during the project and the results obtained. It is conceived as an informative, easy-to-read guide meant to prepare the public stakeholders to apply the model developed for evaluating the costs and benefits of using BIM in public tenders. The cost-benefit analysis tool was designed starting from a preliminary analysis of several literature researches, that was essential to define costs and benefits of using BIM in public tenders. The indicators identified in this preliminary phase were then refined and validated with the support of targeted stakeholders through structured interviews and an online survey. The cost-benefit analysis (CBA) tool was then designed assuming that each project follows a three-phase process (planning and design, construction and operation and maintenance), using ad hoc formulas for the computation of each cost and benefit indicator identified in the first steps. The CBA tool was developed to be easily used by people with varying degrees of knowledge and experience of BIM and it was validated analysing real tenders across Europe that represent various types of projects. The real case studies helped producing a specific database in order to estimate the cost charged to the public clients necessary for 3D modelling an asset (starting from the estimated time needed for the modelling activities). The handbook describes six examples that reflect typical tenders launched by public entities (small-scale infrastructures and buildings with differing budgets and covering diverse phases of the life cycle) with the aim to provide a guide on the use of the tool and on its replication in real frameworks.

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Ilektra Papadaki: *European Commission, DG GROW*
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Souheil Soubra: *EU BIM Task Group, CSTB*
Corrado Marchetti: *European Innovation Council and SMEs Executive Agency (EISMEA)*

This handbook was compiled by a team lead by RINA Consulting S.p.A. and B1P Group S.r.l.:

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Matteo Proia, **Maurizio Giodice**: *B1P Group S.r.l.*

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Belgium	Atelier Stadsbouwmeester, city of Antwerp
	Municipality of Antwerpen
Bulgaria	Ministry of Regional Development and Public Works
	UACEG (University of Architecture, Civil Engineering and Geodesy)
Croatia	Arhitektura minimal d.o.o
	Arhitektonski studio Helman i Jukić
	Baldinistudio d.o.o.
	Croatian Chamber of Chartered Geodetic Engineers (HKOIG)
	Faculty of Architecture, University of Zagreb
	Institute IGH jsc
	State Geodetic Administration
Cyprus	Cyprus Energy Agency (CEA)
Czech Republic	Czech Agency for Standardisation (ČAS)
	Regional Office of the Pardubice Region
	Vysočina Region
Estonia	Estonian Ministry of Economic Affairs and Communications
	Estonian Transport Agency
	RB Rail AS (Rail Baltica)
	Riigi Kinnisvara AS
	TalTech (Tallinn University of Technology)
	TTK UAS Tallinn Tehnikakõrgkool
Finland	Finnish Transport Infrastructure Agency (FTIA)
	VTT
France	AITENDERS
	CEREMA
	CHU de Dijon (Centre Hospitalier Universitaire)
	EDF (Energy - Électricité de France)
	Groupe ADP SA (Aeroports de Paris)
	Ministère de la Transition Ecologique
	SNCF Gares & Connexions
	State Real Estate Directorate
	University of Caen Normandy
	VINCI
	BIM in Motion
Germany	The Federal Office for Building and Regional Planning (BBR)
	BImA (Institute for Federal Real Estate)
Greece	BIM Design Hub
	CERTH/ITI (Information Technologies Institute at the Centre for Research and Technology-Hellas)
	Dektis Consultant Engineers S.A.
	HELLASCO (The Hellenic Association of Consulting Firms)
	IsZEB (Intelligent Solutions for Zero and Positive Energy Buildings - DIH CNPC)
	Ministry of Environment and Energy - General Secretariat of Spatial Planning and Urban Environment
	PEDMEDE (Panhellenic Association of Engineers)
	Technical Chamber of Greece (TCG)

Ireland	Limerick Institute of Technology - Development Unit
	TU Dublin - School of Surveying and Construction Management
Italy	A2A Ciclo Idrico S.p.A
	ACEA Elabori S.p.A.
	Aeroporti di Roma (the managing company of the Rome airport system)
	AICOM S.p.A.
	Anas S.p.A. - Ferrovie dello Stato Italiane Group
	Bank of Italy
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	Energia Calabria
	Ferrotramviaria S.p.A.
	Graphnet S.r.l
	Hexagon
	Institute for Building Information Modelling Italy (IBIMI)
	Italian National Agency for New Technologies, Energy and Sustainable Economic Development - Laboratory Resources Valorisation (ENEA)
	IRE Liguria (Infrastructure Energy Recovery Ligurian Regional Agency)
	Italian State Property Agency
	Italian State Property Office, Liguria Regional Directorate
	Marche Region - Department of Health and Hospital Construction
	Ministry of Sustainable Infrastructures and Mobility
	Municipality of Bari
	Municipality of Florence
	Municipality of Genoa
	Municipality of Milan
	Municipality of Orsomano
	Municipality of San Lucido
	NKE
	Risorse per Roma SpA - In-house Agency of the City of Rome
	Roma Servizi per la Mobilita S.r.l.
	Piselli & Partners
	Polytechnic University of Bari, DICATECh Department of Civil, Environmental, Land, Construction and Chemistry
	Port System Authority of the Northern Tyrrhenian Sea
	Sport e Salute S.p.A
	UniGE (University of Genoa)
Latvia	Riga City Council Building Department
	State Joint-Stock Company ‘State real estate’
Lithuania	LTG Infra
	Ministry of Environment of the Republic of Lithuania
	Municipality of Vilnius
	State enterprise Lithuanian Road Administration
	Vilnius Development Company
	VGTU (Vilnius Gediminas Technical University, Department of Construction Technology and Management)
Luxembourg	CRTI-B (Centre de Ressources des Technologies et de l’Innovation pour le Bâtiment)
	Luxembourg Institute of Science and Technology (LIST)
Norway	Norwegian Mapping Authority
	BaneNOR
	Statsbygg
Poland	Politechnika Poznańska (University of Poznań)
Portugal	Iscte - University Institute of Lisbon
	Câmara Municipal de Lisboa (Lisbon City Council)
	Lisbon School of Architecture
	XISPOLI – Engenharia, Lda
Romania	Cluj-napoca City Hall
Slovenia	DRI upravljanje investicij, d. o. o. (DRI Investment Management, Ltd.)
	Housing Fund of the Republic of Slovenia
	Slovenian National Building and Civil Engineering Institute
	Slovenian Infrastructure Agency
	University of Maribor
	ZRMK d.o.o. (Building and Civil Engineering Institute)
Spain	ADIF (Railway Administrator)
	Barcelona City Council
	Ferrocarrils de la Generalitat Valenciana (FGV)
	Gorliz Town Council
	Ineco
	IteC - The Catalonia Institute of Construction Technology
	MITMA (Ministerio de Transportes, Movilidad y Agenda Urbana)
	Ministry of Finance - State Heritage
	Municipal Housing and Land Company of Madrid (EMVS)
	Municipality of San Cugat
	University of Extremadura
	University of La Laguna
	University of the Basque Country
Switzerland	Federal Office of Topography swisstopo
Turkey	Municipality of Başakşehir

Executive summary

Construction is a strategic sector for the development of the European economy, and governments and public players are its largest client base. However, there are some commonly recognised problems that could affect the construction process: levels of collaboration, under-investment in technology and R&D and poor information management.

Implementing Building Information Modelling (BIM) could both solve these issues and bring further benefits to public and private stakeholders, although the method of effectively evaluating these benefits remains to be worked out. For this reason, EISMEA, under the powers delegated by DG GROW, announced a tender to develop a methodology for cost-benefit analysis for the use of BIM in public tenders.

RINA Consulting S.p.A., together with its subcontractor, B1P Group S.r.l., were awarded this project that started on 1 September 2020 and lasted for nine months. The implementation of the contract, funded by the COSME programme of the European Union, was supervised by an ad hoc 'advisory board' composed of representatives from the European Commission, EISMEA and the EU BIM Task Group (EUBIMTG).

The aim of the project was to develop a model which enables EU public clients to measure the costs and benefits of using BIM in their public construction projects. The project addressed three main objectives:

- **COST-BENEFIT MODEL DEVELOPMENT**
- **MODEL VALIDATION AND CASE STUDIES**
- **HANDBOOK CREATION**

OBJ 1 - Cost-Benefit Model development

The model for measuring the costs and benefits (both monetary and non-monetary) of using BIM in public construction projects enables EU public clients to assess the estimated advantages for their specific projects on their own. The consolidated cost-benefit analysis model is tailored to the needs and challenges of stakeholders involved in BIM adoption and in its regular use throughout the whole life cycle of a built asset at various levels.

The development of the model:

- leveraged on extensive desk research aimed at obtaining a comprehensive overview of the actual cost-benefit models created and applied for measuring the impacts of BIM adoption in private and public projects
- was based on the identification and quantification of BIM-associated costs and benefits, properly weighted, by means of an online survey addressed to 122 stakeholders (mainly public entities at various administrative levels). This helped to understand the main challenges in the adoption of BIM and what the authorities consider as (monetary and non-monetary) costs and benefits
- relied on validation of the desk research findings through 40 structured interviews

The developed model:

- considers both financial and economic analyses which drive the users to the evaluation of the benefit-cost ratio to measure the value for money of using BIM, thus calculating the eventual profitability of using BIM in public projects
- allows the performance of a sensitivity analysis to verify the robustness of the model, the risk grade deriving from critical variables in the project and the measurement of their impacts on the sustainability of the project

OBJ 2 - Model Validation & Case Studies

The practical usage and relevance of the cost-benefit methodology was demonstrated with its application to several representative types of projects. It focused on small-scale infrastructures and buildings of various budgets and covered various phases of the life cycle (e.g., design, planning, construction and operation).
The new model was developed for its potential application throughout the entire European Union territory and for various framework conditions, through the analysis of real six case studies.

Each case study, representing different BIM maturity levels for specific types of assets and project life cycle phases, was analysed to show how costs and benefits can differ in diverse BIM maturity level scenarios.

Based on the analysis of the six real case studies, six separate tender examples have been produced which diverge from the original ones but may, in fact, be more representative of the projects most dealt with in Europe. The purpose of this exercise is to show that the cost-benefit analysis (CBA) model (downloadable at http://www.eubim.eu/) can be applied in every European country with various contexts and diverse starting conditions. Moreover, these additional sample scenarios serve as examples enabling increased understanding of the inputs required by the CBA tool and the interpretation of its results.

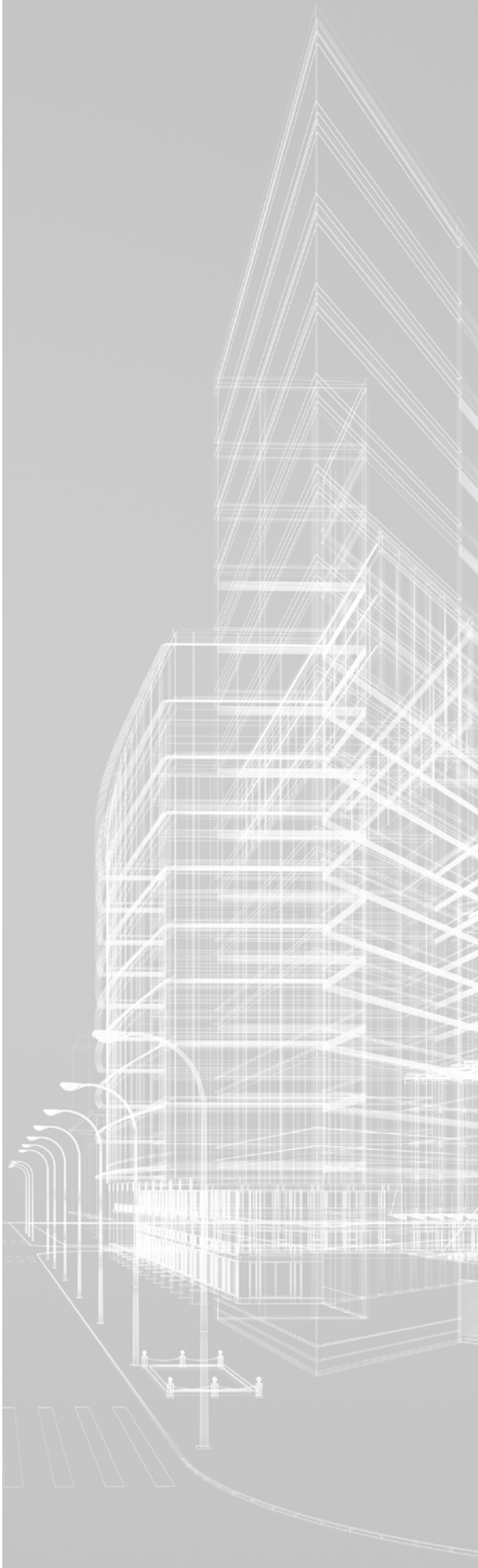
The intended outcome of the project is to provide the main beneficiaries of the model (e.g., public entities, policy makers, European Commission) with quantitative and qualitative information necessary to evaluate whether the use of BIM in public works is expected to be advantageous and sustainable.

OBJ 3 - Handbook creation

The third result is this handbook, an easy-to-read and illustrated document to serve as a guideline for the EU public entities wishing to learn about the BIM cost-benefit analysis and use it.

The handbook includes the problem definition as the lack of clear costs and benefits associated with BIM and the approach used for identifying and measuring these. Furthermore, it presents the model developed to simulate the costs and benefits of adopting BIM in public projects and the case studies that can guide the users in understanding better and utilising the model.

CONTENTS



1 Introduction

1.1 Construction sector, Sustainability and BIM

Digitalisation in the construction sector and its related monetary and non-monetary benefits is considered a key action for the improvement of productivity in the architecture, engineering and construction (AEC) industry, as well as in the operation and facilities management (FM) sector. Subsequently, the overall development of the European economy would also be boosted considerably by digitalisation.

The construction sector is strategic because of its capability to generate incomes from the built environment throughout its whole life cycle (from the design to the operation and maintenance phase), creating new jobs positions and services. In addition, the improved productivity of the AEC and FM sectors through the digitalisation of their processes could also generate high savings leading to economic upturn, especially at public level. The Government and public sector clients represent the construction industry's single biggest client. Therefore, the investment in improving the construction process at public level, represented by BIM methodology, is fundamental in helping ensure the success of digitalisation in the construction sector.

The construction industry, especially in the public sector, faces some commonly recognized issues such as low levels of collaboration, under-investment in technology and research and development (R&D), as well as poor information management. These issues then create a chain of problems which end up affecting the construction framework, resulting in poor value for money, unpredictable cost overruns, late delivery of projects and more project changes than are necessary.

It is widely understood that positive returns on investment can be achieved with Building Information Modelling (BIM) implementation[1]. There are two popular BIM maturity evaluation systems: the BIM maturity and the BIM maturity index levels (levels of initial/ad hoc, defined, managed, integrated and optimised). However, most organisations which are not familiar with BIM implementation or which are at the low maturity level refrain from adopting such comprehensive approaches, unaware of the related benefits of BIM process and how to evaluate them.

BIM, also known as n-D modelling, virtual model or virtual prototyping technology, can be defined as a collaborative process to produce, communicate and analyse construction projects using a digital information model throughout the project construction life cycle[2,3].

BIM is at the centre of a digital transformation of the construction sector and the built environment. Governments and public procurers across Europe and around the world are recognising the value of BIM as a strategic enabler for cost, quality and policy goals. Many are taking proactive steps to foster the use of BIM in their construction sectors and public asset delivery and operations to secure these economic, environmental and social benefits.
Benefits related to BIM have to be framed within the overall sustainability and environmental goals set for the AEC and FM sectors.
There has been a large number of studies elaborating the benefits of using BIM in the construction industry. In less than ten years, more than 900 studies on BIM utilisation have been published as academic papers, and most of these illustrate how BIM could change the construction industry, increasing its productivity[4,5]).

