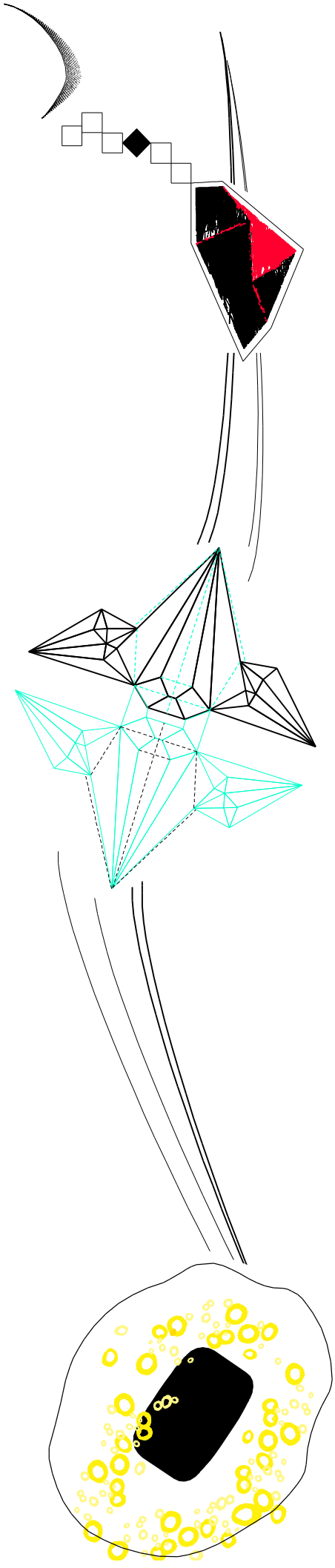

GRADUATION PROJECT

STIMULATING THE DIGITAL TRANSITION IN THE ITALIAN CONSTRUCTION INDUSTRY

ACADEMIC YEAR 2018-2019

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UNIVERSITY OF TWENTE.

Summary

Graduation Project

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Stimulating the digital transition in the Italian construction industry

0. Abstract

In the last couple of years, Information Technology (IT) has found its way to the Architecture, Engineering and Construction (AEC) industry, since IT-enabled application have shown their capability of taking over mechanical business and data operations. Within the construction sector, IT application has found its way under the denominator Building Information Modelling (BIM). The adoption of BIM for a design company doesn't require only a change from the traditional 2D way of design to 3D projects, but a whole process of transition change is necessary. a whole process regarding the company organization, structure and knowledge is necessary to fully understand and use all the advantages deriving from BIM, even if not without challenges, due to the difficulties and costs related to the transition CAD-BIM. Even if BIM implementation in Europe started few years ago, BIM maturity level of European countries is not the same. The literature shows how BIM implementation topic has not reached a high level in the Italian construction sector yet. To this extend, there is insufficient lack of knowledge among BIM design companies on BIM implementation problems and what needs to be done to successfully carry out the digital transition CAD-BIM. As a consequence of the above mentioned problem, the goal of this research is to provide to Italian design companies an overview about what the BIM implementation challenges are and what needs to be done to overcome those issues by defining a sequence of actions to carry out the digitalization process (BIM implementation roadmap). The research aims to provide an answer to the following questions:
1. What are the challenges related to BIM implementation an Italian design firm might encounter?
2. What are the possible strategies and recommendations needed for an Italian design company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?

This research can be divided into three main phases.
In phase one, a theoretical framework have been developed from previous studies such as the TOE framework, the IDT theory and Adriaanse's framework about what the main BIM implementation challenges are when adopting BIM inside a design firm. Four groups (environmental, organizational, individual and technological) and twenty BIM implementation challenges were collected in the theoretical framework. Specifically, four environmental challenges were collected (regulations and norms, common standards and information exchange, BIM adoption at a national level, level of clients' request for the use of BIM), eleven organizational challenges (time necessary to adopt new processes, high investment, organizational structure and strategy, top management support, re-define the business model, assign responsibilities for BIM implementation, re-organization of teams, data exchange within the firm, developing a collaborative way of working, promotion of the company's BIM capacity, contract change arrangements and costs), three individual challenges (cultural aspect, individual drive towards change, knowledge and skills) and three technological challenges (interoperability, current IT infrastructure support, scalability of BIM models).

In phase two a case-study approach has been used to analyze the current and expected BIM situation of General Planning (GP), 12th Italian design firm for revenue, investigating which BIM implementation

challenges of the previously developed framework were present in the case-study. To this extend, twelve BIM implementation challenges emerged as result of the interview process, which are: (1) Lack of clients' awareness about BIM advantages and request of BIM, (2) Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM, (3) Lack of collaboration between companies, especially when data are not protected, (4) Traditional way of working is still followed without a clear BIM workflow, (5) Lack of well-defined roles and responsibilities, (6) Overcoming the comfort of employees to change their working practice, (7) High initial investment without assessing BIM economic advantages in the short-term, (8) Lack of all the company's members direction to BIM, (9) exchange and set up of information from the beginning, (10) Promotion of the company's BIM capacity, (11) Interoperability between different software version, (12) High initial time to be invested to create templates, collaborative way of working and first projects with BIM. All these challenges emerged to be interrelated with the theoretical framework, however sometimes a different definition has been used because more specific and adapted to the context to which the research was conducted. For the environmental challenges found out from the case-study, the framework does not include directly the common standards and information exchange as a relevant challenge, because of a lack of regulations about this concept. However, it can be seen that the lack of regulations refers to the BIM models' privacy, while the lack of collaboration between companies emerged when data are not protected. From the technological challenges which came up from the theoretical framework, only the interoperability between different software slightly affected the BIM implementation in GP as a result of the strong IT system implemented by the company in the last years. For the individual challenges it can be noticed as inside GP, almost all the designers seem to show difficulties in overcoming the comfort to change their working practice. Some of the challenges from the theoretical framework emerged in the case-study, such as the high initial investment, the lack of company's direction to BIM, lack of BIM capability's promotion, information exchange and time-consuming process. However, two new challenges came up, the lack of a clear BIM workflow and, as a consequence, the lack of well-defined roles and responsibilities aligned with the tasks developed through the workflow itself. Moreover, a lack of all company's members direction to BIM appeared to be relevant, a high top management support emerged, while the business model re-definition did not emerge as a relevant challenge and contract changes will be an important future challenge.

In Phase 3, twelve BIM implementation actions and recommendations have been proposed on what needs to be done to overcome the challenges which came up in phase 2. To this extend, the BIM implementation actions proposed are: (A) Development of new regulations about BIM models' privacy and BIM process, (B) Stimulating the clients' BIM request in construction projects, (C) Developing a feasibility study for BIM, (D) set up the BIM strategy, (E) Developing a business model for BIM, (F) Developing a BIM workflow, (G) Developing roles and responsibilities inside the BIM workflow, (H) Creation of a marketing department, (I) Forming the BIM implementation group, (J) Trainings of resources and employees – human resource development plan, (K) Developing collaboration and procedural protocol, (L) Developing the technical resource plan. Those actions have been grouped up in a BIM implementation roadmap which is going to be used by Italian design firms facing the digitalization process CAD-BIM. The roadmap represents the sequence of actions which can be followed by a generic Italian design firm trying to overcome the BIM implementation challenges, however, it needs to be adapted to the specific situation of the firm itself. The roadmap was divided into five phases which are: the Initial or preliminary phase, Decision-making phase, Planning phase, Implementing phase and Post implementation phase.

The research can find its consistency as part of the literature regarding BIM implementation, explaining what are the issues regarding BIM adoption in the Italian construction sector for which the existing literature does not provide enough results. To this extend, the study can be useful for either theoretical (new researches, extension of the theoretical framework, new case-study analysis) and practical (Italian design firm trying to implement BIM inside an organization) purposes.

1. Introduction

In the last couple of years, Information Technology (IT) has found its way to the Architecture, Engineering and Construction (AEC) industry, since IT-enabled application have shown their capability of taking over mechanical business and data operations (Bughin et al., 2013), (Schmidt and Cohen, 2013). Employing IT applications in the construction process serves to make information activities, such as information retrieval and communication, more efficient as well as enabling stakeholders to effectively handle materials, by reducing for example inventory demands (Bjork, 2002). Within the construction sector, IT application has found its way under the denominator Building Information Modelling (BIM) which was proposed and defined during an ambitious project under the supervision of Stichting Bouwresearch of Rotterdam between the years 1987 and 1989 as a design process model (Bjork, 2002).

According to Murphy (2014) BIM is an integrated model in which information is collated, processed and then disseminated to key stakeholders and eventually is to provide coordinated production information. BIM technologies can also improve work processes and data exchange between all the stakeholders through the sharing of information providing by the model (Palos et al., 2014) that helps to overcome information asymmetry. As Murphy (2014) stated, the adoption of BIM as a tool for five-dimensional modeling improves the quality and efficiency of cost management services for front-end projects.

Indeed, the usage of BIM into the construction process has been proved to be beneficial for construction companies due to its countless advantages, such as the improvement of collaboration between different stakeholders, a better cost control and predictability and the reduction of mistakes during the construction phase of each project and the positive impact in a project delivery and outcome (Poirier et al., 2015).

In the recent literature it is found that the adoption is a pivotal factor for construction firms to harness the full potential of BIM applications (Wang and Chong, 2015). Even when the full potential is recognized, there continues to be a pervasive resistance to adopt innovation in construction due to barriers from a business perspective (Brewer and Gajendran, 2012) as well as from a technological perspective (Palos et al., 2014).

BIM implementation process refers to a socio-technical view in which it does not only consider the implementation of technology but also the socio-cultural environment that provides the context for its implementation (Arayici et al. 2011).

The adoption of BIM for a design company doesn’t require only a change from the traditional 2D way of design to 3D projects, but a whole process of transition change is necessary.

Change management is an integral process related to all project internal and external factors, influencing project changes. It can be used to solve problems by introducing all necessary changes and controlling this process of changing. Change management is closely connected with all the different aspects related to an organization, such as goals, costs, risks, quality, communications and other key integrative processes (Voropajev, 1998). For all the reasons mentioned above, a whole process regarding the company organization, structure and knowledge is necessary to fully understand and use all the advantages deriving from BIM (Khosrowshahi and Arayici, 2012). However, this process of transition into BIM practices for construction companies is not without challenges. Indeed, several construction companies , due to the difficulties and costs related to the BIM transition, prefer to keep the old way of working, delaying the passage to parametric IT applications (Elmualim and J. Gilder, 2013).

2. Concretizing the problem

This section aims to describe more specifically the problem mess. The context of the research will be the Italian construction market, focusing on the implementation of BIM in Italian design companies.
BIM implementation in Europe started few years ago, with countries such as Norway, Sweden, Finland (COBIM , 2012) and UK (AEC BIM Technology Protocol, 2015), which can be considered the first European developers of common BIM standards used as guidelines in construction projects. The European Union started in 2014 to stimulate the adoption of BIM with the Directive 2014/24/EU, which states " For public works contracts and design contests, Member States may require the use of specific electronic tools, such as building information modeling tools or similar" (The European Parliament, 2014). As it can be seen, the main regulation's goal is to stimulate public European authorities to adopt and consider BIM for future national construction codes. The Italian Minister of Infrastructures and Transports has recently developed a new regulation, called *"Decreto. N. 560, 1 December 2017"*. This regulation's goal is to stimulate the implementation of BIM into Italian construction companies (Ministro delle Infrastrutture e dei Trasporti, 2017). These firms have few years to embrace the digital transition from CAD to BIM and not be excluded from the construction market. However, in the Italian construction market, which has a tradition of decades and differs from region to region (cultural and national aspect), there is not a wide knowledge regarding the BIM topic yet. Moreover, Italian construction companies' managers lack of the basic knowledge about BIM implementation challenges, problems and the difficulties they might encounter while conducting the digital transition from CAD to BIM in their companies.

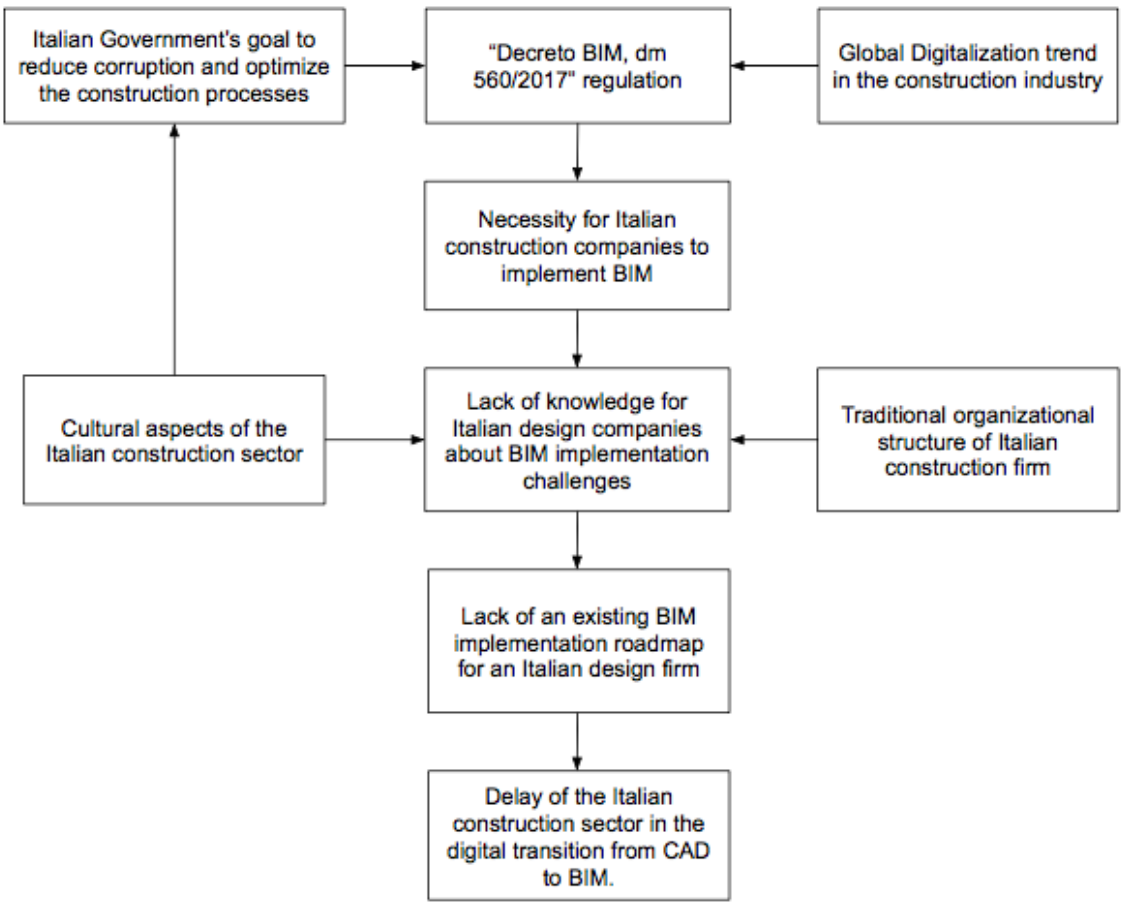


Fig. 1. Problem mess.

A whole process of change management will be necessary in order to change the traditional way of working (CAD), modify the traditional organizational structure of construction companies and implement BIM in the

every-day working routine of firms. However, due to the relatively new regulation, Italian managers do not know how to correctly and effectively carry out the process of digitalization into their company, because of lack of knowledge or experience in a similar topic. A business strategy would be necessary in order to help Italian construction companies' managers to understand what is necessary, from a change management, ICT and organizational structure's perspective, to conduct the digitalization CAD-BIM . All the reasons above mentioned, address to the general problem, which is a delay of the Italian construction sector in the digital transition from CAD to BIM. A graphical overview of the problem mess can be found in Fig. 1.