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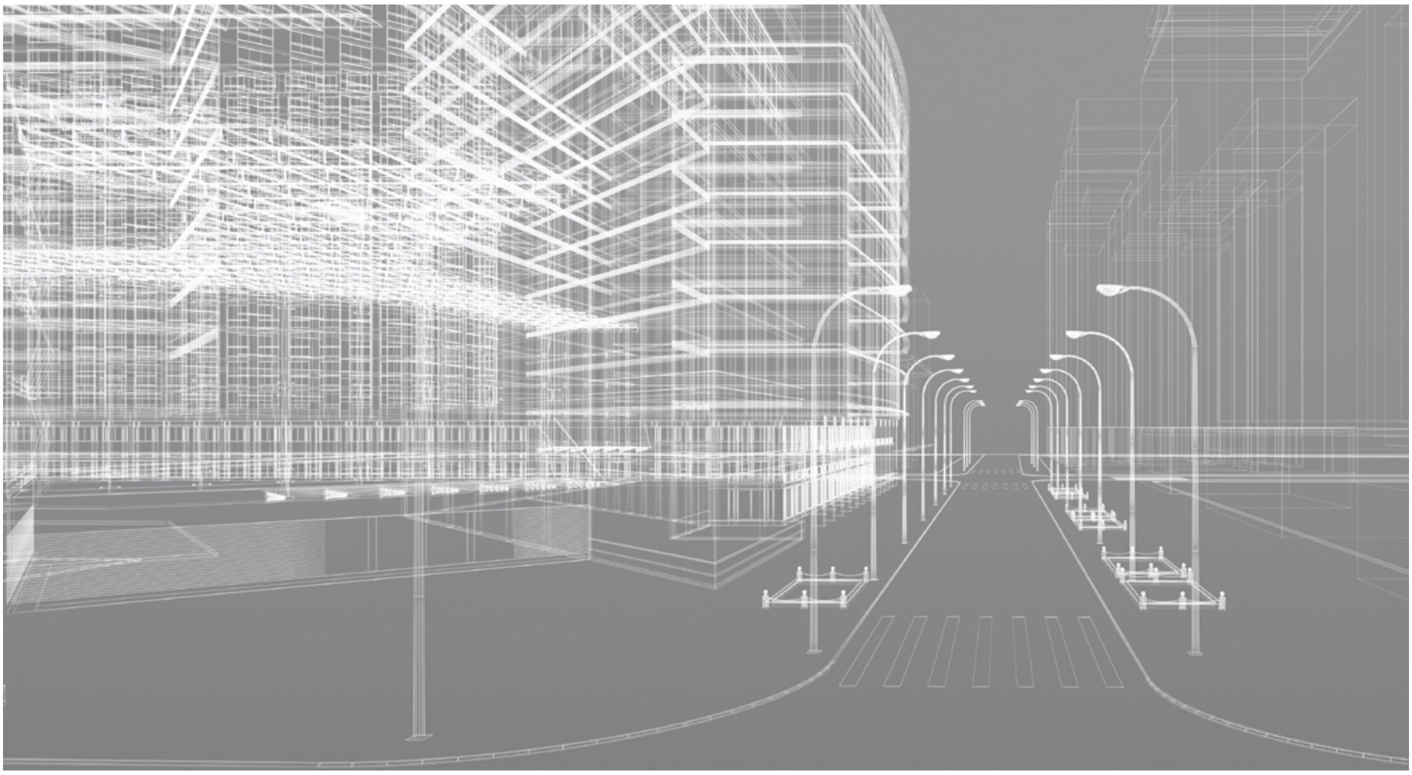
[1] Neelamkavil, J.; Ahamed, S. S. The Return on Investment from BIM-driven Projects in Construction. 2012
[2] Azhar S, Khalfan M, Maqsood T. Building Information Modeling (BIM): now and beyond. Australas J Constr Econ Build 2012;12(4):15-28.
[3] Eastman C, Teicholz P, Sacks R, Liston K. BIM handbook A: a guide to building information modeling for owners, managers, designers, engineers, and contractors. 2011.
[4] Volk, R., J., Stengel and F., Shultmann (2014) Building Information Modelling (BIM) for existing Buildings - Literature Review and future Needs. Automation in Construction 38: 109-127
[5] Yalcinkaya & Singh (2014) Building Information Modelling (BIM) for Facility Management - Literature Review and Future Needs. Product Lifecycle management for a Global Market: 1-10

Various studies have shown how effective BIM is and considerable effort has been put into identifying the benefits and obstacles of using it [6,7]. From these scientific papers it appears that BIM technology can improve the life cycle control of the built environment, considering the construction phase, the design activities and the quality of an asset, as well as the decision-making process and risk management practices. Among the positive aspects of using BIM the main benefits are recognised in the ability to share information, in the reduction of construction and design errors[8], faster working environments, enhancing efficiency, operational efficiency, and so on. Some of the aspects mentioned here have been further investigated during this project and the results of this analysis can be found in the following sections 2.2 and 2.3.

Therefore, with its three-dimensional ability combined with the versatility to control vast amounts of associated data, BIM is supported by many industry professionals as an effective tool for improving the construction industry.

Among the positive aspects of using BIM the main benefits are recognised in the ability to share information, in the reduction of construction and design errors , faster working environments, enhancing efficiency, operational efficiency, and so on.



[6] Li J., L. Hou, J. Wang and X. Wang (2014) A Project Based Quantification of BIM Benefits. International Journal of Advanced Robotic Systems, 11(1):1
[7] Dakhil A., J. Underwood, & M. Al Shawi (2016) BIM benefits-maturity relationship awareness among UK construction clients. Conference: Proceedings of the First International Conference of the BIM Academic Forum Held at Glasgow Caledonian University, Glasgow, September 13-15, 2016 (ISBN – 9781905866816)
[8] Ho Shin M.,H. Kyung Lee and H. Yong Kim (2018) Benefit–Cost Analysis of Building Information Modeling (BIM) in a Railway Site. Sustainability 2018, 10(11), 4303

1.2 Purpose of this handbook

This handbook will prepare the reader to apply the model developed for evaluating the costs and benefits of using Building Information Modelling (BIM) in public tenders without the need for any additional resources.

This informative, easy-to-read and illustrative handbook is aimed at public stakeholders who want to learn about BIM cost-benefit analysis and who wish to implement recommendations for the introduction of BIM as part of a wider change programme.

What the handbook IS:

- a document that clearly describes the new BIM cost-benefit methodology, and develops a theoretical map of how those benefits could drive public stakeholders toward BIM adoption and implementation
- a guideline for the identification of the costs and benefits of BIM, covering some aspects that, at the moment, are not so clear (e.g. cost-benefit ratio)
- a collection of strategic recommendations for widening BIM usage in the public construction sector
- a practical guide to replicate the proposed cost-benefit analysis (CBA) methodology and assess BIM process viability for any public tender

What the handbook IS NOT:

- a technical introduction to BIM (which is covered widely in other literature) or a development of standards that could 'com pete' with documents produced by standards bodies, academia and industry association

The handbook includes:

- Problem definition (i.e., BIM can be beneficial although its cost-benefit ratio is not clear)
- The approach used for identifying and measuring the potential costs and benefits
- The model that public organisations can use to simulate the costs and benefits of their projects
- Case studies which could guide the model users in the methodology application and results interpretation

1.3 How to use this handbook

EU public authorities, for whom this handbook has been written, can use it to:

- provide a practical and easy-to-understand model which can directly simulate costs and benefits in an individual construction project
- promote the introduction of Building Information Modelling (BIM) in the public construction sector, one of the least digitalised industries. Many researchers have highlighted awareness of BIM implementation and its benefits as important aspects to encourage its adoption by industry as a new method of delivering projects. However, some aspects of BIM adoption still remain unanswered, for example, the method for working out the cost-benefit ratio; this handbook intends to address this issue
- define a clear new cost-benefit analysis (CBA) BIM methodology for identifying and measuring potential costs and benefits
- describe practical case studies, to be considered as reference examples on how to use the CBA model
- bring the current understanding of the AEC and FM sectors closer to the costs and benefits (both monetary and non-monetary) of using BIM in public tenders
- stimulate, through a wider introduction of BIM and implementation of a new BIM cost-benefit methodology, competitiveness and economic growth while delivering value for public money
- encourage greater dialogue across the public and private sectors for further collective actions, accelerating growth and fostering competitiveness in the construction sector, especially in the Small and Medium Size Enterprises (SMEs)
- provide support to enable Governments and public sector clients to transition construction to the digital era

1.4 Target groups

Public entities at various administrative levels (national, regional, local) are the main target groups of this handbook. However, the EU BIM Task Group has also identified the following target groups:

Public policy makers involved in the development of policy for infrastructure or construction sectors

National or local public clients/procurers primarily concerned with service procurement

Operators responsible for the ongoing management and operation of the built asset or environment

2 Where are we now? Background analysis

2.1 BIM and public sector stakeholder needs

Building Information Modelling (BIM) methodology is recognised as a strategic process for achieving digitalisation in the architecture, engineering and construction (AEC) industry, as well as in the operation and facilities management (FM) sector, especially considering the public framework

The adoption of BIM enables the cost, quality and policy goals to be met through its coordinated approach and the interoperability between all the disciplines involved in a building project.

The public sector can benefit from the adoption of BIM in three distinct stakeholder roles:

- Public procurer or an infrastructure and estate owner concerned with the project phase (i.e., delivery of built assets)
- Public infrastructure and estate owner concerned with the operations and maintenance phase (i.e., use of public built assets)
- Policymaker concerned with the development of legislation, policy, regulations or standards for improving performance of the sector or built environment (i.e., sector focus)

The analysis performed during the project highlighted a heterogeneous status of BIM implementation and thus various levels of BIM maturity in the public sector across Europe. Even though most of the organisations displayed good knowledge of BIM processes, the perception is that this could be considered a fairly new methodology, not yet fully consolidated.

The experiences collected from the interviews and online survey indicated that BIM could reduce the overall costs of a project during its life cycle, solving the collaboration issues and lowering the number of unexpected changes. Nevertheless, the lack of short-term benefits, together with a long payback period are listed as the main negative factors slowing down BIM adoption. Cultural resistance to changes in the traditional procedures plus the lack of a legislative framework and an incentives system are seen as the main barriers to the development of BIM in the public sector.

However, on the positive side, several benefits are achieved from the adoption and use of BIM in a public organisation. These benefits include improved management of a construction project throughout its life cycle, reduced times when compared with the traditional processes and the achievement of a higher quality product. Indeed, the use of BIM processes allows storage of large amounts of data, cutting down on errors and unforeseen changes and collaboration and interaction with various disciplines.

The experiences collected highlighted that a large number of public organisations which have adopted or are willing to implement BIM do so not only to produce Exchange and Organizational Information Requirements[1] (EIR and OIR), but also to check the models and verify their compliance with the tendered specifications. In this framework a primary goal refers to the improvement of the coordination activities, during the construction phase, however an additional ambition relates to the exploitation of the information stored, in order to improve the management and maintenance of the public asset.

The lack of short-term benefits, together with a long payback period are listed as the main negative factors slowing down BIM adoption

[1] or older version of Employer and Organisation Information Requirements according to BSI/PAS 1192 series

2.2 Literature review

Literature review has been a preliminary essential step in identifying costs and benefits of using BIM in public tenders. Twelve main scientific documents have been selected based on the high relevance of the information they report and they are indicated at the end of this section. More specifically, the first five scientific papers of the provided list were identified considering their valuable insights on other past cost-benefit analysis experiences. The information collected refers to the approaches used for measuring costs and benefits associated with BIM adoption. It was useful to evaluate how those methodologies were tested and validated through case studies and understand the main challenges faced by researchers. The information analysed also highlights the critical risks to be addressed during the design of the methodology. Seven additional literature sources were carefully examined in order to define a suitable list of indicators for capturing the most significant costs and benefits for the adoption of BIM in public tenders.

The key elements which emerged from the analysis of each resource were fundamental for the identification of indicators that a consistent cost-benefit analysis (CBA) should involve. The most significant costs and benefits reflecting the point of view of the public clients are summarised in the following table. It is worth highlighting that the literature review results have been reinterpreted considering the public clients' perspectives.

BENEFITS

INDICATOR	MEASURABILITY AND COMMENTS
Savings related to early clash detection	These items are related to the reduction of costs from the creation of a high-quality model which enables the detection of interferences and errors during the design phase, preventing expensive changes during the construction stage of a project
Savings related to prevention of changes in construction phase	
Savings associated with schedule reduction	These values are associated with the quantification of the time saved using BIM for a project
Savings associated with accuracy in quantity take-offs	This benefit is associated with more accurate estimates of the required material and the connected activities
Environmental benefits	The environmental benefit is associated with a reduction in the quantity of material wasted and so with the overall CO_2 emissions of the project
Savings associated with lower risks (enhanced certainty)	This value is an advantage for the enhanced certainty in expenses. After careful consideration, this benefit was excluded from the CBA as it does not reflect the condition of a large set of public clients across Europe
Savings realized in FM and maintenance activities	Savings made through BIM adoption in the operations phase (once the asset has been completed) are often referred to as those largest in size and being realised over a longer period of time
Savings associated with lower number of litigations	These last two items are event-related benefits whose quantification is strictly dependent upon the occurrence of an event, e.g., a litigation, a claim or an accident, and the associated costs of settling the individual negative issue
Savings related to better H&S	
Enhanced communication and collaboration	These are the most mentioned benefits connected to BIM adoption and cited in the majority of literature sources reviewed. This indicator was excluded from the CBA, as a credible universal estimate of this advantage in monetary terms could not be calculated, especially considering the 'ex-ante' nature of the analysis provided by the CBA methodology

COSTS

INDICATOR	MEASURABILITY AND COMMENTS
Hardware related investments	These three investment items were mentioned in various resources as the most relevant expenses associated to BIM adoption
Software related investments	
Training related expenses	
Design phase cost/ BIM model creation	This cost is associated with the BIM model creation expenses which are charged to the public entity
Consulting costs	This expense appears to be significant (especially in the early stages of BIM adoption)

Besides the costs and benefits, several limitations and challenges which dealt with the employment of BIM in the construction industry were also reported by various authors. The research underlined that both a comprehensive database of BIM adoption experiences and a common baseline for evaluating BIM implementation impact are still missing. In this framework, the various costs and benefits have so far been quantified using diverse approaches, based on differing assumptions, reflecting the perspectives of diverse stakeholders and employing case-specific data.

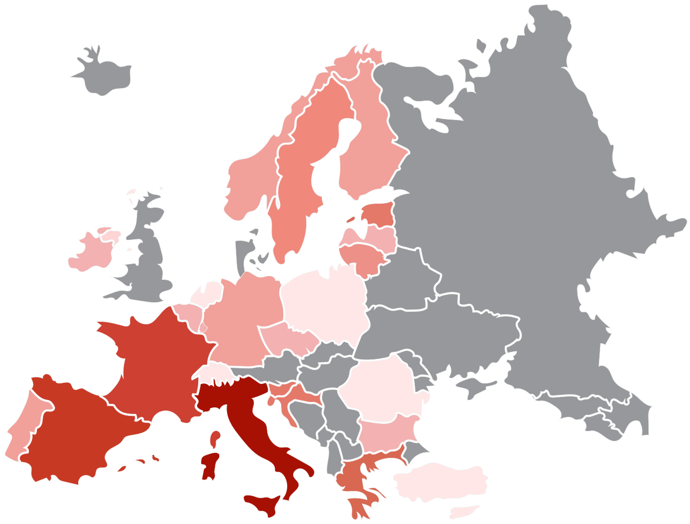
The research underlined that both a comprehensive database of BIM adoption experiences and a common baseline for evaluating BIM implementation impact are still missing.

Main Reference methodology/study

- **The Economics of BIM and added Value of BIM to Construction Sector and Society,** Schultz, A., U. M. Essiet, D. V. Souza de Souza, G. Kapogiannis and L. Ruddock (2013)
- **BIM Level 2 Benefits Measurement (the full report),** PWC (2018)
- **Benefit-Cost Analysis of Building Information Modeling (BIM) in a Railway Site,** Shin, M. H., H. K. Lee and H. Y. Kim (2018),
- **The Potential Cost Implications and Benefits from Building Information Modeling in Malaysian Construction Industry,** Chai, C. S., C. S. Tana, E. Aminudina, S. C. Loob, K. C. Gohc, M. C. Theongd, X. S. Leed, L. W. Chin (2017)
- **Building Information Modelling: Evaluating Tools for Maturity and Benefits Measurement,** M. Kassem, J. Li et al., (2020)
- **Cost-benefit analysis of Building Information Modeling implementation in building projects through demystification of time-effort distribution curves,** W. Lu, A. Fung, Y. Peng, C. Liang, S. Rowlinson (2014)
- **The project benefits of Building Information Modelling (BIM),** D. Bryde, M. Broquetas, J. M. Volm (2012)
- **How to Measure the Benefits of BIM, A Case Study App roach,** K. Barlish (2011)
- **Cost Benefit Analysis of implementing Building Information Modeling (BIM) for construction management of the Sports Arena of University of Alaska Anchorage,** C. C. McConnell (2014)
- **A Project-based Quantification of BIM Benefits,** J. Li, L. Hou, X. Wang, J. Wang, J. Guo, S. Zhang and Y, Jiao (2014)
- **The key performance indicators of the BIM implementation process,** P. Coates, Y. Arayici, L. Koskela, M. Kagioglou, C. Usher and K. O'Reilly (2010)
- **Creation of Formula to Predict Time and Cost Benefit by Using 5D BIM Rather than Traditional Method of Construction,** A. Khan and A. Muneeb (2019)

2.3 On-site data collection: interviews and online survey results

With the aim of accurately quantifying the indicators assessed through the literature review, an online survey was distributed to a list of public contractors and telephone interviews were conducted with selected stakeholders. This activity enabled the measurement, in practice, of the effects associated with the implementation of Building Information Modelling (BIM) in the public construction sector, through ad hoc questions and relying on the direct experience of public stakeholders.



Countries involved in the surveys and interviews

Interviews results

40 stakeholders from various European countries were interviewed. They were able to provide helpful perspectives on BIM implementation in a public framework. Amongst these were public authorities, national companies, research institutes and universities. All participants supplied very interesting information based on their unique experience with BIM, not only from its direct adoption but also in their support for organisations which are implementing BIM.

The interviews were individual and semi-structured; the questions were focused on identifying the main costs and benefits and strengths and weaknesses of using BIM. The information which was collected and analysed further emphasised that BIM adoption in public procurements is a very long and complex process, more related to a deep cultural change towards digital thinking rather than simply the introduction of new software and hardware to support the regular work.

Two main topics emerged from the interviews:

- the main benefits, weaknesses, opportunities and threats found in the processes which lead a public administration to adopt and regularly use BIM in public procurements
- the costs associated with the integration of BIM methodology in the common procedures within a public organisation

A SWOT analysis was set up in order to present the results obtained in terms of strengths and weaknesses directly associated with the implementation of BIM. Threats and opportunities were also identified as barriers which could slow down the process or as vehicles to foster it.