2.1 Problem statement

The problem context can be summarized in one *problem definition*, which is defined as follows:

> There is insufficient understanding among Italian design firms about BIM implementation challenges and what needs to be done to successfully carry out the process of digital transition from CAD to BIM.

2.2 Research Objective

This research project is meant to produce good answers and solutions to the problem sketched. In order to make that possible, the following *research objective* is derived from the problem definition:

> Providing to Italian design firms an overview about challenges related to BIM implementation and how these can be overcome by developing a BIM implementation roadmap in order to stimulate the digital transition (CAD-BIM) and successfully implement BIM into their every-day working routine.

2.3 Research questions

The research questions should be related to the research objective in order to translate a certain problem into a need of information that has to be investigated. As a consequence, the research questions are followed by a process of searching for specific information that can be used to solve the problem (Bougie et al., 2017). For this specific case two main research questions can be identified. However, in order to solve the main problem, the research questions need to be split up in sub-questions which divide the problem into its different components.
The main questions are:

1. *What are the challenges related to BIM implementation an Italian design firm might encounter?*
2. *What are the possible strategies and recommendations needed for an Italian design company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?*

The sub-questions can be classified in:

1.1 What are the main challenges related to BIM implementation which can be found in the literature and how can those be structure in a framework, which can be used for the case-study?
1.2 What is the current practice of BIM within an Italian design company (General Planning)?
1.3 What is the opinion of experts of the organization about the challenges they faced with when implementing BIM?

And:

2.1 What kind of recommendations can be provided to an Italian design firm to overcome the challenges identified in q.1.2?
2.2 What kind of change management is it necessary in a design firm and what needs to be done from an ICT perspective to facilitate and apply correctly the BIM methodology into Italian design companies?
2.3 What is the sequence of actions which can be followed by an Italian design firm to correctly implement BIM into its every-day working routine?

By answering to question 2, a BIM implementation roadmap will be developed by sequencing the actions to be conducted when implementing BIM into an Italian design firm.

2.4 Discussion on relevance

This section aims to justify the relevance to conduct a research on this topic. First of all, as mentioned in the previous sections, in the last years the theme of Digitalization in the construction industry has had a great emphasis, as it can be seen from the large numbers of researchers about this topic. The digital transition from CAD to BIM has been stimulated by the European Union, with the "Directive 2014/24/EU" as well as in the respective EU countries such as in Italy with the *Decreto. N. 560, 1 December 2017"* regulation, aiming to stimulate the implementation of BIM into Italian construction companies (Ministro delle Infrastrutture e dei Trasporti, 2017). Because of the relatively new regulation, Italian managers do not know how to correctly and effectively carry out the process of digitalization into their company, because of lack of knowledge or experience in a similar topic. For this reason, this research aims to provide to practitioners, after analyzing the problems and challenges related to BIM implementation in the Italian construction market, a practical guide on which actions have to be followed by an Italian design firm to correctly implement BIM in a design organization. The lack of knowledge and expertise about the topic in the Italian Construction market provides relevance to the research and at the same time it opens the possibility of future researchers in the same topic. Moreover, the practical need of a guideline on how to implement BIM in a design company can be useful for practitioners and the Italian construction sector.
For all the reasons mentioned above, the research can be considered relevant for both theoretical and practical purposes.

3. Research Design

This section aims to describe the research design, which corresponds to the plan of a research study. In this chapter a description of the research strategy, the data collection methods and the data analysis are provided in order to solve the specific problem described in the previous section.
As it can be seen in Fig. 2, the research study can be divided into four main phases.
Phase 1 (Chapter 4) includes an overview of BIM implementation challenges, which can be found in the literature, will be provided. In this phase the *theoretical framework*, which will be used to analyze the BIM implementation challenges in the case-study, will be developed based on the literature review carried out earlier in the project. Phases 2 (Chapter 5) and 3 (Chapter 6) are the core of the study with interviews, case-study observation and literature study to answer respectively to the research questions. For this reason, a specific paragraph is dedicated to the explanation of the data collection methods and structure of these two phases. Finally Phase 4 (Chapter 7-8) ends the research with discussions, conclusions and recommendations for future works.

In this research, a Design Science Research strategy will be used, because of the practical rather than theoretical orientation of the research and its aim to find solutions for practical problems rather than develop new theories. Design science research (DSR) have been used by various researchers in order to develop valid knowledge and directly/indirectly support managers' problem solving efforts. DSR is conceptualized as a research strategy, aimed at knowledge that can be used in an instrumental way to design and implement actions, processes or systems to achieve desired outcomes in practice. It is driven by field problems or opportunities; instrumental knowledge is developed by deep engagement with real-life problems or opportunities (Van Aken et al., 2016). This research strategy will help to find solutions to a practice-oriented research which, According to Verschuren (2010), is characterized by the following stages:

- Problem identification (Chapter 2);
- Diagnosis of the causes (BIM implementation challenges in a design firm, Chapter 5 and 6);
- Design a plan (actions and recommendations for the transition CAD-BIM, BIM implementation roadmap, Chapter 6);
- Intervention and monitoring of implementation;
- Evaluation of the result.

Considering the scope and the time constraint of this research project, it will not go further than creating recommendations for an implementation plan and therefore will not reach the stages of monitoring and evaluating the actual implementation process.
As stated by (Van Aken et al., 2016) a DSR project is typically driven by a type of field problem, or an opportunity such as new Technology (in the research's context the implementation of BIM within a firm). A context is chosen where this problem is important (or the opportunity has potential) and where its management and other stakeholders are prepared to engage with it in cooperation with researchers in order to develop a solution (*General Planning*, case-study of the research). After an intake process an improvement project is started. The problem, its context and causes are analyzed (BIM implementation problems and challenges), a solution is designed (recommendations and actions on how effectively implement BIM).

The prescriptions in a design research follows the statement "If you want to achieve Y in situation Z, then perform action X" (Van Aken, 2004), which can be translated into this research by assigning to the variable Y the perfect situation of BIM usage within the firm, which allows the organization to get advantages from its use, to Z the phase when BIM is implemented within the firm and to X the strategies and recommendations which need to be followed in order to correctly implement BIM within an organization.
DSR focuses on improving the present and current situation and, to this extent, can be used to extend the body of knowledge regarding organizations. Design science research has the following characteristics:

- research questions are driven by field problems (as opposed to pure knowledge problems);

- there is an emphasis on solution-oriented knowledge, linking interventions or systems to outcomes, as the key to solve field problems;
- the justification of research products is largely based on pragmatic validity (do the actions, based on this knowledge indeed produce the intended outcomes?) (Van Aken and Romme, 2012).

DSR aims to improve, like also consultancy does (Van Aken et al., 2016). This research might be considered as a consultancy for the selected case-study, aiming to provide practical solutions for the BIM implementation process. However, consultancy aims to improve a local context through case-specific designs, while academic research aims for generic knowledge that can be transferred to various contexts within a specified application domain. For this reason the results of this research can be used by different Italian construction companies which are facing with BIM implementation and the digitalization CAD-BIM and are not only limited to the selected case-study.

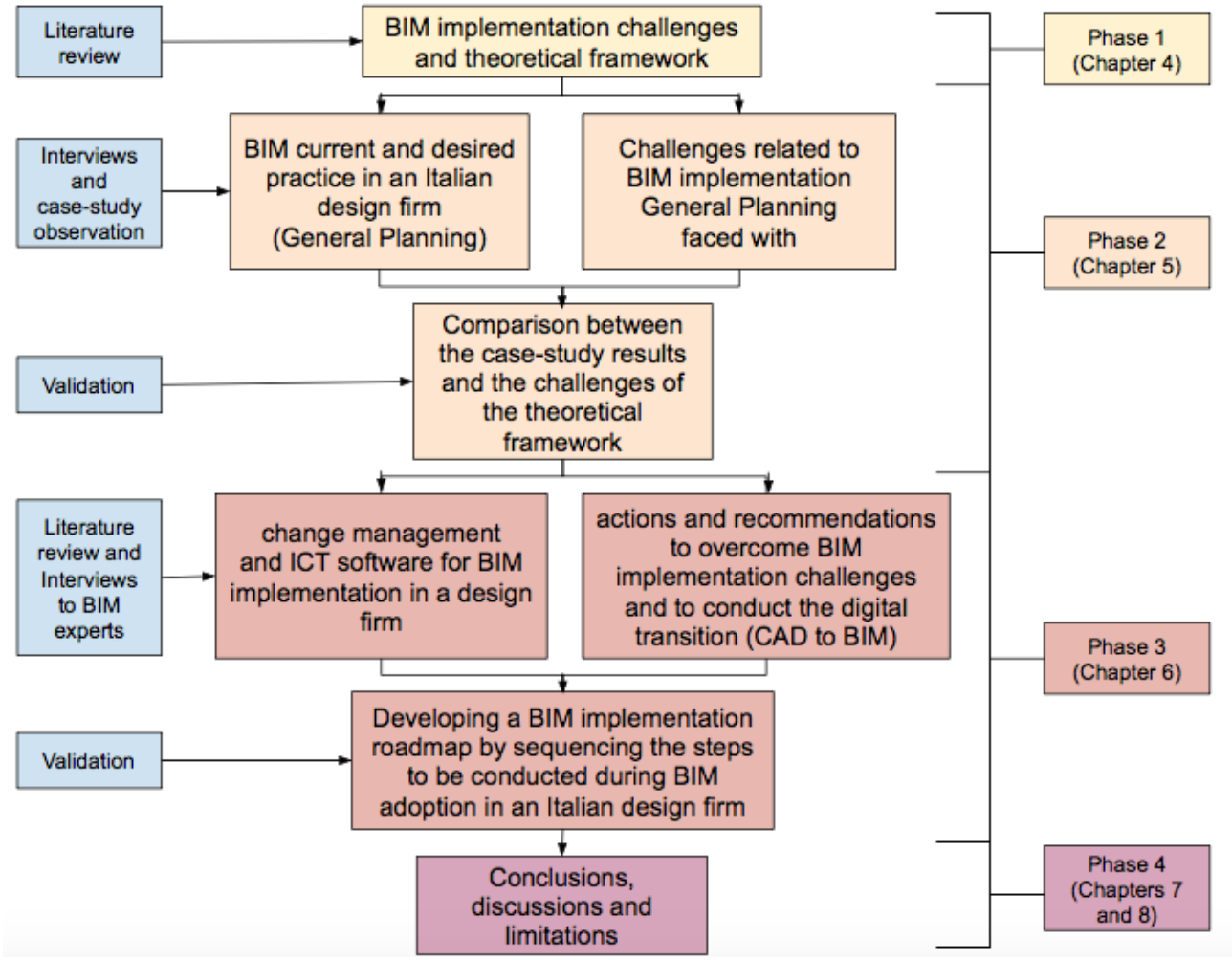


Fig.2 Research Design

Phase 1 and 2 - BIM implementation challenges for an Italian design firm

Phase 1 (Chapter 4) and Phase 2 (Chapter 5) of the research aim to answer to the first main research question, about what are the obstacles, problems and challenges the implementation of BIM in the Italian market might encounter. To this purpose, as it can be seen in Figure 3, this phase of the research can be divided into two sub-phases. During the first one, a literature review will be carried out to find information about BIM implementation challenges and problems related to technology implementation and organizational changes in a company who decides to implement BIM. At the end of this stage a theoretical framework about BIM implementation challenges will be developed, which will be used in and an answer to

first sub-question (1.1 in the research questions chapter) will be provided. The second sub-phase will regard interviews to experts of the case-study, as well as a case-study observation for an organization which decided to implement BIM into the every-day working practices (*General Planning*), in order to understand the level of BIM adoption within the firm and the problems regarding BIM implementation the company had to faced with. This second stage will answer to the second and third sub-questions (1.2 and 1.3 in the research questions chapter, respectively). As a consequence, a comparison between the case-study results and the challenges which came up from the literature will be provided, describing what are the differences which can be found when comparing theory and practice.
A more accurate description of the data collection methods can be found in the following chapter (Chapter 3.1).

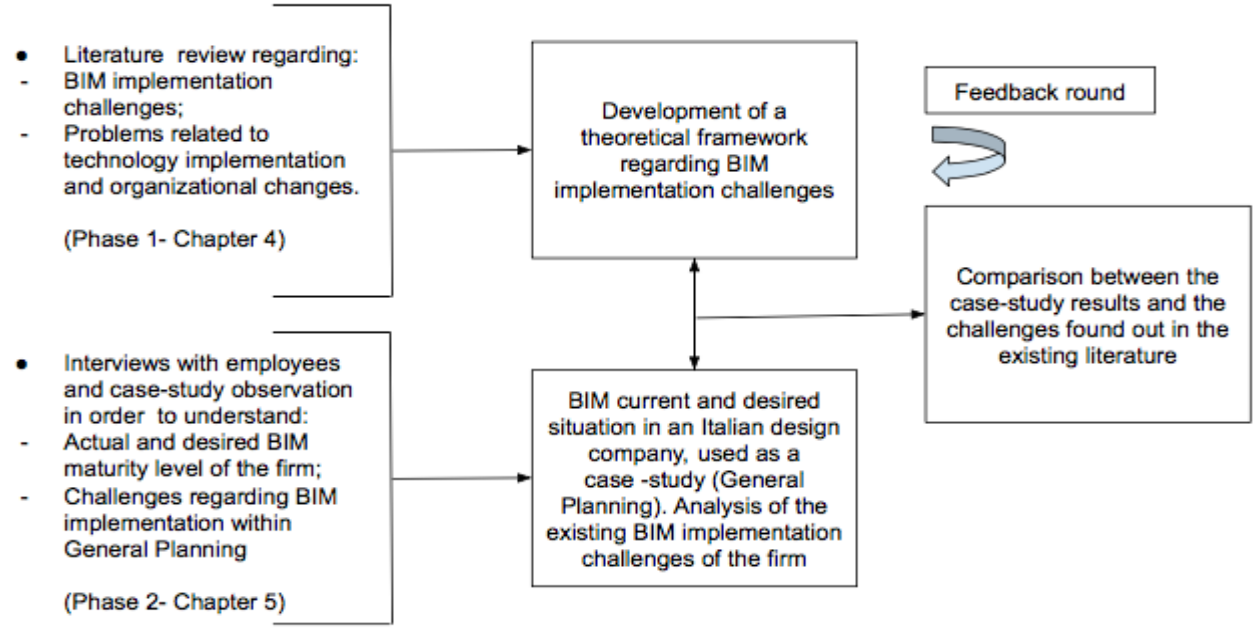


Fig. 3. Phase 1-2 – Research Design

Phase 3 – Actions and recommendations needed for an Italian construction company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine.

Phase 3 of the research (Chapter 6) will provide an answer to the second main research question of the study on which actions and recommendations can be provided to an Italian design company to successfully conduct the digital transition from CAD to BIM. During this phase, as it can be seen in Figure 4, interviews with BIM implementation experts and a literature review will be carried out. A more accurate description of the data collection methods can be found in the following chapter (Chapter 3.1). This two data collection methods aim to answer to the three sub-questions about (2.1) the recommendations which can be provided for an organization to overcome the challenges identified in q.1.2, (2.2) the change management in people, organizations and ICT software adoption necessaries when implementing BIM in an Italian construction firm, (2.3) the sequence of actions to be conducted by an Italian design firm when implementing BIM. By answering to these questions, a BIM implementation roadmap will be developed by sequencing all the steps previously pointed out, on which activities have to be conducted when implementing BIM.