BIM adoption in public procurements is a very long and complex process, more related to a deep cultural change towards digital thinking rather than simply the introduction of new software and hardware to support the regular work.

BIM ADOPTION IN PUBLIC TENDERS	STRENGTHS	WEAKNESSES
	Improvement in management and coordination	Few or no benefits at the beginning
	Improvement in maintenance activities - operation phase	Low productivity and additional effort required
	Reduction of contingencies through improvement of clash detection and quality check	Specific knowledge and expertise required
	Improved time management and efficiency in time scheduling	High costs of adoption
	Improvement in costs estimation and information management	Complexity and lack of flexibility
	Reduction of total projects' costs	Interoperability issues
	Improvement in projects' quality	

BIM ADOPTION IN PUBLIC TENDERS	OPPORTUNITIES	THREATS
	Regularisation and streamlining of the national AEC and FM procedures	Lack of a clear regulatory framework and incentives for adoption
	Digitalisation of the AEC and operation and FM sectors	Cultural and procedural obstacles
	Specific studies on and analyses of costs and benefits associated with BIM	Monopoly of certain software companies
	Development of a clear regulatory frameworks and introduction of incentives	High costs of adoption

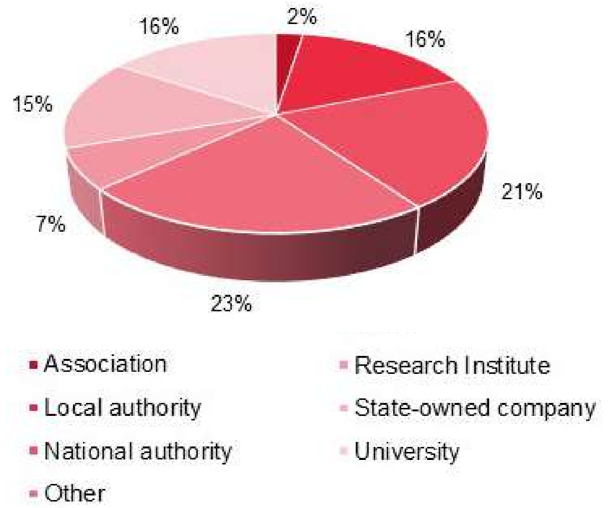
Regarding the costs associated with the use of BIM, the main outcome of the interviews is that the initial costs of starting to use BIM methodologies are higher than the immediate benefits gained. These costs refer in particular to the necessary training for the staff and to the required software and hardware. It is commonly agreed that an estimate of the return of the investment associated with BIM adoption can be assessed only after several years from its implementation. However, after those initial expenditures, no more extra costs are identified and all the expenditures are completely absorbed by the projects' costs. In this context, it is worth recalling that the point of view used to develop the methodology corresponds to the one of the public client/procurer and not to architectural or engineering firms' nor to contractors'.

AVERAGE COSTS FOR BIM ADOPTION			
Training costs (cost/person)	Software licenses costs - modelling & verification (person/year)	Hardware costs (cost/person)	Total costs (cost/person considering the first year of adoption)
5 - 8 k€	8 – 10 k€	2 - 3 k€	15-20 k€

Survey results

The invitation to complete the online survey was sent to more than 500 potential respondents in European countries and 122 of these complied. This sample is made up of respondents from various public and private entities categorised as: 'national authority', 'local authority', 'state-owned company', 'university', 'association', 'research institute' and 'other' comprising organisations which cannot be included in the previous categories (e.g., architectural firms, engineering firms, companies which are only partially state-owned, chambers of commerce and NGOs).

Each respondent was required to self-assess the BIM maturity level of their entity based on the descriptions contained in the table below, based on Bew's and Richards' study[1] from 2008:

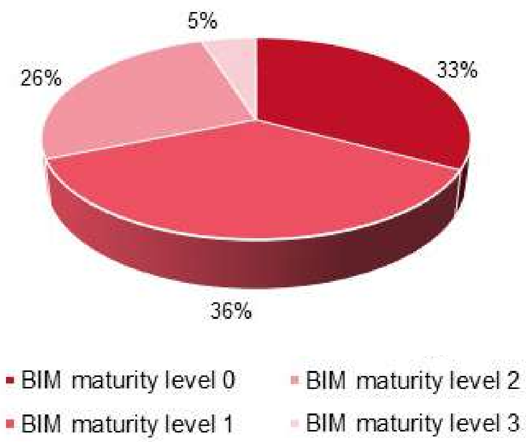


Sample distribution of survey participants broken down by category

BIM Maturity levels description[2] (extracted from the survey)

BIM Maturity Level	Description
Level 0	There is very little collaboration among stakeholders and 2D CAD drafting is employed - BIM is not adopted
Level 1	Both 2D and 3D CAD drafting is employed and information on the project are shared among stakeholders through a Common Data Environment
Level 2	Each stakeholder works on its own 3D model, but a federated model exists, time-management and cost-management information are shared among stakeholders
Level 3	All project stakeholders are working on a single shared 3D model and the model is employed also to carry out facility management and maintenance

Almost 70% of respondents indicated that their organisation belongs to BIM maturity level 0 or 1. 26% belongs to BIM Maturity Level 2 while only 5% declared to be at BIM maturity level 3. (See Figure below) No statistically significant pattern was identified correlating the geographical location with a particular BIM maturity level.



BIM maturity level distribution of the sample

[1] Bew, M., & Richards, M., 2008, BIM Maturity Model. Paper presented at the Construct IT Autumn 2008 Members' Meeting. Brighton, UK.
[2] This BIM maturity level matrix is currently replaced with EN ISO 19650 concept and it is used only for the purpose of this version of the document and tool.

The main results obtained from the survey show the current state of BIM adoption in the public construction sector: the project phases in which BIM is employed and the most common costs and benefits associated with each phase.

As indicated in the following graphs, it appears that most public procurers tend to adopt BIM in the design phase. The highest expenses, however, were found in the renovation projects, design and operations phases.

With regard to BIM associated benefits (and savings), most of the stakeholders agreed that BIM can generate a substantially positive impact during the operations phase (including facility management and maintenance activities).

This result is extremely interesting when combined with the fact that, as highlighted above, only a small percentage of respondents' organisations (less than 20%) are employing BIM during this phase. Hence, it appears that the majority of public procurers expect to obtain substantial benefits from the BIM model used for facility management and maintenance activities.

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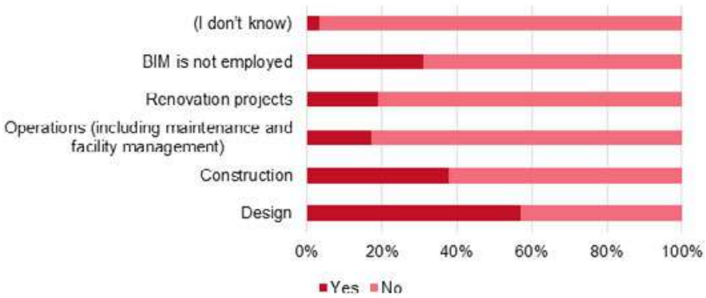
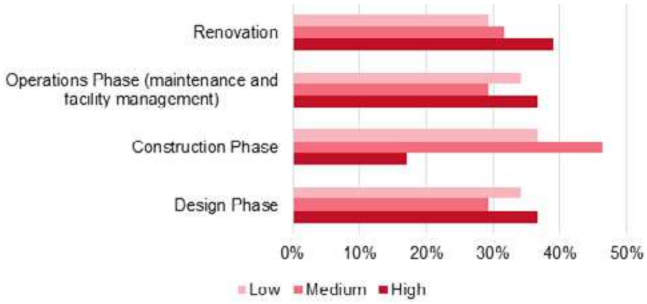
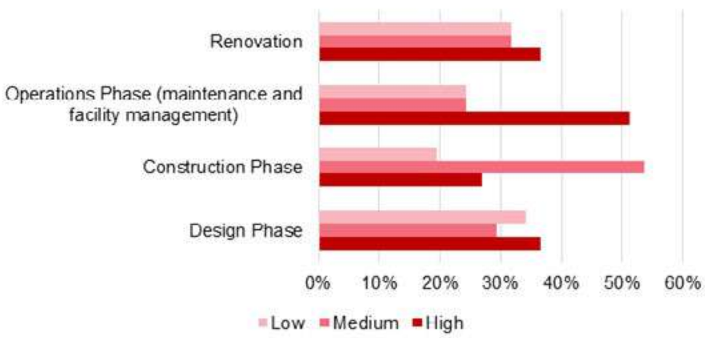


Project phases in which BIM is mostly employed by public procurers



BIM adoption associated costs for each phase



BIM adoption associated benefits for each phase

3 Is BIM cost-effective for public entities? Development of Cost-Benefit Analysis tool

3.1 Approach: CBA, BIM and public authorities

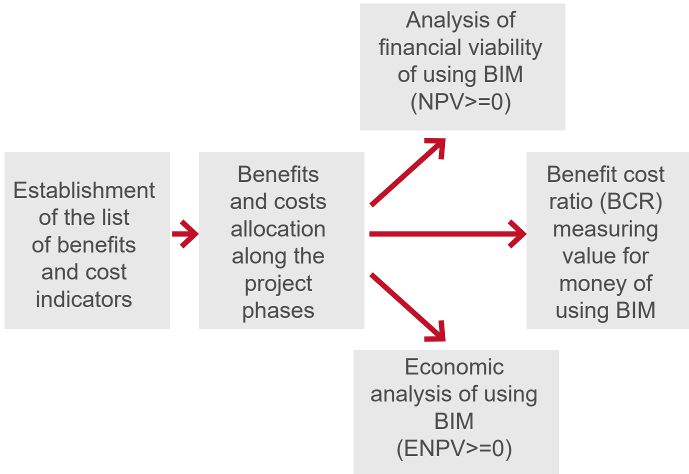
The need to produce such a cost-benefit analysis (CBA) tool (downloadable at http://www.eubim.eu/) relates to the fact that Building Information Modelling (BIM) is a critical driver in the digitalisation of the construction sector in Europe. Despite the many advantages that are often attributed to its employment, a consistent and replicable methodology for estimating BIM's concrete impact on public tenders appears necessary to foster its adoption further. The tool enables EU public clients to assess the costs and advantages of adopting BIM in their specific projects. It was developed following a consolidated cost-benefit analysis methodology tailored to the needs of and challenges faced by public stakeholders.

The cost-benefit analysis tool was designed for ease-of-use by people with varying degrees of knowledge and experience of BIM.

The steps followed to reach this aim are reported below and are expanded upon in the previous and following chapters:

- Literature review and identification of main BIM cost-benefits
- Validation of the literature research through the on-site consultation phase: online surveys and telephone interviews
- Definition of the tool
- Application of the tool in practical case studies, representing various types of projects (small-scale infrastructures and buildings with differing budgets and covering diverse phases of the life cycle), in order to refine and validate the model

The definition of the tool followed the process described in the block diagram, starting with the monetary and non-monetary cost-benefit indicators identified and selected in the previous phases of this study. Next, it was assumed that each project follows a three-phase process, starting with 'Planning and design', then 'Construction' and, finally, 'Operation and maintenance'. Ad hoc formulas were established for the computation of each indicator whose value was set to be automatically allocated over a time-period reflecting the project specifications. The difference between benefits and costs related to BIM adoption over the period enabled the computation of the project-related cashflow. In this context, benefits consist of savings arising from BIM adoption in the project, while costs relate to additional expenses associated with BIM implementation in the project and a share of the investments necessary for its adoption. The cashflow obtained, once discounted, led to the computation of the Net Present Value (NPV). Two versions of this indicator were considered: the NPV, addressing solely the financial viability of adopting BIM in the project, and the ENPV (Economic Net Present Value) which incorporates positive environmental and 'social' externalities in the analysis. When the value of these two indicators is positive (NPV>=0 and ENPV>=0), the implementation of BIM in the project is considered a sustainable solution. By analysing benefits and costs separately, it is possible to measure how much benefits exceed costs and how many euros are gained for each euro invested in BIM. This value is given by the Benefits-Costs Ratio (BCR) and is a measure of the so-called Value for Money (VfM).



The methodology was built to carry out an ex-ante assessment of the use of BIM in a public procurement process. In this framework the results cannot capture and reflect the information that could be easily collected through an ex-post analysis. Therefore, the tool relies heavily on preliminary established values in order to limit the amount and complexity of information required by the user. These values ensure that the tool can be used to assess the sustainability of adopting BIM in various investment projects, providing estimates of related costs and benefits.

By analysing benefits and costs separately, it is possible to measure how much benefits exceed costs and how many euros are gained for each euro invested in BIM.

3.2 Methodology: model for identifying and measuring potential costs and benefits

The work carried out during the project led to the creation of the CBA tool for estimating the costs and benefits of employing BIM in a construction project.
As described in the previous chapters of this handbook, the study began with the review of several existing research projects and methodologies to measure benefits and costs associated with BIM adoption. The findings of the literature review process were combined with the results of the online survey, and discussed further during the interviews conducted throughout the study. These steps led to the definition of the list of cost and benefit indicators reported below.

COSTS

Public entity personnel labour cost increase during pre-tendering phase	Costs related to lower productivity and additional effort required
Public entity personnel labour cost increase during tendering phase	
Public entity personnel labour cost increase during post-award phase	
Increased cost for consulting services to the public procurement process	
BIM modelling activity cost	
Public entity hardware upgrade investment	BIM related investment costs - share allocated to the specific project
Public entity annual software license fee	
Personnel training costs	
BIM coordination cost	

BENEFITS

Cost reduction due to early clashes and errors detection with subsequent reduction of changes necessary during construction phase
Cost reduction associated to more precise quantity take-offs
Cost reduction related to lower costs for claims/litigations
Time savings in design and construction phases and associated project duration reduction
Public entity personnel labour cost reduction due to faster document analysis for facility management and maintenance
Cost reduction associated with more efficient annual maintenance
Cost reduction attributable to the government/society due to better Health & Safety
CO_2 emission reduction due to reduced material wasted

THE WORK BEHIND THE CBA TOOL

Background computations

The CBA tool calculates most of the indicator values relying on a database created using the data collected in the online questionnaire. The computations of the cost and benefit indicators follow various approaches which were adopted to capture and reflect the specificities of each possible project assessed using the CBA tool. The value of a set of those indicators varies depending on the BIM maturity level considered; both level 1 and 2 scenarios are provided for each project.

As an example of how the CBA tool calculates the values of the costs, three diverse approaches are presented.

Approach 1 used to obtain the values of the following indicators

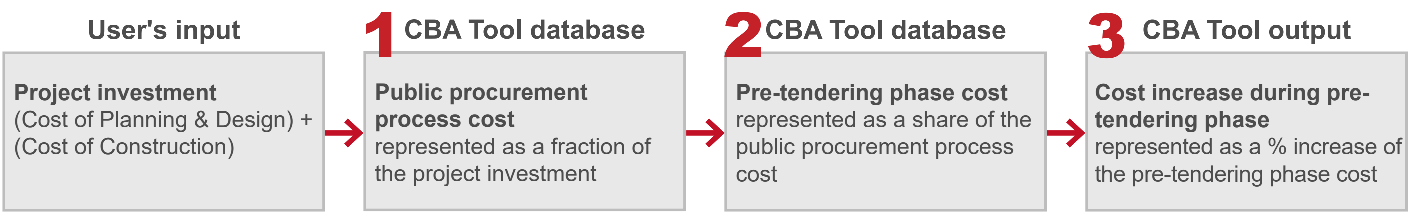
- Public entity personnel labour cost increase during pre-tendering phase
- Public entity personnel labour cost increase during tendering phase
- Public entity personnel labour cost increase during post-award phase
- Increased cost for consulting services to the public procurement process

When the investment cost of a project is indicated as an input, the method for calculating the values of these indicators can be described in three phases:

1. Computation of the public procurement process cost. From the survey results, an average percentage (whose value is dependent upon the investment value) was extracted. This percentage represents the public procurement process cost connected to the specific project investment in a scenario where BIM is not adopted. For example, for investments between 1 and 5 million euros, the public procurement process cost is represented by about 8.5% of the total investment value

2. Extraction of four expense items (e.g., Public entity personnel labour cost) from the resulting cost of the procurement process (once again related to a baseline scenario without BIM). Each item represents a share of the procurement process value (the value of each share is once again obtained from the analysis of the survey results)

3. Application of a percentage increase representing additional costs, efforts and/or productivity reduction related to the use of BIM in the project.



At the same time, the BIM-related cost increase is dependent upon a set of additional variables which affect the related percentage used in each scenario. In particular, concerning the cost increase involving the pre-tendering and tendering phases of a procurement process, the additional variables impacting the computation are:

- The BIM maturity level of the scenario which is being considered (1 or 2)
- The level of experience of the public client with BIM (some or no experience)
- The ‘Project category’ (‘New asset construction’ or ‘Work on an existing asset’)

These factors increase or decrease the related expense item by pre-fixed percentages which were established following both discussions with stakeholders and experts and internal assumptions.

Approach 2 used to obtain the value of BIM modelling activity cost

The 'BIM modelling activity cost' computation follows a completely different process that was established on the analysis of six real case studies. In particular, it was possible to produce an ad hoc database in order to estimate the time necessary for 3D modelling an asset.

The assets of the case studies were modelled following the specifications of the relative tender documentation and recording the actual time necessary for this activity. Furthermore, the time required to perform additional activities such as the quantity take-off extraction was also recorded. These data were analysed and, after several tests and discussions, they were used to establish the basic effort time necessary to model different areas and MEP systems of individual assets.

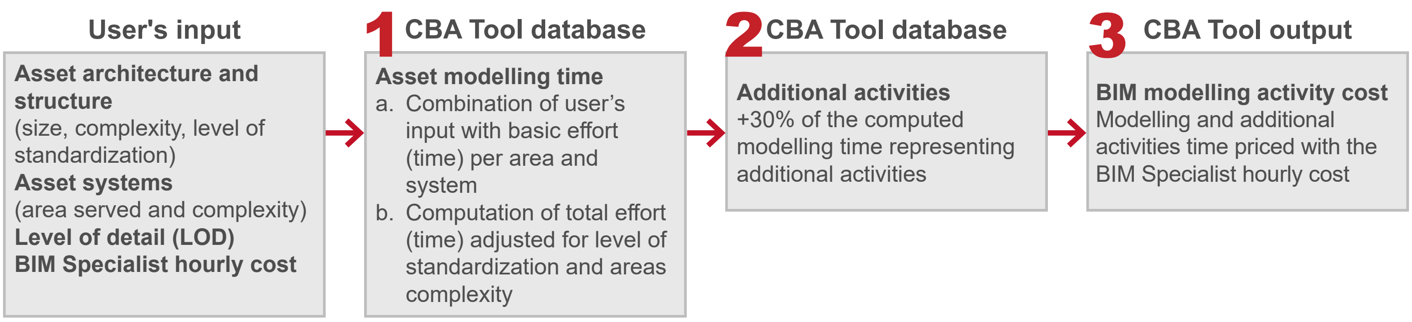
In this framework, two slightly similar approaches were developed in order to differentiate the cases in which the asset under study can be categorised as "Building", "Infrastructure" or as a "Mixed" asset (an infrastructural asset with building(s) included in its area).

The overall approach can be summarised in three phases:

1. Once the inputs related to the asset are inserted in the CBA tool, the resulting number of hours necessary for the 3D modelling activities are calculated based both on this information and on the internal database. The modelling time is established in relation to the level of detail of the model, the size of the areas to be modelled, their average level of complexity and the level of standardisation. The latter refers to the extent to which an area already modelled could be replicated in order to obtain other parts of the same building. A similar approach was also adopted for the systems whose modelling time depends on their complexity and the size of the area served

2. The modelling time is then increased by a percentage which represents the activities to be developed after the modelling process. These activities can be summarised as follows: initial documentation analysis, production of 2D drawings from the 3D model, quantity take-off extraction and other activities foreseen by the tender specifications or by the public authority

3. The resulting number of hours is subsequently priced in line with the national hourly cost of a BIM Specialist in the country where the asset is located



The BIM coordination cost in the case of a scenario with BIM maturity level 1 is proportional to the modelling time and adjusted according to the complexity of the asset architecture, structure and systems.
Level of detail (LOD) in the part User´s input is a value connected to the geometrical information only. The concept is based on USA AIA/BIMForum.org documents and it is used only for the purpose of this tool and not as a general rule. The general rules for use in EU are currently developed as the standard EN 17412-1 on level of information need.

Approach 3 used to obtain the value of BIM related investment costs

For the computation of BIM-related investment costs, the approach can be explained directly through an example: the 'Public entity hardware upgrade investment'. The methodology employs once again an average value extracted from the survey: the hardware upgrade cost per employee of the public organisation. In the context of this indicator computation, this average value is directly multiplied by the ratio of the number of employees involved in BIM-related activities (whose daily work is affected by the introduction of BIM in the organisation, who either need to start using new software and/or attend trainings) and the average number of projects using BIM in a year. It is a simple approach which enables the user to account for a limited share of the overall hardware upgrade investment in each organisation project.

User's input		CBA Tool database		CBA Tool output
Number of employees involved in BIM related activities needing to attend training and/or start to use BIM-related software **Average number of projects per year that adopt/will adopt BIM** in case of organizations without prior experience with BIM	→	**Hardware upgrade investment** 1. Combination of the two user's input to obtain the number of employees affected by BIM introduction assigned to each project 2. Combination of the previous result with the average hardware upgrade cost per employee extracted from the survey	→	**Hardware upgrade investment allocated to the project** Considering an average cost per employee applied on every project

For each cost and benefit included in the methodology, the tool allows the user to select whether he/she is willing to exclude the specific indicator from the computation. This option was included to encompass scenarios where not all cost savings and cost increases occur simultaneously in the project. For example, a public organisation might want to avoid accounting for hardware-related investments while assessing the use of BIM in a project. It might also be willing to exclude the possibility that any reduction in the project schedule might occur in relation to BIM adoption.

With regard to benefits, computations are generally more straightforward as, for most of these, an average percentage extracted from the survey is directly applied to the estimated project-related investment. Once again, additional factors like those affecting the BIM impact on the procurement process cost, reported above, affect the computation. For example, the benefit related to early clashes and error detection is computed on the project construction investment, but its value is adjusted depending on:

- Level of information need according to EN 17412-1, or another methodology (f.ex. LOD 200/350 or 450/500 according to BIMForum.org. This concept is used in the current version of the CBA tool)
- The 'Project category' ('New asset construction' or 'Work on an existing asset')

Another example is represented by the 'Cost reduction attributable to the government/society due to better Health & Safety' for which an average number of accidents avoided per construction project was established and priced, based on an estimated average societal cost of work-related injuries and illnesses (per case) in Europe.

For each cost and benefit included in the methodology, the tool allows the user to select whether he/she is willing to exclude the specific indicator from the computation, in order to encompass scenarios where not all cost savings and cost increases occur simultaneously in the project.

Allocation of the indicators along the project phases

Once the basic value of each cost and benefit is established, it is allocated over the project period, depending on the duration of each phase. The 'Planning and design' phase duration varies between 1 and 5 years, the 'Construction' stage duration ranges between 1 and 10 years while the 'Operation and maintenance' is set at 20 years. Each indicator is allocated using one of the approaches indicated in the following examples:

1. 'Cost reduction associated to more precise quantity take-offs' is set to be allocated on the first year of each project construction phase
2. 'Cost reduction associated to more efficient annual maintenance' reduces the annual maintenance cost of the asset and it is allocated on each year of the operation and maintenance phase.
3. The initial amount of the 'Cost reduction related to lower costs for claims/litigations' is divided by the number of years of 'Planning and design' and 'Construction' phases. The annual share of the indicator value is then allocated during the two phases and its yearly share values are adjusted for inflation.

The allocation of cost and benefit values throughout the project period enables the final computation of the main tool outputs: the financial and economic indicators measuring the profitability and the value for money of adopting BIM in a specific project. With this regard, the Net Present Value and the Economic Net Present Value as well as the Benefit-Cost Ratio and the Economic B/C Ratio are computed. Moreover, the ENPV and the Economic Benefit-Cost Ratio are calculated for each of the three phases of a construction project which are assessed in the analysis.

A final interesting feature of the CBA tool is the possibility to assess three potential scenarios for each project, leading to three diverse results for each estimate:

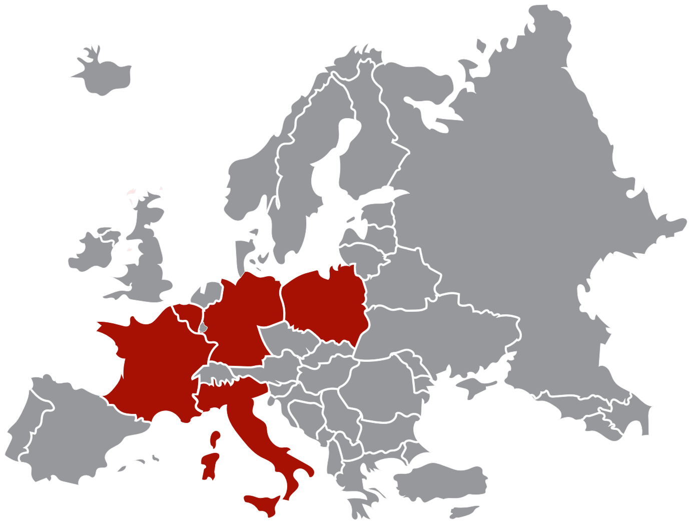
- Baseline Estimate
- Optimistic Estimate
- Pessimistic Estimate

The scenarios are obtained through the variation in the values of eight critical variables (four associated with the computation of costs of adopting BIM in construction projects and four connected to the calculation of the related benefits). These are:

CRITICAL VARIABLES	
investment reduction percentage associated with enhanced accuracy of BIM-based quantity take-off	Values associated with the computation of costs of adopting BIM in public construction projects
investment reduction percentage associated with early clashes and error detection.	
investment reduction percentage associated with time savings during the design and construction phases of a project	
reduction percentage associated with the operations phase related to enhanced efficiency in asset maintenance activities	
Value of the public organisation procurement process cost	Values associated with the calculation of the related benefits
Value of the annual BIM-related software investment allocated to the project	
Value of the BIM-related investment in training allocated to the project	
BIM modelling and coordination costs (the modelling activity cost refers solely to BIM maturity level 1)	

THE ANALYSIS OF REAL CASE STUDIES

The case studies analysed in the context of this project have been identified to capture a diverse set of scenarios, encompassing different levels of development and geographical locations of the asset. Most of these case studies represent maturity level 0, however, BIM maturity levels 1 and 2 scenarios have also been included. The presence of case studies with such different features and located in different countries was representative of the heterogeneity of tenders that could be launched across Europe but it also reflected the predominance of public clients at BIM maturity level 0. This distribution also provided the opportunity to validate the use of the tool at BIM maturity level 1 and 2. The latter represents a situation which is uncommon across most European countries (as was shown by the analysis of the survey data).



Distribution of the case studies in Europe

The six case studies, described below, have been analysed for two main objectives:

1. To support the development of the Cost-Benefit Analysis (CBA) tool (downloadable at http://www.eubim.eu/) by providing useful information on the definition of the ad hoc database estimating the time and the cost of the BIM modelling activity and feeding the dataset underlying the CBA tool
2. To validate the usability of the CBA tool for BIM maturity levels 1 and 2

In relation to objective 2 above, each case study has been analysed for multiple information categories, such as the asset involved in the project, the document phase, the total investment required, its architectural and structural elements, its systems and other relevant data. Thus, it has been possible to verify whether the CBA tool is able to provide usable results set of inputs that can generally be extracted from tender documents.

Each case study has been analysed for multiple information categories, such as the asset involved in the project, the document phase, the total investment required, its architectural and structural elements, its systems and other relevant data. Thus, it has been possible to verify whether the CBA tool is able to provide usable results

With the aim to illustrate how the six case studies have been employed to validate the CBA tool usability, some of the basic information for each project, required as data for the tool and which is generally available for public client tenders, is outlined briefly in the case study descriptions below. The full list of information that is required by the tool can be found in the six tender examples in the last section of the handbook. In fact, these sample scenarios, that match the case studies, show data which are independent of the asset size, location and any other information. For this reason, they can be used to understand how to use the tool as they represent repeatable data expected to be similar to typical tenders launched by a vast number of public clients across Europe

Case study 1

The first case study involves the analysis of a construction project launched by a medium-sized municipality. The tender required the development of a new sports-related centre with structures to accommodate audiences. The asset has a rectangular shape and it is served by mechanical, piping, electrical and lighting as well as special systems. It has been assumed that the public client in this case study hasn't got any prior experience of BIM. Considering the peculiar architecture of the building, it has been assigned to this asset a level of standardisation equal to 1 (the lowest). This asset has been useful to verify the CBA tool results with buildings requiring investments lower than 1 million €.

The main data on this case study are summarised in the table below.

Relevant information	
Asset category	Building
Project category	New asset construction
Document phase	Detailed design
BIM maturity level	0
Estimated investment	Less than 1 million €
Gross floor area	Less than 1500 m^2

Case study 2

The second case study involves works on a specific section of a road infrastructure. The tender has been launched by a medium-sized local authority. The site requires works on both the road surface and the green systems and sidewalks. This case study has been useful to test the function of the CBA tool on existing infrastructural assets.

The main data on this case study are summarised in the table below.

Relevant information	
Asset category	Infrastructure
Project category	Work on an existing asset
Document phase	Detailed design
BIM maturity level	0
Estimated investment	Between 10 and 15 million €
Infrastructural asset surface	About 40000 m^2

Case study 3

The third case study involves works on an existing infrastructural asset located in a small municipality. The local public authority launched the tender requiring a set of works necessary to refurbish and strengthen the existing port and the construction of a number of small buildings which are to be served by mechanical, piping, electrical and lighting systems. This case study has been especially useful to test whether the CBA tool works properly with assets that can be categorised as “Mixed”, infrastructural assets which include buildings within their areas.

The main data on this case study is summarised in the table below.

Relevant information	
Asset category	Mixed
Project category	Work on an existing asset
Document phase	Basic design
BIM maturity level	0
Estimated investment	Between 1 and 5 million €
Infrastructural asset surface	Less than 5600 m^2

Case study 4

The fourth case study refers to the refurbishment project of a large public building. It is composed of various levels below and above the ground and the works refer especially to the internal areas while the external façade is to be preserved. The asset also includes an external space and once the refurbishment is completed, the building will have an educational function. The tender documents for this work clearly required the development of the 3D BIM model and so, it has been possible to test how the tool performs with public clients that are experienced in the use of BIM and to verify the results produced in an example of a large refurbishment work.

The main data on this case study is summarised in the table below.

Relevant information	
Asset category	Building
Project category	Work on an existing asset
Document phase	Detailed design
BIM maturity level	1
Estimated investment	Between 15 and 20 million €
Gross floor area	Less than 5000 m^2

Case study 5

The fifth case study refers to the construction of a new public building, hosting administrative offices and laboratories, in a large European city. The asset is composed of various floors and it requires very complex systems that serves laboratories. The most relevant element of this case study is the fact that the public client organisation can be classified as having a BIM maturity level 2. It has, therefore, been possible to compare the expenses associated with BIM coordination resulting from the application of the CBA tool and the cost actually incurred by the public client.

The main data on this case study is summarised in the table below.

Relevant information	
Asset category	Building
Project category	New asset construction
Document phase	Detailed design
BIM maturity level	2
Estimated investment	Between 40 and 45 million €
Gross floor area	About 6000 m^2

Case study 6

The last case study analysed refers to a public residential complex built by a large national public authority. The building is made up of multiple floors connected by staircases and elevators. Elevators and each floor comprise of a set of similar lodging units.
Considering that each floor has very similar features it has been possible to test how a level of standardisation equal to 3 affects the cost of the BIM modelling activity (that resulted significantly reduced) and the coordination cost (at BIM maturity level 1).

The main data on this case study is summarised in the table below.

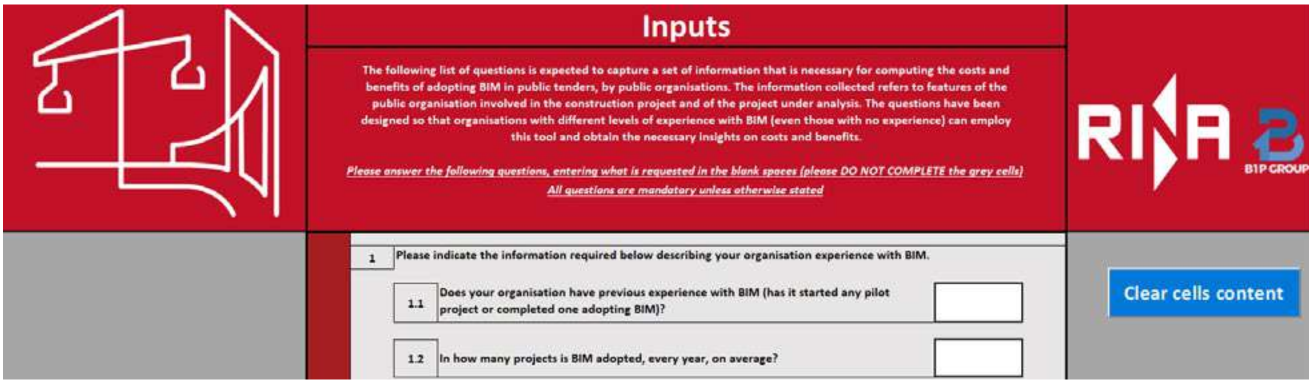
Relevant information	
Asset category	Building
Project category	New asset construction
Document phase	Basic design
BIM maturity level	0
Estimated investment	Between 1 and 5 million €
Gross floor area	Less than 2600 m^2

In conclusion, it must be highlighted that the case studies described above are related to tenders focusing on just one of the phases or a limited set of activities connected to a public project. They are, thus only representing specific stages of an asset life cycle. Also, these case studies have been directly assessed to support the construction of the CBA tool, taking into consideration their specificities. For these two reasons, it has been chosen to produce six tender examples, those reported in the last section of this handbook, that are more representative of scenarios that are generally faced by public clients. The input data of these examples, despite the descriptions that refer to specific phases of a construction project, are used to evaluate the benefits and costs of adopting BIM during all the stages. This approach reflects the reality of a public client that has to manage the whole asset life cycle, from the start of the planning activities to its operations phase. In addition, the examples allow the possibility to create sample scenarios in which the user gets some suggestions on dealing with individual cost and benefit indicators and an understanding of when to switch them on and off.