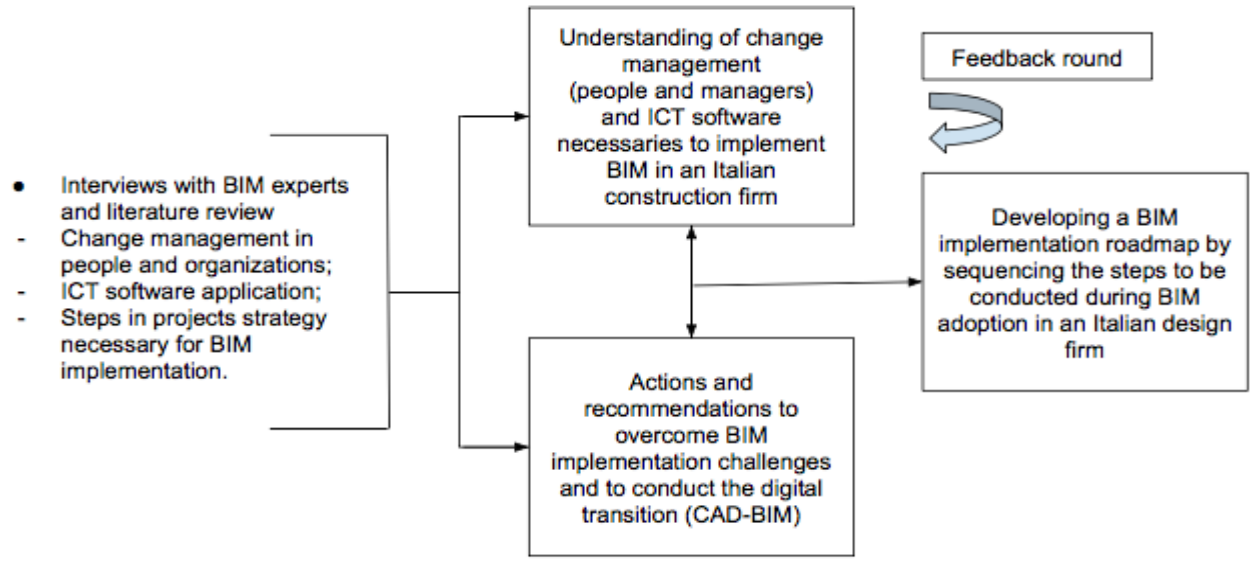


Fig. 4. Phase 3 – Research Design

3.1 Data collection methods

In this section an overview of the data collection methods, which will be used while conducting the research, is provided. Four different data collection methods have been chosen in order to collect information and answer to the research questions. Specifically, a literature review, interviews and a case-study observation will be used to answer to the first main research question of the study, respectively the theory review is necessary to understand what are the main BIM implementation challenges which can be found in the literature and can be collected in a theoretical framework (1.1), while through the interviews within the organization and the case-study observation the level of BIM adoption within the firm (1.2) and the problems related to BIM implementation the company faced with (1.3) will be investigated. Moreover, interviews with BIM implementation experts (external from the case-study) and a literature review will provide data about what possible recommendations can be given to overcome the BIM implementation problems and challenges the identified in the previous section and which emerged from the case-study observation (2.1), the change management and ICT software necessaries to implement BIM in an Italian construction firm (2.2) and what is a possible sequence of actions necessaries to implement BIM into the every-day working routine of an Italian design firm (2.3). The collected data will be useful to develop a BIM implementation roadmap to be used by other Italian design firm implementing BIM inside the organization.

Sampling

In this chapter, a description of the sampling method, which is relevant for the interviews, is mentioned. According to Fowler (2014), sampling refers to the selection of a population representative of the whole population. In this study the purposive sampling will be used. The purposive sampling technique, also called judgment sampling, is a type of non-probability sampling that is most effective when one needs to study a certain cultural domain with knowledgeable experts within. Purposive sampling may also be used with both qualitative and quantitative research techniques (Dolores, 2007). With this nonrandom technique there is no need to underline theories or a set number of informants, but the researcher can decide what needs to be known and set out to find people who can and are willing to provide the information by virtue of knowledge or experience (Lewis and Sheppard, 2006). While the case-study has been selected through the list of the best Italian design firms and a direct contact to the human resources of the organization, BIM implementation experts (external from the organization) are going to be selected via the app LinkedIn, through a private message explaining the importance and aim of this research. Some BIM experts are professors of technical

universities, such as Polytechnic of Turin and Polytechnic of Milan and can be contacted directly via the academic email. Moreover, as stated by Dolores (2007), if a sample is representative, it becomes valid over the domain it characterizes and there is no limit to the number of participants that could be made by a sample.

Literature review

The first main source of data, will be through a literature study. In this phase, scientific papers, articles and previous studies will be reviewed and analyzed to support and provide insights to the research. Particularly, the literature study will provide an answer to the first sub-question, about the challenges related to BIM implementation which can be found in the literature (1.1), in order to answer to the first main question about what are the obstacles, challenges and problems the implementation of BIM in the Italian market might encounter. The aim of this literature study is to develop a theoretical framework which is going to be used to understand the BIM implementation challenges within the organization. Moreover, academic papers and journals will be used as sources of information in Phase 3 of the research (Chapter 6), to provide recommendations about how the identified challenges can be overcome.

Interviews

Semi-structured interviews will take place in phase 2 (Chapter 5) and 3 (Chapter 6) of the research. The choice of semi-structured interviews instead of the traditional ones is due to the fact that this method enables the respondents to add new insights, while in a classical interview the answers are limited in the framework of the question (Cassell and Symon, 2004). In phase 2, interviews will be conducted with the employees of General Planning in order to get data of what is the actual and desired BIM situation of the firm and what are the BIM implementation challenges the firm is facing.
In phase 3 of the research, after the selection of respondents (via LinkedIn, as explained above) a specific email will be sent to all the experts, with a presentation letter, goal of the study and why their participation is important. Afterwards, the interviews will be made in person. Indeed, the problem of distance will be overcome with a phase of data collection which will be held in Italy, specifically in Milan, where different BIM experts have their own company. Moreover, with the availability of electronic instruments, such as Skype, different Italian experts can might be interviewed, even the ones not resident in Milan.

In order to answer to the specific questions, the people to which the interview will be held should fit in one of these categories:
- They should be BIM experts of the selected company, or directly involved in BIM implementation of the company.
- They should come from different disciplines related to BIM (managers, architects, ICT expert etc).
- To provide recommendations, the respondents need to be BIM experts, researchers or Professors (of Politecnico of Turin and Politecnico of Milan) involved in studies related to BIM implementation into Italian construction companies;
- The respondents are working as digital transition managers to implement BIM into Italian construction companies;
- The number of respondents chosen should be enough to collect information to answer to the first and second main research question, but at the same time should be close enough to circumscribe the answers given. Moreover, interviews will be conducted until a recommendation to all the BIM challenges will be found.