3.3 Guide: step-by-step procedure to simulate cost-benefit analysis

This section will guide you through the different steps required to create the tool (downloadable at http://www.eubim.eu/) for calculating the costs and benefits of adopting BIM in public tenders by public organisations.

INPUTS REQUIRED



General rules for the Inputs page:

- The information required must be entered in the white spaces
- When cells are grey, the user should not type in any information
- Unless otherwise stated, all white cells must be completed
- Numerical information required might refer to specific values (such as the number of years), the selection of options (‘1’,’2’,’3’, etc.), monetary amounts (expressed in €), surface areas (expressed in m^2) and percentages

1 **Preliminary General Information** *(questions 1 to 11)*

2 **BIM Model Creation Information** *(questions 12 to 14)*

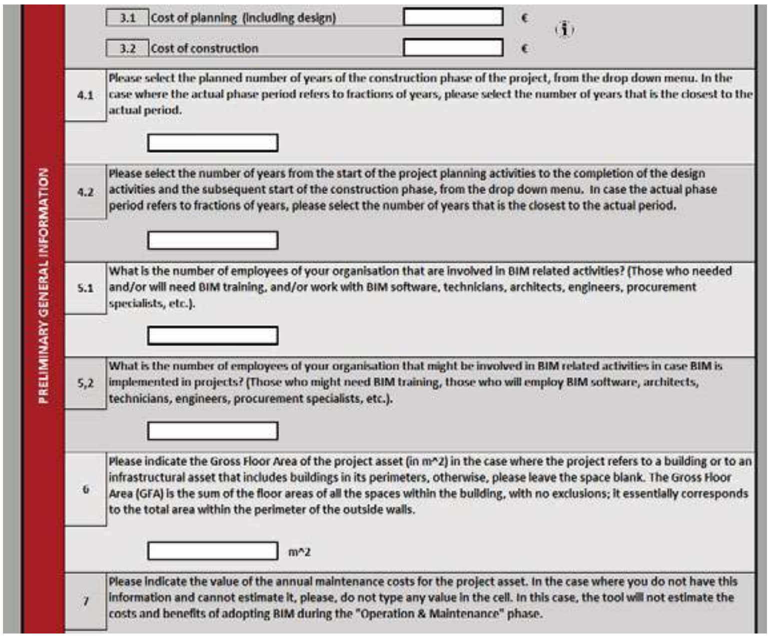
3 **Category of Asset Information** *(questions 15 to 26)*

1

Preliminary General Information *(questions 1 to 11)*

Here you are required to answer a set of questions which serve to acquire general information on the use of BIM in the public organisation involved in the project, and on the characteristics of the projects where BIM is or might be adopted.
The user is required to provide information on:

- the organisation's experience with BIM
- the number of tenders in which BIM is or is expected to be used every year
- the project costs and timing
- internal employees
- other specific data necessary for defining the main features of the project



PRELIMINARY GENERAL INFORMATION

3.1	Cost of planning (including design)	€
3.2	Cost of construction	€
4.1	Please select the planned number of years of the construction phase of the project, from the drop down menu. In the case where the actual phase period refers to fractions of years, please select the number of years that is the closest to the actual period.	
4.2	Please select the number of years from the start of the project planning activities to the completion of the design activities and the subsequent start of the construction phase, from the drop down menu. In case the actual phase period refers to fractions of years, please select the number of years that is the closest to the actual period.	
5.1	What is the number of employees of your organisation that are involved in BIM related activities? (Those who needed and/or will need BIM training, and/or work with BIM software, technicians, architects, engineers, procurement specialists, etc.).	
5,2	What is the number of employees of your organisation that might be involved in BIM related activities in case BIM is implemented in projects? (Those who might need BIM training, those who will employ BIM software, architects, technicians, engineers, procurement specialists, etc.).	
6	Please indicate the Gross Floor Area of the project asset (in m^2) in the case where the project refers to a building or to an infrastructural asset that includes buildings in its perimeters, otherwise, please leave the space blank. The Gross Floor Area (GFA) is the sum of the floor areas of all the spaces within the building, with no exclusions; it essentially corresponds to the total area within the perimeter of the outside walls.	m^2
7	Please indicate the value of the annual maintenance costs for the project asset. In the case where you do not have this information and cannot estimate it, please, do not type any value in the cell. In this case, the tool will not estimate the costs and benefits of adopting BIM during the "Operation & Maintenance" phase.	

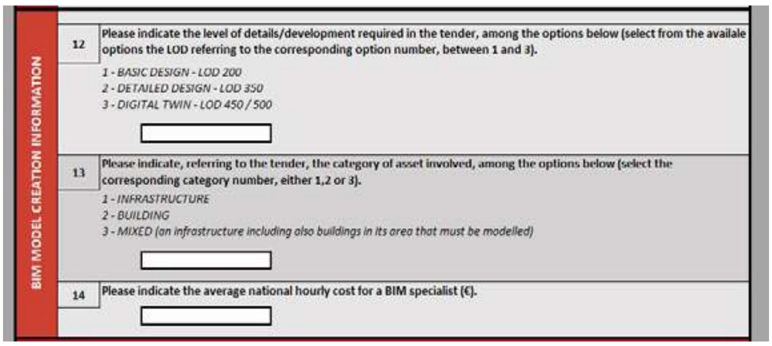
2

BIM Model Creation Information *(questions 12 to 14)*

This section is made up of three questions respectively on:

- the level of detail (LOD) of the model needed in the tender
- the asset category ('Building', 'Infrastructure' and 'Mixed')
- the average cost of a BIM specialist in the country (for enabling the tool to adapt costs computations to the national context of the user)

Depending on the answer to the second of these questions, you will be required to fill in one, two or all subsequent sections as explained in the following point.



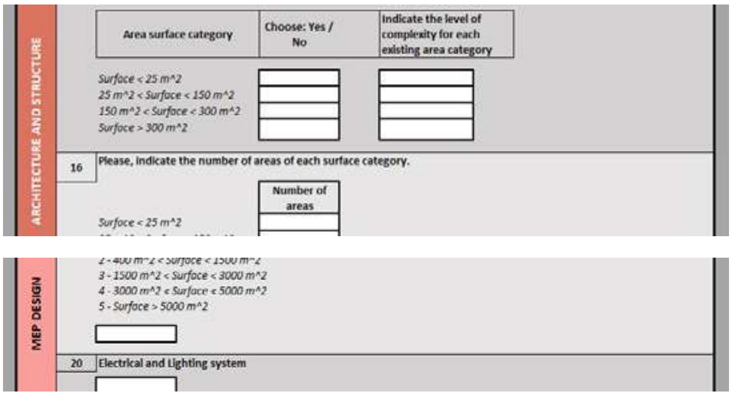
BIM MODEL CREATION INFORMATION

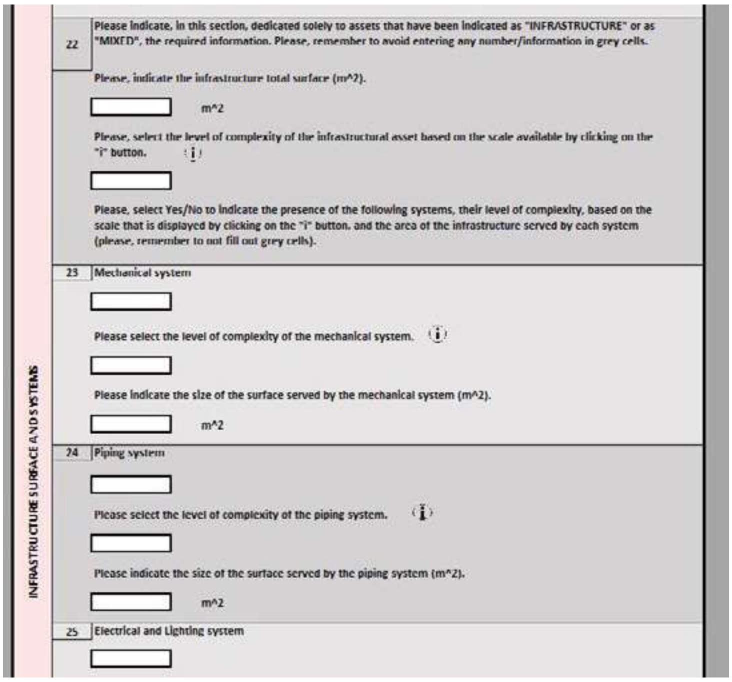
12	Please indicate the level of details/development required in the tender, among the options below (select from the availale options the LOD referring to the corresponding option number, between 1 and 3). *1 - BASIC DESIGN - LOD 200* *2 - DETAILED DESIGN - LOD 350* *3 - DIGITAL TWIN - LOD 450 / 500*
13	Please indicate, referring to the tender, the category of asset involved, among the options below (select the corresponding category number, either 1,2 or 3). *1 - INFRASTRUCTURE* *2 - BUILDING* *3 - MIXED (an infrastructure including also buildings in its area that must be modelled)*
14	Please indicate the average national hourly cost for a BIM specialist (€).

3

Category of Asset Information *(questions 15 to 26)*

- If the asset category indicated is ‘BUILDING’, you should complete the sections:
  – Architecture and Structure (questions 15 to 17): information on surface size, average level of complexity and the level of standardization based on the scales provided in the tool interface
  – MEP design (questions 18 to 21): information on the four systems (if present in the project) and as foreseen by the tool: mechanical; piping; electrical and lighting and special systems
- If the category of the asset indicated in question 13 is ‘INFRASTRUCTURE’, you should complete the section:
  – Infrastructure Surface and Systems (questions 22 to 26): information on surface size, systems and their level of complexity (based on the provided scales)
- If the asset category indicated is ‘MIXED’, you should complete all the three sections described above.



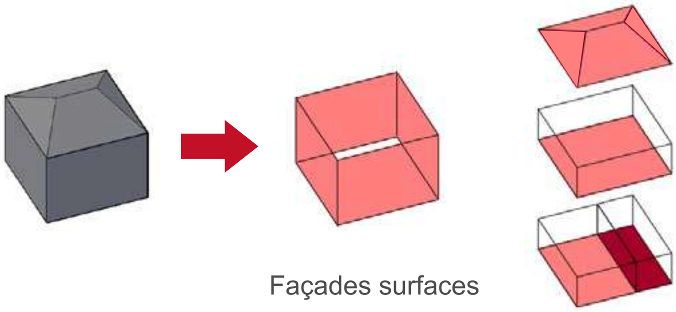


FOCUS ON CATEGORY OF ASSET INFORMATION

The data required in the “category of asset information” are explained through the following examples.

Area surface category

Surface < 25 m^2
25 m^2 < Surface > 150 m^2
150 m^2 < Surface < 300 m^2
Surface > 300 m^2



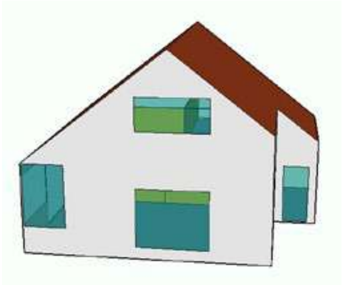
Surface < 25 m2: **n°1**

25 m2 < Surface < 150 m2: **n°7**

Level of complexity

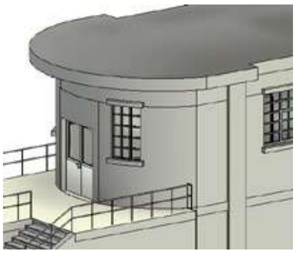
LOW

E.g. a façade made up of a wall of a small number of simple windows and few architectural details



HIGH

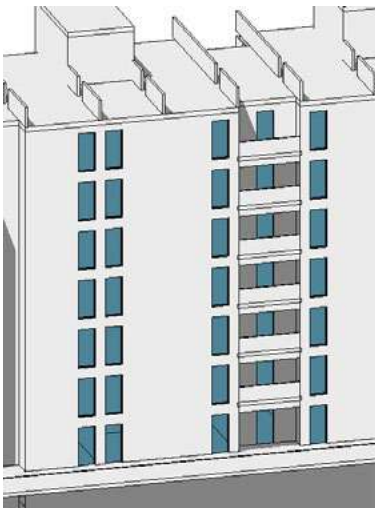
E.g. a façade made up of a curved wall with a large number of architectural details typical of a historical building



Level of standardisation

HIGH

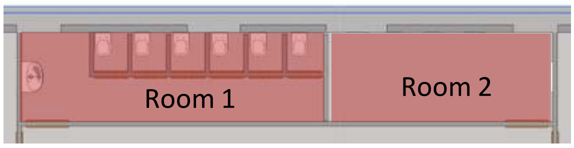
Very similar areas that can be duplicated with few adjustments



Area served by MEP systems

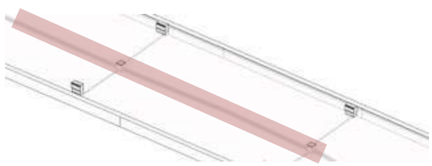
BUILDING

Sum the gross floor areas of all the rooms (e.g. area Room1+area Room2) served by a system and repeat it for each MEP system present in these rooms

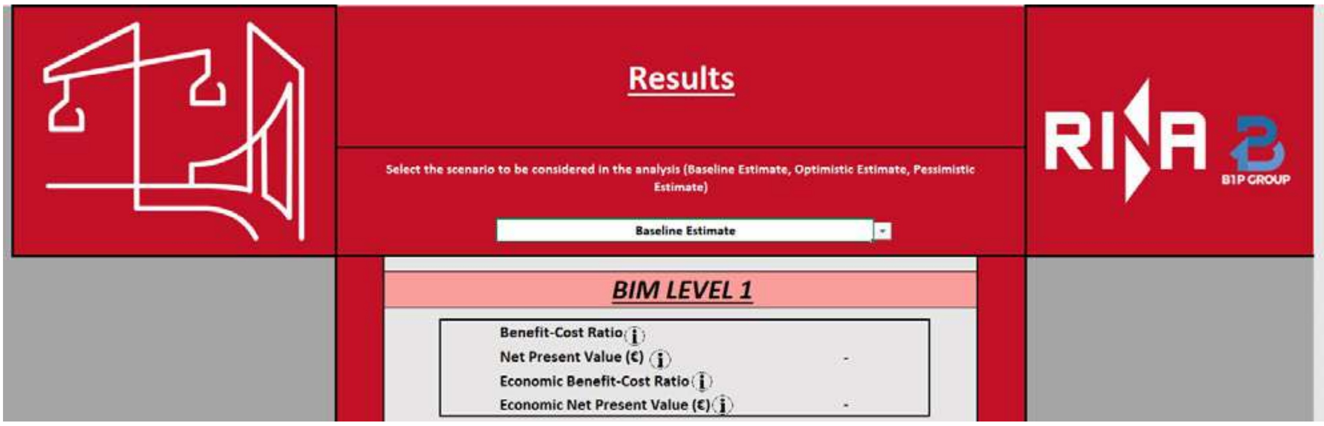


INFRASTRUCTURE

Calculate the area served by MEP systems as a rectangular projection (only for the specific zones where there are systems) and repeat it for all the systems present



OUTPUTS OBTAINED



Results sheet

The ‘Results’ sheet shows the overall results of the application of the cost-benefit analysis on the adoption of BIM in your project both for BIM maturity level 1 and 2.
The four indicators that are computed according to the level of BIM maturity are:

- the Benefit-Cost Ratio
- the Net Present Value (NPV)
- the Economic Benefit-Cost Ratio
- the Economic Net Present Value (ENPV)

Additionally, the BIM direct expenses (model costs and coordination costs) are displayed along with the Economic Benefit-Cost Ratio and the Economic Net Present Value (ENPV) associated with each phase of the project (planning & design, construction, and operational and maintenance).

It must be highlighted that in the BIM level 2 section, there is no cost associated to the modelling activity.

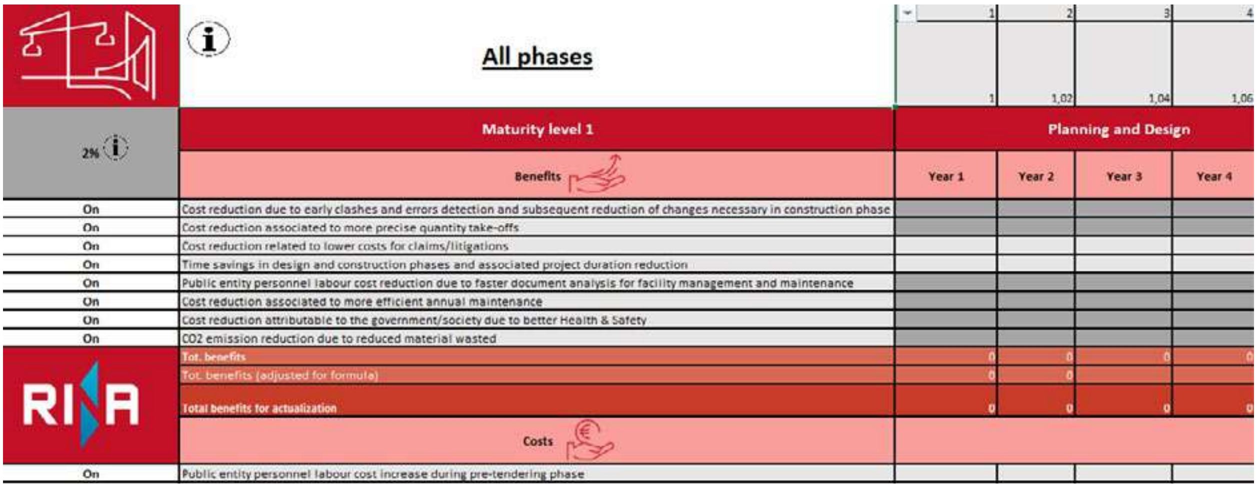
Benefit Cost Ratio / Economic Benefit Cost Ratio

These indicators describe the relationship between the benefits and the costs associated to the adoption of BIM in the project.
When their values are higher than 1, it means that the advantages (expressed in monetary terms) of using BIM in the project outweigh the cost of its implementation.