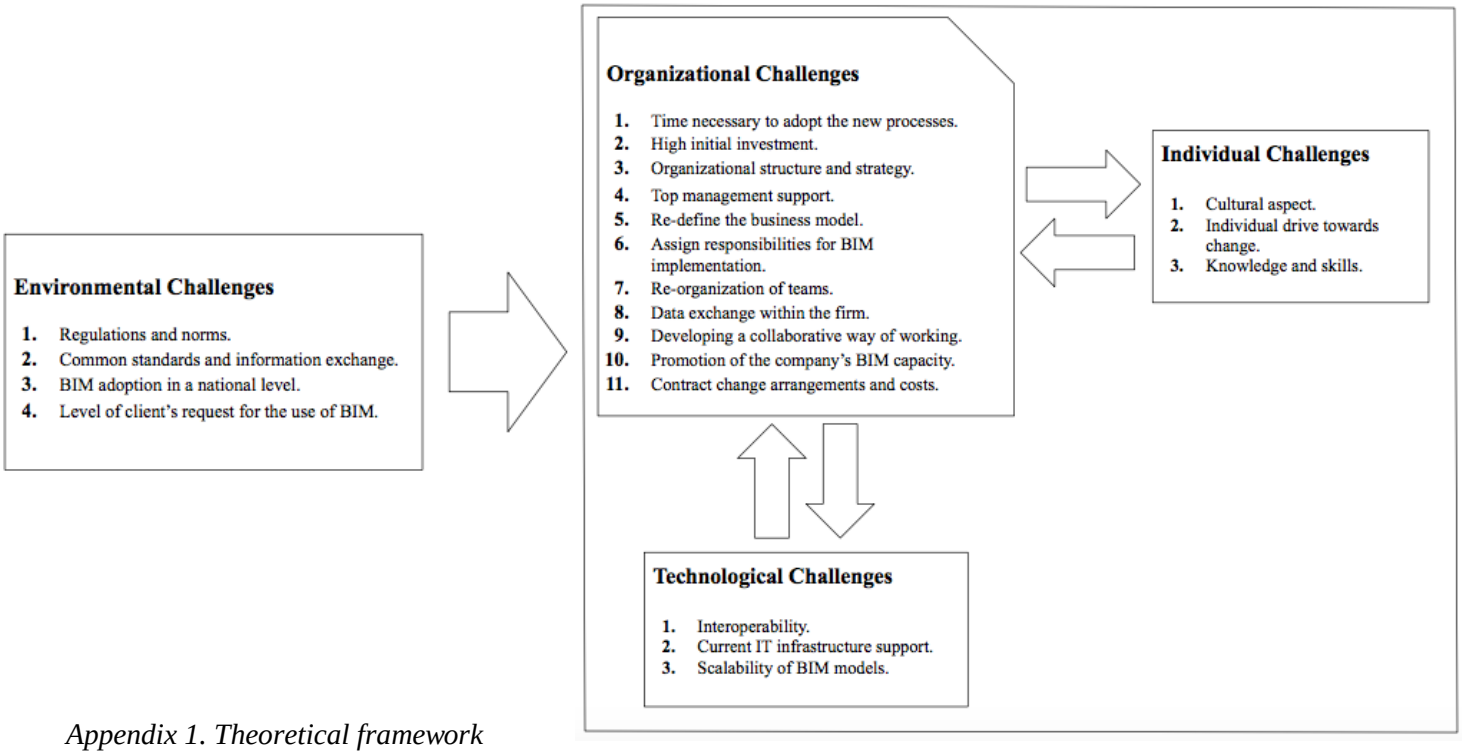
Case-study method

The selection of case study is an important instrument to provide rigor to the process and credibility in the research findings. In Phase 2 of the research, a case-study will be used as an example of an Italian design firm which conducted the process of digital transition from CAD to BIM. A case-study method is essential in this phase of the research to get relevant data about what kind of BIM implementation challenges an Italian design firm is facing. The case-study has to be a frontrunner for BIM implementation in the Italian construction industry because the results of the research have to be considered an example for other Italian design companies. The company, selected from the list of best Italian design firms, is *General Planning Srl*, based in Milan, which decided to adopt BIM into its every-day working practices. General Planning is a Company Leader in the Construction Engineering Design with an internal staff of 60 people including Architects, Engineers and Technicians supported by Associated Firms and external collaborators making a working group of about 100 professionals. General Planning, using the most advanced tools (including BIM) and design method, provides services of: Integrated Coordinate Design, Construction Supervision, Project and Construction Management. The company has contributed in the design and realization of different types of buildings, such as: Office and Headquarters, Laboratories, Hospitals, Industrial buildings, Residential buildings. The findings of this observation will provide data to answer to the first main research question of the study. For this reason, interviews to BIM experts of the selected organization will provide an overview of what kind of challenges the company encountered when implementing BIM into the organization. The contact person of the firm, Alessandro Sandrelli, is a construction engineer who is actually working as a BIM manager for *General Planning*, and is directly involved in all the BIM procedures of the firm. A clear description of current BIM situation of the case-study will be provided in Chapter 6, when answering to the sub-question 1.2.

3.2 Data analysis

The collected data from literature study, interviews and case-study will then be analyzed. The interviews will be recorded via mobile phone, the recordings will be translated in paper and the most important information from the interviews will be collected. The data will be gathered in a Word file, while an Iphone 7 will be used for the recordings. Moreover, documents of the company will be analyzed as well to get information about projects and about the firm in general. As mentioned above, the information provided by the interviews within the case-study will be analyzed to answer to the first main research question (1), while interviews to BIM experts (external from the organization) and a literature study will be used as a data collection method for the second main research question. The results from either the interviews and literature review will be then combined into the actions or recommendations which can be found in chapter 6. Afterwards, based on the collected data during the research, a roadmap on how a generic design Italian construction company should conduct the digital transition from CAD to BIM will be developed. The BIM implementation roadmap will provide an answer to the second main research question of the study and consequently will close the research.

4. BIM Implementation Challenges



Appendix 1. Theoretical framework

This Chapter aims to collect all the challenges related to the adoption of BIM, by explaining the causes which delay its implementation in a design firm. To this purpose, a literature review will be carried out. Four different main groups of challenges emerge from the literature, specifically: environmental, organizational, individual and technological challenges. These challenges will be combined in a framework and compared with those which will come up from the analysis of the case-study, when implementing BIM in an Italian construction firm (Appendix 1). Indeed, all the identified challenges are linked to the theories reviewed in the previous section, and, when combined in a framework, they form the basis from which the challenges related to BIM implementation of the selected case-study can be reviewed. By building up the theoretical framework, an answer to the first sub-question of the research will be provided.
For convenience of the reader, Appendix 1 has been introduced in this chapter.

4.1 Environmental challenges

The first group of challenges, identified through a literature review, is related to the external condition of the organization which might affect the BIM implementation process. Environmental challenges are those barriers which do not depend directly to the organization but are external and out of its power. These challenges can only be managed, avoided or influenced by a certain company, but are not generated by the organization itself. The environmental context needs to be taken into account when implementing ICT in a firm (Tornatzky et al., 1990). Specifically, four different environmental challenges have been identified to be important when adopting BIM in a construction firm. Regulations and norms, common standards and information exchange, BIM adoption in a national level and level of client's request for the use of BIM will be reviewed in the following sections.

4.1.1 Regulations and norms

The use of BIM can be mandated by public policies and national regulations. From an European point of view, the Directive 2014/24/EU states " For public works contracts and design contests, Member States may

require the use of specific electronic tools, such as building information modeling tools or similar" (The European Parliament, 2014). As a consequence, the main regulation's goal is to stimulate public European authorities to adopt and consider BIM for future national construction codes. From a national perspective, regulations and norms can stimulate the adoption of BIM into the market, while from a construction company's perspective, the pressure which derives from the government might be seen as an environmental challenge. When the use of BIM is mandated and is not a strategic management choice, its implementation can be a difficult challenge to overcome in a short-time period. For this reason, the external pressure which derives from regulations and norms regarding the adoption of BIM can be difficult to manage for an organization. Even if BIM implementation in Europe has begun few years ago, with Norway, Sweden, Finland (COBIM, 2012) and UK (AEC, BIM Technology Protocol, 2015) first countries to stimulate and adopt BIM for public and private works, the European situation regarding BIM implementation norms and regulations is not clear yet. For this reason, BIM implementation might be delayed in some countries, even if several European governments are trying to stimulate and incentivize its adoption in a broader perspective. A clearer overview of how regulations affect BIM implementation in Italy, and what are the main norms concerning BIM adoption will be provided in Chapter 6.

4.1.2 Common standards and information exchange

Directly connected with regulations and norms, common standards need to be defined. Recently, several countries are trying to develop common standards and regulations about information exchange. In the construction sector, the Industry Foundation Classes (IFC) standard is used to specify how the objects with attributes can be classified. The use of a common standard helps to avoid problems of communication, information exchange and to improve interoperability. A BIM model is a common digital space which allows different stakeholders involved in the project (architects, structural engineers, MEP engineers etc.) to collaborate in order to avoid clashes and design problems. Using IFC format enables all the different disciplines which take part in a single project to have a unique standard, preventing problem of interoperability and communication (Monteiro and Martins, 2013). This appears to be important especially in multi-disciplinary projects, where different stakeholders need to collaborate with their specific competence in the parametric model. The lack of common standards and regulations about information exchange is one of the reasons why public governments are showing difficulties to promote the digital transition CAD-BIM and, as a consequence, there are still several differences between the BIM maturity levels of different European countries. Indeed, not all the European countries are showing the same level of BIM adoption, promotion and use in the public and private sector, and this fact can be considered a consequence of either the lack of regulations and common standards which align BIM use at a national and international level. For this reason, construction companies see in the lack of common standards one of the challenges which affect the implementation of BIM in a firm.

4.1.3 BIM adoption in a national level

The level of BIM adoption in a specific country is the third identified environmental challenge. In an historical period characterized by the spread of digitalization and Industry 4.0, ICT adoption in a construction company can be seen as the only way to keep a spot in the future market. However, there is still great uncertainty in several construction countries about the contributes BIM might have and how to deal with the digitalization process from CAD to BIM. The level of BIM adoption differs from country to country and even within the same country the differences between the maturity level of companies appear to be evident. Without knowledge about BIM advantages and benefits, the real use of BIM cannot be understood by managers and clients. The requirement of BIM in a market where only few companies implemented it, may result in limiting the pool of potential bidders and, as a consequence, it may lead to an increase in the project's price. As explained in the theory of diffusion for an innovation, with the S-curve, the adoption of

technology in a market is divided into different phases, and the first adopters, if it is the right period for the innovation's adoption, can take the best advantages from it. The implementation of BIM in a certain market follows the same rules, and a construction company needs to understand which is the best moment to implement BIM into the organization. According to Rogers (1995), surveys can be considered a relevant instrument to analyze the situation regarding the level of BIM adoption in a specific market.

4.1.4 Level of client's request for the use of BIM

The spread of BIM in a market, depends on the level of client's request for the use of BIM. If clients are aware about BIM advantages, benefits and what might be the advantages in a certain project, they can be more convinced to request it more frequently. The lack of request about BIM from clients represents the fourth identified environmental challenges (Eastman et al., 2011). From a construction company's perspective, the requesting use of BIM by a client is seen as more as a challenge rather than a strategic decision, and it might occur that the organization is not ready or does not have the capabilities required to implement BIM. A client's request for the use of BIM in projects, especially in a country where BIM implementation has not reached an advanced level yet, can be felt as an external pressure for a company.

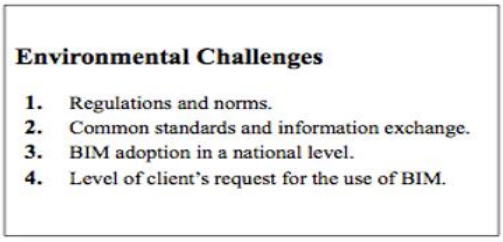


Fig. 5. Environmental challenges.

4.2 Organizational challenges

The second group of BIM implementation challenges regards the organization, and how it reacts with a change in the common processes and routines when adopting innovation within the firm. In contrast with the environmental challenges, which do not depend directly to the company but are out of its power, organizational challenges can be overcome by the company itself, through a long-term vision of BIM benefits, a change in the working-practices and the creation of a new business model according to the necessities of the new processes with BIM. Several organizational challenges can be found in the literature and have to be taken into account when implementing BIM into a firm. Organizational challenges can be clustered into four main groups. The first two issues are related to the investment, in terms of cost and time, which has to be considered relevant when deciding to implement BIM (Chapters 4.2.1 and 4.2.2). Secondly, the strategy of the firm has been analyzed with the changes in the organizational structure, top management support and the re-definition of the business model (Chapters 4.2.3, 4.2.4 and 4.2.5). The third group of challenges relates to the change of responsibilities and data exchange inside the firm, emphasizing the importance of assign responsibilities for BIM implementation and re-organize the teams (Chapters 4.2.6, 4.2.7 and 4.2.8).Lastly, the fourth group of organizational challenges refers to the collaborative way of working, change in the contracts and promotion of the BIM capacity of a firm (Chapters 4.2.9, 4.2.10 and 4.2.11). A description of the above-mentioned BIM implementation organizational challenges is provided in this chapter, while in Chapter 5 an analysis of which of these challenges affect the case-study will be provided.

4.2.1 Time necessary to adopt the new processes

The implementation of BIM is usually seen as a complex and time-consuming process, which is accompanied with a learning process. BIM implementation benefits might not be seen immediately. In fact, especially in the first phases of the adoption, BIM can be seen as an obstacle more than a resource, and the challenges can be more than the benefits. A certain amount of time is necessary to effectively implement BIM into a company (Eastman et al., 2011). The delay in terms of time is caused not only by trainings and lack of skills, but it is a consequence of all the new procedures which need to be set-up internally for a construction company to conduct the digital transition CAD-BIM. The IDT theory provides an explanation about the factors which affect the timing of innovation adoption described in Rogers' five stages (Rogers, 1995). Normally a company, when facing the digital transition, keeps the traditional way of working for a determined period of time, working at the same time with BIM in other projects. Interesting examples will be given in Chapter 5 by the case-study (*General Planning*) and how the design company faced the digitalization, especially in the first projects. In order to overcome this challenge, a new long-term strategic vision in the company needs to be built. All the possible recommendations about these challenges will be provided in Chapter 6.

4.2.2 High initial investment

BIM implementation is also a complex and costly process. When trying to utilize BIM initially, companies will have to invest in software, hardware and training of their employees. Moreover, a change in system configuration, library and procedures will be necessary when adopting BIM. All these costs can be considered as the initial investment necessary to conduct the digitalization process and implement BIM into the everyday working routine of the company. The high initial costs may serve as a hindrance to implement BIM, especially when the long-term benefits are not taken into consideration. For smaller companies, the initial investment might be too high although they are aware of the long-term benefits of the application of BIM. Another thought belonging to this barrier is the fact that some projects are perceived too small, to achieve the full benefits of the implementation of BIM. High investment costs accompanied with little to no added value also serve as a hindrance to implement BIM. From the outset, the development of BIM and inquiry into its costs/benefits have been inextricably linked (Lu et al., 2014). In BIM adoption, researchers have shown that one of the major hurdles is justification of the additional cost using evident benefits (Li& Huang, 2009). Users who are to adopt BIM need the encouragement of empirical evidence, while investors need to discern clear proof of its benefits in order to justify their investment of time and budget (Peng et al., 2013).

4.2.3 Organizational structure and strategy

In order to exploit the full benefits of BIM, companies must utilize an organizational structure and strategy that facilitates the implementation of BIM. However, several organizational issues that hamper the successful implementation of BIM can be identified, such as professional liability, process problems, and trust. A new organizational structure and vision of the company needs to be set up in order to achieve the goals in a medium-long term. During the implementation process a strong base of consensual organizational vision towards its intentions with the new technology is important, and the goals need to be set with a strategy to achieve them (Smith et al., 2009). When implementing BIM, it is fundamental to have a clear idea of what are the goals set for the upcoming years, and, according to those, the organization can decide which is the best path to follow in order to achieve it. The creation of an effective organizational structure and a future vision towards BIM benefits and uses can be seen as a challenge for construction firms. In order to overcome

it, some guidelines can be developed and a BIM implementation plan needs to be developed at the beginning of a BIM project, as it will be explained in the recommendations chapter (Chapter 6).