Net Present Value / Economic Net Present Value

These indicators are used to evaluate the profitability of an investment over a period of time. In the case of BIM, the profitability is expressed as achieved savings.
The higher are these indicators values, the more “profitable” (in terms of financial savings and socio-economic benefits) is the adoption of BIM in the project. The ENPV includes in its computation social and environmental benefits while the NPV does not.

CBA - BIM level 1 and CBA - BIM Level 2 sheets



For each BIM maturity level, the tool performs a cost-benefit analysis on the use of BIM for the specific project (for which the user has provided information on the Inputs sheet).

For each BIM maturity level, there exists a sheet where eight benefits and nine costs are listed.
Both costs and benefits are entered for the three typical project phases:

- the design and planning (up to 5 years)
- the Construction (up to 10 years after the design phase)
- the Operation and Maintenance phase (20 years after the construction phase)

The values included in the CBA are automatically computed and allocated starting from the information entered in the Input sheet.
On the top left of the page, the user can select which phases should be displayed ('Planning and Design', 'Construction', 'Operation and Maintenance' or 'All phases').

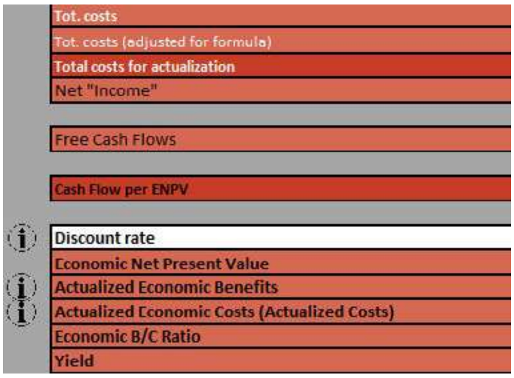
Subsequently, you can find the Free Cashflow that the tool computes and on the basis of which the following indicators are calculated:

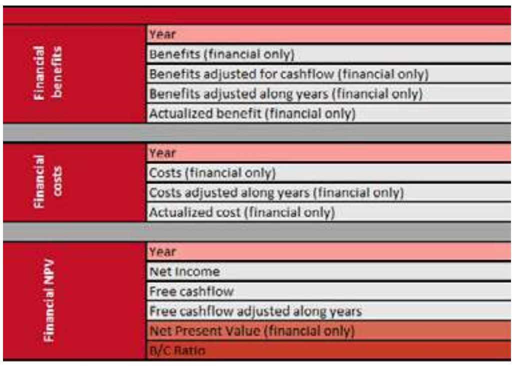
- Economic Net Present Value
- Actualized Economic Benefits
- Actualized Economic Costs (Actualized Costs)
- Economic Benefit-Cost Ratio
- Yield

NOTICE that the **Discount Rate**, set at the standard value of 4%, is the **unique value** that **the user can change in the excel sheet**, according to the characteristics of the project.

- By scrolling down the page, you will see displayed the ENPV, the Economic B/C Ratio and the associated Free Cashflow for each of the three phases

- By scrolling down even further, you will see displayed the financial aspects inherent to the three phases of the project





4 How to practice the CBA tool? Validation through tender examples

4.1 The validation of the cost-benefit analysis tool

With the aim to show the nature of the results produced by the Cost-Benefit Analysis (CBA) tool (downloadable at http://www.eubim.eu/) as well as how it should be employed. Six tender examples have been defined based on the information analysed in this project. Reflecting the case studies of the BIM maturity levels 1 and 2, the tender examples demonstrate the use of the CBA tool in projects representing various asset categories (Bulding/Infrastructure/Mixed) and all three project life cycle phases (Planning and Design/Construction/Operation and Maintenance), highlighting the relationship between input data and the benefits and costs of each phase. The input data used in the examples represents standard data from construction or refurbishment tenders that may be launched by any public client independent of their geographical location or project specificities.

In this respect, the projects briefly described in the following pages may assist public clients in filling out the required information for their own individual projects.

Some assumptions have been made in order to complete the full list of input data, for example, investments and cost information, length of project periods, public clients' internal organisation-related information, etc.

This kind of data should be easily obtainable from a public authority and so the public client should be able to fill in the input page of the CBA tool effortlessly.

This version of CBA tool is based on the "LOD" concept and take into account only geometrical information (here called "level of detail"). This concept is currently replaced with EN ISO 1965 0 series and it is a topic for the future version of CBA tool.
EN ISO 19650-1 introduces a new framework called "Level of Information Need" as a key part of the EIR described in EN ISO 19650-2 and EN ISO 19650-3.

The input data used in the examples represents standard data from construction or refurbishment tenders that may be launched by any public client independent of their geographical location or project specificities.

The Level of Information Need framework has been further developed in a CEN as a standard EN 17412-1:2020. The new concept of the level of information need and the framework is based on two main aspects:

- alphanumerical information is important as geometrical representation
- information requirements should be related to a purpose as different purposes might require different information (e.g. energy modelling vs. structural modelling)

The new concept has a direct impact on the amount of time to produce information, and therefore connected costs. This version of CBA tool can be used as an introduction to the costs and benefits evaluation and it is important to take into account its limitation.

4.2 TENDER EXAMPLE 1
Conversion of an old building in a sport centre

MAIN PROJECT CHARACTERISTICS

TIPOLOGY — **BUILDING** *conversion*

SIZE — **1680 m^2**

INVESTMENT — **1.174.800 €**

LEVEL — **DETAILED DESIGN**

DESCRIPTION

The building is an old and disused one-floor factory (around 8 metres high) on the edge of the city. The two longest façades are made from metal plates, which give an industrial look to the building, while the other two are brick walls with a simpler aspect.

PURPOSE OF THE PROJECT AND PLANNED INTERVENTIONS

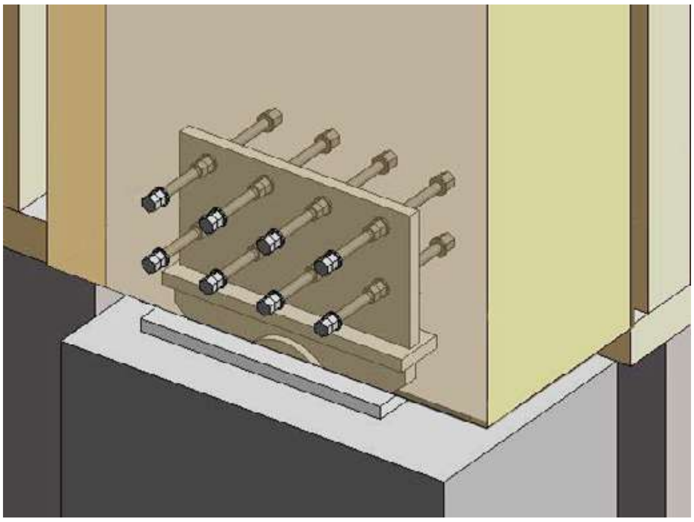
The project destination is a sports centre for the community, composed of two different parts: a large ice rink and a small office and locker room with showers. All the rooms are situated in front of the ice rink area, where the grandstand for the events is located.
The interventions required are summarised as:

- demolition of the interior of the building
- creation of the space for the ice rink including all service mechanical, electrical, plumbing and special systems
- construction of two rooms and the permanent grandstand

Tender requirements

The tender requires the detailed design for the interventions described for the renovation project.

No particularly relevant solutions are foreseen from a technological, architectural or structural point of view. The creation of a BIM model is required in order to extract the drawings and the Quantity take-offs (QTO) from it.



Example of 3D BIM model required: detailed design representation of structural element

PRELIMINARY GENERAL INFORMATION		
	Does your organisation have previous experience with BIM?	No
	In how many projects per year, on average, might BIM be adopted?	6
	Project category (New asset construction / Work on an existing asset)	Work on an existing asset (No BIM model available)
	Cost of planning (including design) (€)	106800
	Cost of construction (€)	1068000
	Number of years for construction	2
	Number of years for planning and design	1
	Number of employees that might be involved in BIM activities in case BIM is implemented in projects	12
	Gross Floor Area (m^2)	1680
	Value of the annual maintenance costs of the project asset	32172 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	15781
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	2 (350)
	Asset Category (Infrastructure/Building/Mixed)	2 (Building)
	BIM Specialist national hourly cost (€/h)	13

ARCHITECTURE AND STRUCTURE	Area surface category	Yes/No	Level of complexity (1/2/3)	Number of areas per category	Level of standardization (1/2/3)
	Surface < 25 m^2	Yes	2	4	1
	25 m^2< Surface < 150 m^2	Yes	2	4	
	150 m^2< Surface < 300 m^2	No	-	-	
	Surface > 300 m^2	Yes	1	6	

MEP DESIGN	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	Mechanical (e.g. HVAC)	Yes	1	400 m^2 < Surface < 1500 m^2
	Piping	Yes	2	1500 m^2 < Surface < 3000 m^2
	Electrical and lighting	Yes	1	400 m^2 < Surface < 1500 m^2
	Special (e.g. safety systems)	Yes	1	Surface < 400 m^2

NOTES

- The hourly cost of a BIM Specialist has been estimated starting from the data indicated in “BIM Salary Report” (2020 Edition), published by BIM Corner. It has been considered the average annual gross salary of a “BIM Technician/BIM Modeler” working in Poland. The hourly wage has been estimated and increased by 50%, assumed it as the company mark-up for the hourly rate charged to the public client
- The average annual salary of employees of the public organisation has been extracted from the report (Ms Excel file) available at: https://stat.gov.pl/files/gfx/portalinformacyjny/en/defaultaktualnosci/3292/1/44/1/employment_wages_and_salaries_in_national_economy_in_2019.xlsx. The data employed refers to “Public administration and defence; compulsory social security”

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

40.414 €

Benefit-Cost Ratio

1,46

BIM direct expenses:

BIM Model Cost

4.945 €

BIM Coordination Cost

1.775 €

Phase Focus:

Operation and Maintenance

ENPV: -10.127 € - EBC Ratio: 0,81

Most Relevant Economic Indicator:

Efficient maintenance

54.575 €

BIM based Quantity Take-Off (QTO)

37.268 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

533 €

Economic Net Present Value (ENPV)

158.506 €

CONSIDERATIONS

- Despite the negative ENPV of the Operation and Maintenance phase, the overall project NPV is positive and the associated B/C Ratio is slightly higher than 1: the adoption of BIM in this example is expected to be advantageous and sustainable
- The most relevant indicators chosen for this tender example are the benefits associated to enhanced accuracy of the quantity take off and improved efficiency in maintenance activities. The latter, despite presenting a substantial value, does not offset the cost associated with a BIM modelling software license, hence the ENPV of the maintenance phase appears to be negative

TIPS

Each cost and benefit indicator could be switched off if its calculation is considered not consistent with the project. In this tender example, the full list of benefits and costs are calculated, so no indicator has been switched off.

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

103.239 €

Benefit-Cost Ratio

2,15

BIM direct expenses:

BIM Coordination Cost

3.301 €

Phase Focus:

Operation and Maintenance

ENPV: 39.100 € - EBC Ratio: 1,73

Most Relevant Economic Indicator:

Efficient maintenance

124.431 €

BIM based Quantity Take-Off (QTO)

37.268 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

533 €

Economic Net Present Value (ENPV)

221.330 €

CONSIDERATIONS

- In this scenario, both the NPV and the B/C Ratio of the project are higher with respect to BIM maturity level 1
- The values of the two most relevant indicators grew if compared to the BIM maturity level 1. In BIM maturity level 2 scenario, in fact, the benefit associated with enhanced efficiency in maintenance grew to such an extent that the operations and maintenance related ENPV is not anymore negative

TIPS

In this scenario the full list of benefits and costs are calculated, so no indicator has been switched off.

4.3 TENDER EXAMPLE 2
Maintenance and renovation project of a road

MAIN PROJECT CHARACTERISTICS

TIPOLOGY
INFRASTRUCTURE
renovation and maintenance

SIZE
34850 m^2

INVESTMENT
11.052.564 €

LEVEL
DIGITAL TWIN

Example of 3D BIM model required: Digital Twin representation of a road portion

DESCRIPTION

The project involves renovation and maintenance interventions aimed at repairing and resurfacing substandard street pavements, providing new safety routes for citizens in several streets throughout the city.

PURPOSE OF THE PROJECT AND PLANNED INTERVENTIONS

The project includes various types of interventions such as maintenance and new installations. The main works involve the replacement of deteriorated road sections and the implementation of new traffic lights and road signs. Particular focus is placed on the underground sub-services, such as the MEP systems like sewers and electrical conduits, which must be connected to the existing network currently in use.

Tender requirements
In the tender documents, the public authority provides detailed design sheets of 2D drawings with the Bill of Quantities (BoQ) for each requested work. During the construction the BIM 3D - Digital Twin model is required including all the works to be carried out and each new element to be implemented for approval. The BIM team must use all the standards indicated by the public contractor's BIM Manager in a Common Data Environment (CDE) provided by the public authority.

PRELIMINARY GENERAL INFORMATION	Does your organisation have previous experience with BIM?	No
	In how many projects per year, on average, might BIM be adopted?	17
	Project category (New asset construction / Work on an existing asset)	Work on an existing asset (No BIM model available)
	Cost of planning (including design) (€)	1004779
	Cost of construction (€)	10047785
	Number of years for construction	1
	Number of years for planning and design	1
	Number of employees that might be involved in BIM activities in case BIM is implemented in projects	38
	Gross Floor Area (m^2)	-
	Value of the annual maintenance costs of the project asset	2686 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	29004
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	3 (450/500)
	Asset Category (Infrastructure/Building/Mixed)	1 (Infrastructure)
	BIM Specialist national hourly cost (€/h)	23

INFRASTRUCTURE SURFACE AND SYSTEMS	Total surface	Level of complexity (1/2/3)	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	34850 m2	3	Mechanical	No	-	-
			Piping	Yes	2	21250 m^2
			Electrical and lighting	Yes	2	21250 m^2
			Special	Yes	2	21250 m^2

NOTES

- The hourly cost of a BIM Specialist has been estimated starting from the data indicated in “BIM Salary Report” (2020 Edition), published by BIM Corner. It has been considered the average annual gross salary of a “BIM Technician/BIM Modeler” working in France. The hourly wage has been estimated and increased by 50%, assumed it as the company mark-up for the hourly rate charged to the public client
- The average annual salary of employees of the public organisation has been extracted from the report available at: https://www.insee.fr/fr/statistiques/4647813#graphique-figure1. The data employed refers to employees from the “Fonction publique territoriale”

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

151.987 €

Benefit-Cost Ratio

1,69

BIM direct expenses:

BIM Model Cost

70.413 €

BIM Coordination Cost

40.623 €

Phase Focus:

Construction

ENPV: 376.059 € - EBC Ratio: 3,80

Most Relevant Economic Indicator:

Clash Detection

237.339 €

BIM based Quantity Take-Off (QTO)

0 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

10.956 €

Economic Net Present Value (ENPV)

281.252 €

CONSIDERATIONS

- Despite the large costs represented by the BIM modelling and coordination activities, and the absence of BIM related benefits during the design phase, the overall project NPV is positive and the associated B/C ratio is slightly higher than 1. In this sense, the use of BIM in this project can potentially be sustainable and lead to savings
- The clash detection related benefit is the largest benefit achievable during the construction phase where the BIM model is used to obtain approvals before each construction step. This step, despite the allocation of BIM direct expenses still shows a positive ENPV

TIPS

- In this tender example it is required the provision of a Digital Twin to be developed during the construction phase, so the benefit associated to the quantity take-off has been switched off as the design phase is assumed to be carried out without BIM
- Considering the limited time-period in which the project is expected to be completed, the benefit related to the time saving has been deactivated. At the same time, assuming that the public organisation does not need any hardware upgrade, the corresponding cost item has been switched off

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

595.306 €

Benefit-Cost Ratio

5,31

BIM direct expenses:

BIM Coordination Cost

30.746 €

Phase Focus:

Construction

751.394 € - EBC Ratio: 16,47

Most Relevant Economic Indicator:

Clash Detection

237.339 €

BIM based Quantity Take-Off (QTO)

350.615 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

10.956 €

Economic Net Present Value (ENPV)

724.571 €

CONSIDERATIONS

- The overall project NPV and B/C ratios improved significantly from BIM maturity level 1 to level 2
- The benefit related to the quantity take-off is considered in this scenario and it contributes significantly in improving the Construction phase Economic B/C Ratio value

TIPS

- Differently from BIM maturity level 1 scenario, BIM is expected to be employed in all phases of a construction project, that is why, at BIM maturity level 2, also the quantity take-off related benefit is active
- As for BIM maturity level 1 scenario, the hardware upgrade cost item and the benefit capturing time-savings are switched off

4.4 TENDER EXAMPLE 3
New port construction project

MAIN PROJECT CHARACTERISTICS

TIPOLOGY — **INFRASTRUCTURE**
new construction

SIZE — **7203 m²**

INVESTMENT — **5.148.000 €**

LEVEL — **BASIC DESIGN**

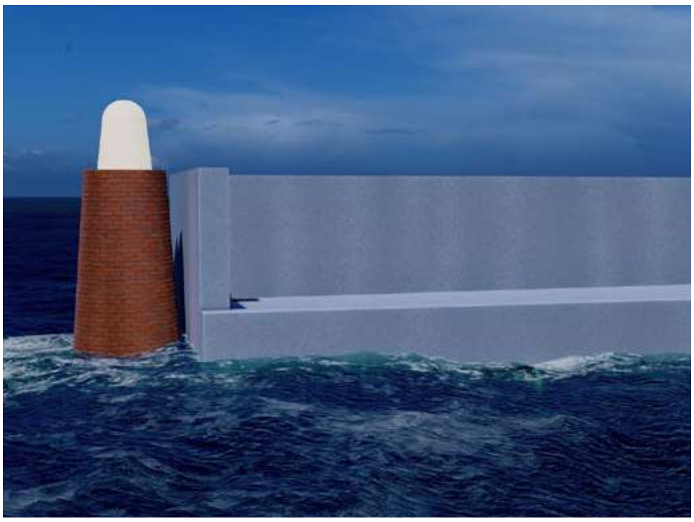
DESCRIPTION

The port is located on the inland coast of the country, overlooking one of the busiest stretches of sea in the region. It is developed for about three kilometres, parallel to the coastline, and the service structures are extended for over a kilometre on flat territory. The docks are uniformly constructed with a homogeneous structure and there are two buildings serving the mooring area for each dock.

PURPOSE OF THE PROJECT AND PLANNED INTERVENTIONS

The project focuses on the northernmost part of the lagoon, a bare area of land which separates the harbour from the sea where there a beach is situated a short distance from the current shoreline.
The construction of new docks and two buildings are the main interventions required by the project.

Tender requirements
No particularly relevant solutions are foreseen from a technological, architectural or structural point of view. The creation of a BIM model is required in order to extract the drawings and the QTO from it.



Example of 3D BIM model basic design detail required: dock's structure

PRELIMINARY GENERAL INFORMATION		
	Does your organisation have previous experience with BIM?	No
	In how many projects per year, on average, might BIM be adopted?	3
	Project category (New asset construction / Work on an existing asset)	New asset construction
	Cost of planning (including design) (€)	468000
	Cost of construction (€)	4680000
	Number of years for construction	2
	Number of years for planning and design	1
	Number of employees that might be involved in BIM activities in case BIM is implemented in projects	10
	Gross Floor Area (m^2)	313
	Value of the annual maintenance costs of the project asset	23400 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	36430
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	1 (200)
	Asset Category (Infrastructure/Building/Mixed)	3 (Mixed)
	BIM Specialist national hourly cost (€/h)	25

ARCHITECTURE AND STRUCTURE	Area surface category	Yes/No	Level of complexity (1/2/3)	Number of areas per category	Level of standardization (1/2/3)
	Surface < 25 m^2	Yes	2	30	2
	25 m^2< Surface < 150 m^2	Yes	2	8	
	150 m^2< Surface < 300 m^2	Yes	1	2	
	Surface > 300 m^2	No	-	-	

MEP DESIGN	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	Mechanical (e.g. HVAC)	Yes	2	400 m^2 < Surface < 1500 m^2
	Piping	Yes	2	400 m^2 < Surface < 1500 m^2
	Electrical and lighting	Yes	2	400 m^2 < Surface < 1500 m^2
	Special (e.g. safety systems)	No	-	-

INFRASTRUCTURE SURFACE AND SYSTEMS	Total surface	Level of complexity (1/2/3)	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	6890 m^2	1	Mechanical	No	-	-
			Piping	Yes	2	5200 m^2
			Electrical and lighting	Yes	2	5200 m^2
			Special	No	-	-

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

211.164 €

Benefit-Cost Ratio

2,72

BIM direct expenses:

BIM Model Cost

10.329 €

BIM Coordination Cost

4.537 €

Phase Focus:

Planning&Design

ENPV: -38.372 € - EBC Ratio: 0,35

Most Relevant Economic Indicator:

Efficient Maintenance

39.695 €

BIM based Quantity Take-Off (QTO)

163.307 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

4.575 €

Economic Net Present Value (ENPV)

333.065 €

CONSIDERATIONS

- Although the costs associated to BIM adoption during the planning & design phase are exceeding benefits, the overall project NPV and B/C Ratio are still indicating that the use of BIM might still be advantageous in this example
- The value of the benefit associated with savings connected to more efficient maintenance activities, despite being referred to a 20 years’ time-period, appears to be limited

TIPS

- Considering the limited time-period required for the design and construction phases of the project, no substantial time-savings are expected for this tender example, so the corresponding benefit has been deactivated
- It is assumed that no additional consulting services supporting the public procurement process are necessary (the corresponding cost item has been switched off)

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

248.079 €

Benefit-Cost Ratio

2,96

BIM direct expenses:

BIM Coordination Cost

14.464 €

Phase Focus:

Planning&Design

ENPV: -26.331 € - EBC Ratio: 0,47

Most Relevant Economic Indicator:

Efficient Maintenance

90.504 €

BIM based Quantity Take-Off (QTO)

163.307 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

4.575 €

Economic Net Present Value (ENPV)

369.980 €

CONSIDERATIONS

- In this tender example, it appears that the shift from BIM maturity level 1 to level 2 does not bring a large improvement to the NPV and the B/C Ratio
- At BIM maturity level 2, the situation of the planning & design phase is slightly improving its ENPV, even if it remains negative as for BIM maturity level 1
- The savings generated through enhanced efficiency in maintenance activities is instead significantly increasing at BIM maturity level 2

4.5 TENDER EXAMPLE 4

Renovation project for a public building

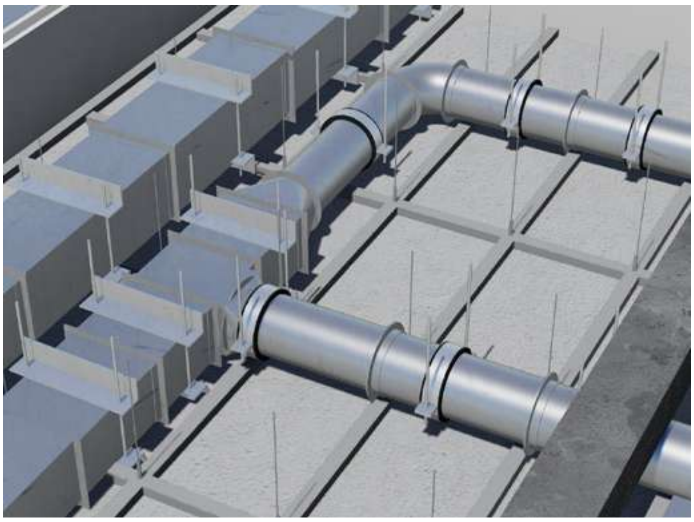
MAIN PROJECT CHARACTERISTICS

TIPOLOGY — **BUILDING** *renovation*

SIZE — **4000 m²**

INVESTMENT — **13.090.000 €**

LEVEL — **DIGITAL TWIN**



Example of 3D BIM model required: Digital Twin representation of MEP system portion

DESCRIPTION

The building is an existing five-storey school located in the centre of a metropolis. The structure is made of concrete and masonry elements.

PURPOSE OF THE PROJECT AND PLANNED INTERVENTIONS

The main objective of the project is the interior renovation of the building, including the reconfiguration of the existing walls and floors, to accommodate new classrooms such as art classrooms, performing arts, gymnasium and widened hallways. The construction of new wheelchair-accessible restrooms is also planned, together with high-end MEP systems improvements, including all the electrical, mechanical and plumbing systems. No interventions are foreseen for the external parts of the building, but the courtyard with the existing asphalt playing field must be demolished together with the fencing and netting, and proper disposal of all demolished materials must be considered. The new project includes the construction of a basketball court using high-end materials.

Tender requirements

In the tender documents, the public authority provides the basic design sheets of 2D drawings and requires a 3D BIM model during each work stage required.

During construction, the 3D BIM - Digital Twin model is required. This includes all the works to be carried out and each new element to be implemented for approval. The BIM team must use all the standards indicated by the public contractor's BIM Manager in a Common Data Environment (CDE) provided by the public authority.

PRELIMINARY GENERAL INFORMATION	Does your organisation have previous experience with BIM?	Yes
	In how many projects is BIM adopted, every year, on average?	14
	Project category (New asset construction / Work on an existing asset)	Work on an existing asset (No BIM model available)
	Cost of planning (including design) (€)	1190000
	Cost of construction (€)	11900000
	Number of years for construction	3
	Number of years for planning and design	1
	Number of employees of your organisation that are involved in BIM related activities?	42
	Gross Floor Area (m^2)	4000
	Value of the annual maintenance costs of the project asset	65497 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	52464
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	3 (450/500)
	Asset Category (Infrastructure/Building/Mixed)	2 (Building)
	BIM Specialist national hourly cost (€/h)	23

ARCHITECTURE AND STRUCTURE	Area surface category	Yes/No	Level of complexity (1/2/3)	Number of areas per category	Level of standardization (1/2/3)
	Surface < 25 m^2	Yes	2	85	2
	25 m^2< Surface < 150 m^2	Yes	2	43	
	150 m^2< Surface < 300 m^2	Yes	2	3	
	Surface > 300 m^2	Yes	2	5	

MEP DESIGN	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	Mechanical (e.g. HVAC)	Yes	2	3000 m^2 < Surface < 5000 m^2
	Piping	Yes	2	400 m^2 < Surface < 1500 m^2
	Electrical and lighting	Yes	2	1500 m^2 < Surface < 3000 m^2
	Special (e.g. safety systems)	No	-	-

NOTES

- The hourly cost of a BIM Specialist has been estimated starting from the data indicated in “BIM Salary Report” (2020 Edition), published by BIM Corner. In this tender example, it has been considered the average annual gross salary of a “BIM Technician/ BIM Modeler” working in Belgium (prudentially slightly increased to be aligned with the values considered for the other case studies). The hourly wage has been estimated and increased by 50%, assumed it as the company mark-up for the hourly rate charged to the public client
- The average annual salary of employees of the public organisation involved in this project, has been extracted from the report of Statbel (Ms Excel file) available at: https://statbel.fgov.be/sites/default/files/files/documents/Werk%20%26%20opleiding/9.1%20Lonen%20en%20arbeidskosten/9.12.%20Gemiddelde%20bruto%20maandlonen/SES2016_FR.xls. Data employed refers to “Architectes, urbanistes et géomètres”

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

403.327 €

Benefit-Cost Ratio

3,44

BIM direct expenses:

BIM Model Cost

41.411 €

BIM Coordination Cost

21.237 €

Phase Focus:

Construction

ENPV: 545.814 € - EBC Ratio: 7,70

Most Relevant Economic Indicator:

Efficient Maintenance

113.328 €

Time-Savings

238.361 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

1.283 €

Economic Net Present Value (ENPV)

520.975 €

CONSIDERATIONS

- The NPV and the B/C ratio highlight the profitability, expressed as savings, of the investment in BIM and its subsequent use in the project. In this scenario a Digital Twin is required, so the modelling activity cost is allocated during the construction phase, as 3D models are used for review and approval before each construction stage
- The two most relevant indicators reported for this tender example refer to the savings generated by an increased efficiency in the asset maintenance activities as well as the time-savings obtained during the three years of the construction stage of the project

TIPS

- In this tender example three indicators have been switched off as they are not considered consistent with the project of this scenario:
  – the savings associated with the reduction of the number of claims and litigations
  – the savings related to the enhanced accuracy of the quantity take-off, as BIM has not been employed during the design phase
  – regarding costs, no increase in effort is required during the post-award phase due to the adoption of BIM

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

1.130.822 €

Benefit-Cost Ratio

8,53

BIM direct expenses:

BIM Coordination Cost

37.147 €

Phase Focus:

Construction

ENPV: 1.097.797 € - EBC Ratio: 19,51

Most Relevant Economic Indicator:

Efficient Maintenance

258.388 €

Time-Savings

472.079 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

1.283 €

Economic Net Present Value (ENPV)

1.248.470 €

CONSIDERATIONS

- The NPV and the Benefit-Cost ratio are showing that the use of BIM in the project is advantageous, with even larger potential benefits with respect to maturity level 1 scenario
- The NPV of the construction phase almost doubles its value from the maturity level 1 to the level 2
- The values of the two most relevant indicators are higher in this scenario than in BIM maturity level 1. The CBA tool in fact foresees an increase of these two benefits at the maturity level 2

TIPS

- The indicators related to savings associated with a reduction in expenses for claims and litigations and the labor cost increase during the post-award phase are both switched off
- Differently from the previous scenario, the indicator representing savings arising from the enhanced accuracy of the quantity take-off is active as, in case of BIM maturity level 2, BIM is employed in all phases of the project life-cycle

4.6 TENDER EXAMPLE 5

New public administrative building construction project

MAIN PROJECT CHARACTERISTICS

TIPOLOGY — **BUILDING**
new construction

SIZE — **4000 m²**

INVESTMENT — **26.880.000 €**

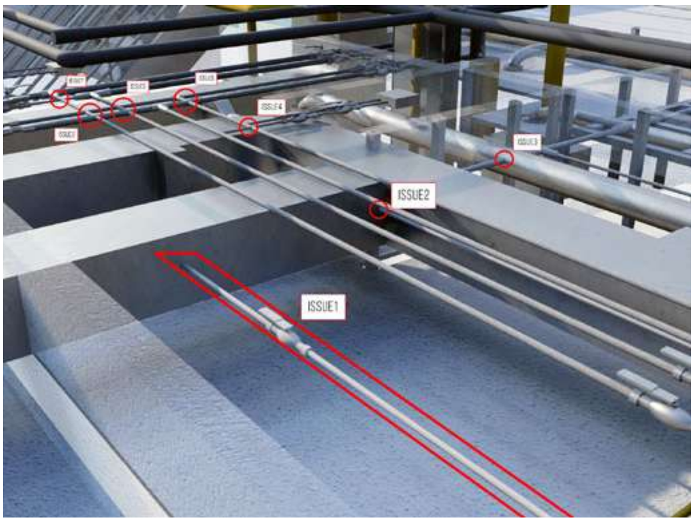
LEVEL — **DETAILED DESIGN**

DESCRIPTION AND PURPOSE OF THE PROJECT

The project is a construction of a new modern administrative office located in the capital of a northern European state. The public authority is the main stakeholder of the building which has been designed by international architects and structural engineers using high-end technical and design solutions. The contracting authority prepared all the design activities, using a highly specialized and controlled BIM process, through consolidated contract documents shared with the key design stakeholders. There are currently multi-disciplinary coordinated BIM models, where each element is listed and can be found with the same name, in the QTO and construction schedule documents.

Tender requirements

In the tender documents, the public authority provides the basic design of the 3D BIM model for the new administration building. The 3D BIM - Detailed design model is required. The BIM team must use all the standards indicated by the public contractor's BIM Manager in a Common Data Environment (CDE) provided by the public authority.



Example of 3D BIM coordinated model to be verified: portion of MEP systems and architectural elements

PRELIMINARY GENERAL INFORMATION		
	Does your organisation have previous experience with BIM?	Yes
	In how many projects is BIM adopted, every year, on average?	8
	Project category (New asset construction / Work on an existing asset)	New asset construction
	Cost of planning (including design) (€)	3600000
	Cost of construction (€)	23280000
	Number of years for construction	4
	Number of years for planning and design	2
	Number of employees of your organisation that are involved in BIM related activities?	28
	Gross Floor Area (m^2)	4000
	Cost of annual maintenance of the completed asset	219.708 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	50837
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	2 (350)
	Asset Category (Infrastructure/Building/Mixed)	2 (Building)
	BIM Specialist national hourly cost (€/h)	43

ARCHITECTURE AND STRUCTURE	Area surface category	Yes/No	Level of complexity (1/2/3)	Number of areas per category	Level of standardization (1/2/3)
	Surface < 25 m^2	Yes	2	61	2
	25 m^2< Surface < 150 m^2	Yes	2	46	
	150 m^2< Surface < 300 m^2	No	-	-	
	Surface > 300 m^2	Yes	1	5	

MEP DESIGN	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	Mechanical (e.g. HVAC)	Yes	3	1500 m^2 < Surface < 3000 m^2
	Piping	Yes	3	1500 m^2 < Surface < 3000 m^2
	Electrical and lighting	Yes	3	3000 m^2 < Surface < 5000 m^2
	Special (e.g. safety systems)	Yes	3	1500 m^2 < Surface < 3000 m^2

NOTES

- The hourly cost of a BIM Specialist has been estimated starting from the data indicated in "BIM Salary Report" (2020 Edition), published by BIM Corner. In this tender example, it has been considered the average annual gross salary of a "BIM Technician/ BIM Modeler" working in Germany. The hourly wage has been estimated and increased by 50%, assumed it as the company mark-up for the hourly rate charged to the public client
- The average annual salary of employees of the public organisation has been extracted from the report available at: https://www.destatis.de/EN/Themes/Labour/Earnings/Earnings-Earnings-Differences/Tables/yearly-gross-earnings.html. The data employed refers to "Public administration and defence; compulsory social security"

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

1.633.533 €

Benefit-Cost Ratio

10,0

BIM direct expenses:

BIM Model Cost

33.626 €

BIM Coordination Cost

22.992 €

Phase Focus:

Operation and Maintenance

ENPV: 234.894 € - EBC Ratio: 5,15

Most Relevant Economic Indicator:

Efficient Maintenance

395.515 €

Clash Detection

577.948 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

2.643 €

Economic Net Present Value (ENPV)

1.748.967 €

CONSIDERATIONS

- The positive ENPV estimated for the operation and maintenance phase is contributing to the potential substantially high NPV result for the overall project. A very high B/C Ratio is estimated to be achievable during the project life-cycle. In this framework the adoption of BIM for this scenario is expected to be advantageous and sustainable
- The most relevant indicator in this tender example refers to the enhanced efficiency in maintenance, where the value reported is the sum of the annual savings realized over a period of 20 years. The other relevant benefit is associated with the clash detection allocated along the construction phase

TIPS

- The indicators representing the decreased productivity during the pre-tendering and tendering phases of the project have been switched off assuming that the public organisation involved in the project has already extensive experience with BIM and so no lowered productivity is foreseen. At the same time, also the benefit representing time-savings has been switched off in this scenario

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

1.930.283 €

Benefit-Cost Ratio

10,60

BIM direct expenses:

BIM Coordination Cost

74.871 €

Phase Focus:

Operation and Maintenance

ENPV: 587.393 € - EBC Ratio: 11,39

Most Relevant Economic Indicator:

Efficient Maintenance

901.773 €

Clash Detection

577.948 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

2.643 €

Economic Net Present Value (ENPV)

2.045.718 €

CONSIDERATIONS

- The overall project NPV and B/C ratio are suggesting that the adoption of BIM in the project is expected to be potentially highly advantageous. No negative ENPV are expected in any phase
- The indicator representing savings from an improved efficiency in maintenance activities is expected to increase its value from maturity level 1 to maturity level 2. At the same time, the benefit connected to clash detection is assumed to be independent from the BIM maturity level

TIPS

The same economic indicators switched off in the BIM maturity level 1 scenario have not been considered here either, as they are identified as not consistent with the project

4.7 TENDER EXAMPLE 6
New residential building construction project

MAIN PROJECT CHARACTERISTICS

TIPOLOGY
BUILDING
new construction

SIZE
1800 m²

INVESTMENT
2.307.780 €

LEVEL
BASIC DESIGN

Example of 3D BIM model required: basic design representation of the external safety stair

DESCRIPTION

The project is the construction of a new residential building in the suburbs of a metropolis.

PURPOSE OF THE PROJECT AND PLANNED INTERVENTIONS

The new building must be a rectangular residential building with three floors connected by an internal staircase and an elevator. The functional characteristics and the distribution of the various floors must comply with the following requirements:

- the ground floor must consist of 10 standard housing units, a technical room, an entrance hall, and a distribution staircase with an elevator
- the entrance hall must be accessible from the main doors and must be connected to a central corridor with the entrance to the housing units
- each flat, which must be big enough to house four people or a small family unit, will consist of an entrance area in front of the living room, two bedrooms each with a balcony, a small kitchen and a toilet designed for disabled people
- the balconies in the bedrooms must be designed to respect the privacy of the other flats so the tenderer must use shades or different architectural elements to achieve this
- the stairway/elevator connecting the three floors must have windows on the external facades to allow adequate lighting and natural ventilation
- two external steel safety stairs must be located on the sides of the building

Tender requirements
The public tender requires the basic design for the interventions described in the new construction project. The creation of a BIM model is required in order to extract the drawings and the QTO from it.

PRELIMINARY GENERAL INFORMATION	Does your organisation have previous experience with BIM?	No
	In how many projects per year, on average, might BIM be adopted?	15
	Project category (New asset construction / Work on an existing asset)	New asset construction
	Cost of planning (including design) (€)	69000
	Cost of construction (€)	2238780
	Number of years for construction	1
	Number of years for planning and design	1
	Number of employees that might be involved in BIM activities in case BIM is implemented in projects	39
	Gross Floor Area (m^2)	1800
	Value of the annual maintenance costs of the project asset	29874 €
	BIM coordination is carried out internally/externally?	Externally
	Average annual salary of an employee of your organisation (€)	36430
	Is a Common Data Environment (CDE) going to be employed in the project?	Yes
	Indicate the inflation rate for the project period (%)	2
BIM MODEL CREATION	LOD Required in the tender (200/350/450/500)	1 (200)
	Asset Category (Infrastructure/Building/Mixed)	2 (Building)
	BIM Specialist national hourly cost (€/h)	25

ARCHITECTURE AND STRUCTURE	Area surface category	Yes/No	Level of complexity (1/2/3)	Number of areas per category	Level of standardization (1/2/3)
	Surface < 25 m^2	Yes	2	125	3
	25 m^2< Surface < 150 m^2	Yes	2	5	
	150 m^2< Surface < 300 m^2	Yes	1	4	
	Surface > 300 m^2	Yes	1	1	

MEP DESIGN	System	Yes/No	Level of complexity (1/2/3)	Area served by the system
	Mechanical (e.g. HVAC)	Yes	1	400 m^2 < Surface < 1500 m^2
	Piping	Yes	1	Surface < 400 m^2
	Electrical and lighting	Yes	1	1500 m^2 < Surface < 3000 m^2
	Special (e.g. safety systems)	Yes	1	400 m^2 < Surface < 1500 m^2

NOTES

- The hourly cost of a BIM Specialist has been estimated starting from the data indicated in “BIM Salary Report” (2020 Edition), published by BIM Corner. It has been considered the average annual gross salary of a “BIM Technician/BIM Modeler” working in Italy. This data has been increased by 50%, assumed it as the company mark-up for the hourly rate charged to the public client
- The average annual salary of employees of the public organisation has been extracted from the report (Ms Excel file) available at: https://www.istat.it/it/files//2021/03/Tavole_ses2018.xlsx. The data employed refers to “Public control”

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 1

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)
58.758 €

Benefit-Cost Ratio
1,60

BIM direct expenses:

BIM Model Cost
7.883 €

BIM Coordination Cost
2.223 €

Phase Focus:

Planning&Design
ENPV: -39.813 € - EBC Ratio: -

Most Relevant Economic Indicator:

Clash Detection
39.662 €

BIM based Quantity Take-Off (QTO):
78.122 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction
1.132 €

Economic Net Present Value (ENPV)
178.576 €

CONSIDERATIONS

- The overall project Benefit-Cost Ratio is higher than 1 and the associated Net Present Value resulting estimate is positive: the adoption of BIM in this tender example is expected to be advantageous and sustainable
- This positive potential result is obtained despite the negative ENPV of the Planning and Design phase, that is expected to be offset by a high value during the year of construction
- The values of the most relevant economic indicators reported are those adjusted for inflations set at 2% and allocated over the Construction phase

TIPS

In this case studio the hardware upgrade investment has not been considered and the related cost has been switched off, as it has been assumed that the current hardware of the public organisation involved in the project is already enabling a smooth adoption of BIM. The benefit representing the savings through the reduction of claims and litigations and the benefit related to the time-savings have been both switched off.

OUTPUTS FROM THE TOOL

BIM MATURITY LEVEL 2

ECONOMIC IMPACT

Project General Indicators:

Net Present Value (NPV)

100.715 €

Benefit-Cost Ratio

2,02

BIM direct expenses:

BIM Coordination Cost

6.851 €

Phase Focus:

Planning&Design

ENPV: -34.649 € - EBC Ratio: -

Most Relevant Economic Indicator:

Clash Detection

39.662 €

BIM based Quantity Take-Off (QTO):

78.122 €

ENVIRONMENTAL IMPACT

CO_2 Emissions Reduction

1.132 €

Economic Net Present Value (ENPV)

220.533 €

CONSIDERATIONS

- The NPV and the Cost-Benefit ratio are suggesting that the adoption of BIM in the project is expected to be sustainable. In addition, considering the same phase as for BIM maturity level 1, the planning and design ENPV is not anymore negative
- The values of the two most relevant indicators are equal to that for BIM maturity level 1. The CBA tool, in fact, does not foresee any increase of these two benefits shifting from one maturity level to the other. One of the reasons leading to this result relates to the fact that BIM maturity level 2 entails that, as a standard practice, the design activity is carried out using BIM, that is why no cost associated with this activity is charged to the public client

TIPS

The same economic indicators switched off in the BIM maturity level 1 scenario have not been considered here either, as they are identified as not consistent with the project.

5 Conclusions

5 Conclusions

Fostering BIM adoption in the construction industry, starting from its use in public tendering and throughout the whole life cycle of a built asset, is a key issue to address in order to improve the industry performance and pave the way toward digitalization.

However, this study showed a lack of awareness by public procurers about the benefits of using BIM and how these benefits could in part, or totally, compensate the costs of its adoption.

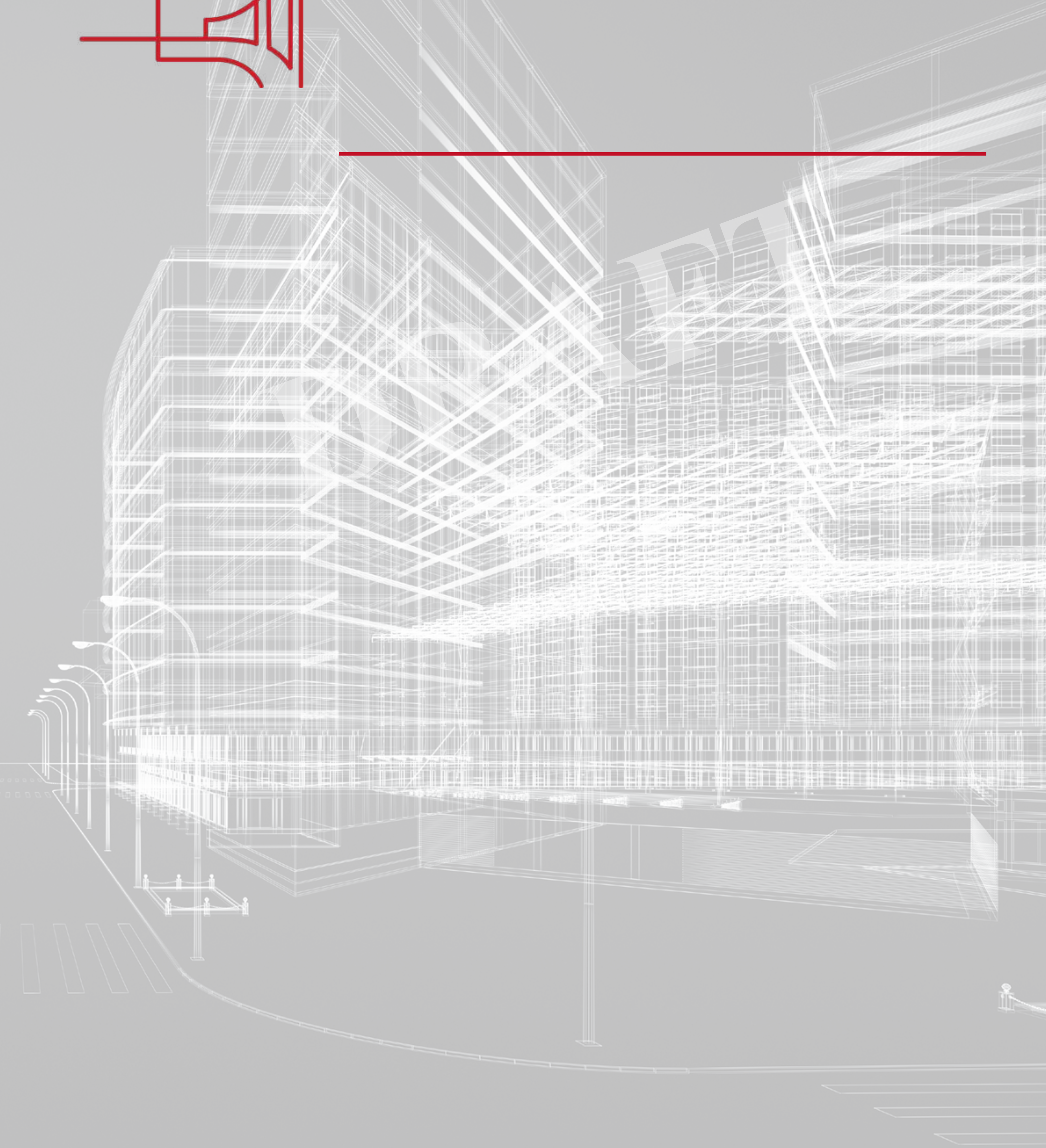
Thus, this study and the developed cost-benefit analysis (CBA) tool (downloadable at http://www.eubim.eu/) for the use of BIM in public tenders aim to educate public procurers and enable them to estimate, ex-ante, the benefit-cost ratio of the adoption/decision for a specific foreseen investment.

The tool presented in this handbook, in fact, provides an investment-specific CBA which supports public decision-making case by case.

It is worth emphasising that the focus on public tenders has lead to the need for measuring not only the financial benefits (for example, savings due to precise quantity take-offs) but also economic benefits more related to the socio-environmental field (for example, reduction of wastes and CO2 emissions). For this reason, two clusters of performance indicators have been created to measure the viability of using BIM in an investment project: NPV and BC ratio, from a financial point of view, ENPV and EBC ratio, from the economic one.

The developed methodology could foster the implementation of Building Information Modelling (BIM) in the construction sector, bringing further benefits to public stakeholders, by assessing the estimated costs and advantages for their specific projects.

6 Abbreviations



6 Abbreviations

AEC	Architecture, Engineering and Construction
BCR	Benefit-Cost Ratio
B/C	Benefit-Cost
BIM	Building Information Modelling
BoQ	Bill of Quantities
CBA	Cost-Benefit Analisys
CDE	Common Data Environment
COSME	EU programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises
DG GROW	The Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
EASME	Executive Agency for Small and Medium Enterprises
EBC	Economic Benefit-Cost
EIR	Exchange Information Requirement
EISMEA	European Innovation Council and SMEs Executive Agency
ENPV	Economic Net Present Value
EU	European Union
EUBIMTG	EU BIM Task Group
FM	Facilities Management
IRR	Internal Rate of Return
LOD	Level of Detail - geometrical information
MEP	Mechanical, Electrical, Plumbing
NPV	Net Present Value
QTO	Quantity Take-Off
R&D	Research and Development
VfM	Value for Money

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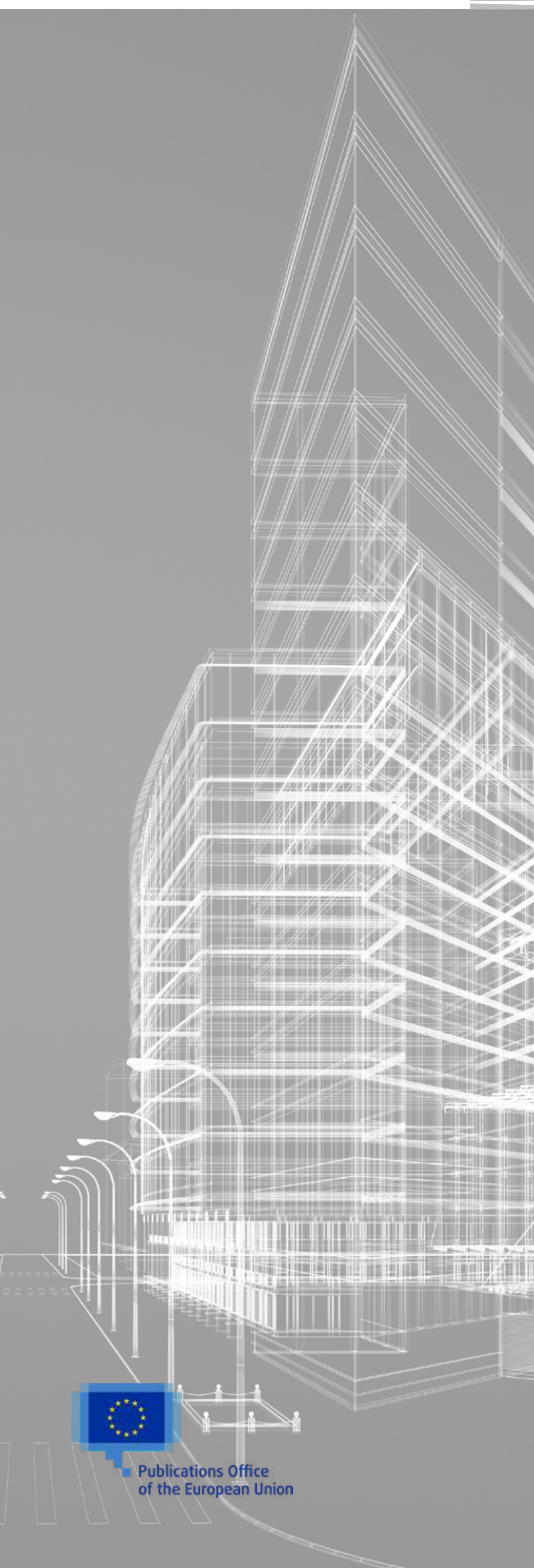

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