4.2.4 Top management support

The support of the management team is one of the most important drivers when implementing technology in a company. The implementation of BIM is a process which requires action and strategic decisions need to be undertaken to adopt the new methodology. For this reason, BIM adoption can be seen as a top management's decision. Senior managers are often reluctant to introduce new technologies and processes to the organization, while management support for BIM implementation is essential (Liu et al, 2015). Without the necessary support or with a wrong allocation of resources and strategic choices, the BIM implementation process may fail, delay or can cost much effort and money. For these reasons the management team need to have a clear idea of what are the BIM implementation goals and how to achieve them. An example of how the management team influenced BIM adoption within a firm, will be provided during the case-study (Chapter 5).

4.2.5 Re-define the business model

One of the organizational issues which a company encounters while implementing BIM into the organization, is related to a change in the way the firm's business is structured. In order to create value, a company needs to adapt the business model according to the new implemented technology. The old business model used by a company, can never automatically provide benefits, if not translated and modified according to the necessities and practices related to BIM. For this reason, the business model has to be adapted, in order to incorporate the advantages of the implemented technology and, as a consequence, generate value. The challenge in this case, is related to what kind of business model can be considered adequate when implementing BIM. As it can be seen from the Mc-Leamy curve (Lu et al., 2014), the use of BIM changes and anticipates the design in the earliest phases of a project and consequently, a new way of working will provide different services to the customers. The problem is to understand how much customers are willing to pay, especially in projects where BIM is not mandated, to benefit of all the advantages BIM can provide in a project. The firm's business model needs to be re-structured by considering all the different advantages the use of BIM has in terms of costs, time and customers' satisfaction.

4.2.6 Assign responsibilities for BIM implementation

BIM implementation, after the decision and the approval from the top management team of proceeding with it, is a process which requires action. The dynamics regarding BIM adoption may be outside the knowledge and competences of the top management team and for this reason an ongoing negotiation process is necessary. BIM implementation's responsibility has to be assigned to a specific group of people, internal (BIM implementation experts) or external (BIM implementation consultants), in order to facilitate the digital transition. This leads to concentration of interest and knowledge to a specific group, while the rest of the team will continue with the every-day practices. According to Jones (2011), this person, or group of people, who have the responsibility for the BIM adoption, can act as a BIM champion in the implementation process. The need of assigning this important role to a specific group, internal or external, can be seen as a challenge regarding BIM implementation, and it may happen that, if the implementation process is not led by a certain group or person, the rate of failure is higher.

4.2.7 Re-organization of teams

Conducting the digital transition from the traditional way of working (CAD) to the BIM methodology for a construction firm means a change in the repartition of team members and the creation of new roles within the firm. New skills and BIM knowledge are necessary to perfectly adopt the new way of working. Not only designers but new professional figures are required, such as the BIM manager, and in most of the cases the creation of a new department specialized in BIM can help to facilitate the use of BIM in the company. Particularly, a new organizational culture needs to be developed within the firm, and the roles need to be defined according to it (Underwood et al., 2010). This re-organization of the company requires time and is coats, and for this reason can be considered one of the organizational challenges regarding BIM implementation. Moreover, it is clearly affected by the competences the market can offer in term of knowledge and skills and, at the same time, by the level of BIM adoption in a country level. The case study of General Planning can be an interesting example on what are the challenges a design company has to face with, in terms of re-organization of teams and new roles during the digital transition to BIM. All the possible recommendations on how to overcome those challenges in a practical way will be provided in Chapter 6.

4.2.8 Data exchange within the firm

As mentioned earlier, BIM implementation requires a change in the way procedures within a firm are conducted. With the traditional way of working, files are exchanged as “DWG” as AutoCAD drawings with all the information stored in PDF, Word or Excel sheets. BIM literally changes this way of working with a share environment where all the information are stored in a parametric model, and all the different stakeholders can work at the same time, on the same project, from different places (Eastman et al., 2011). This means that Data exchange methods need to be adapted according to the new required procedures. This challenge is directly connected to the development of a collaborative way of working, because information and data are exchanged and shared in a different way when using BIM in a project. The case-study will provide insights on how data are exchanged in a design company who decided to implement BIM. Moreover, due to the large size of BIM files, files have to be stored in an appropriate database, which can be considered a technological challenge (Chapter 4.4).

4.2.9 Developing a collaborative way of working

Collaboration is the key-word when using BIM. In a BIM project all the stakeholders and team members collaborate in the same model, sharing information and working in the a shared virtual environment. This fact completely changes the traditional way of working, where, with a lack of collaboration, mistakes are easy to be made. Using IFC format enables all the different disciplines which take part in a single project to have a unique standard, preventing problem of interoperability and communication (Monteiro and Martins, 2013). This appears to be important especially in multi-disciplinary projects, where different stakeholders need to collaborate with their specific competence in the parametric model. A collaborative way of working needs to be developed by all the employees of a construction firm in order to prevent misunderstandings and create the best conditions to work with BIM. Interoperability is also a challenge related to collaboration, which will be analyzed in the technological issues. For these reasons, establishing a collaborative mindset, and learning how to approach the new collaborative way of working will be necessary for team members of a company which decides to implement BIM.

4.2.10 Promotion of the company's BIM capacity

Due to the high level of competition in the construction sector, having good BIM capacity does not mean a direct advantage in the market. The company, after a first period dedicated to the implementation of BIM, needs to be able "to sell" its BIM capabilities to clients and customers. For this reason, a secondary step will be the promotion and marketing of the company's BIM capabilities, by sharing to the market an idea of BIM as part of the firm's brand, philosophy and DNA (Joseph, 2012). Most of the companies, when implementing BIM, focus only on the internal changes, underestimating the importance of a good marketing campaign about the company's use of BIM in construction projects. Informing a client about the previous uses of BIM in certain projects, can give the company advantages to get the contract, while final users can be informed about the advantages derived from the use of BIM, especially in the maintenance phase. Hence, the development of marketing and promotion of the company's BIM capacity needs to be considered an important factor after the implementation of BIM.

4.2.11 Contract change arrangements and costs

As explained earlier, the use of BIM in a project changes the way information are shared and workflows are set up. With a change in collaboration, the traditional contractual arrangements between different parties need to be modified by sharing responsibilities and risks to all the stakeholders involved in a project. The challenge which emerges here, is related to the development of knowledge and experience to the people responsible for contractual arrangements, and the time necessary to change the contracts according to the new processes with BIM. Moreover, a cost is would be essential, to re-structure all the contracts and to train the contractual experts of the team (Eastman et al., 2011). The time required to adapt the contracts to the new methodology is also part of the challenge and needs to be avoided. More information about the contractual arrangements in the Italian construction market will be provided while analyzing the case-study (Chapter 6).

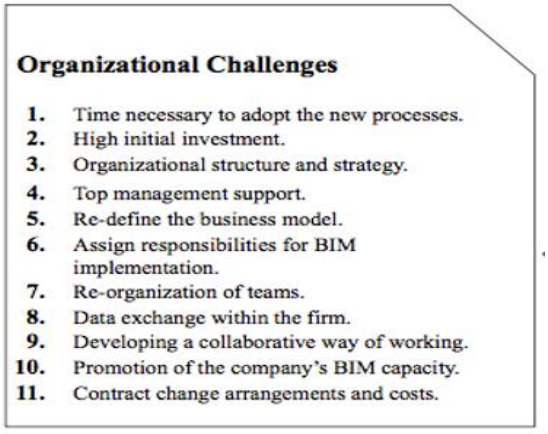


Fig. 6. Organizational challenges.

4.3 Individual challenges

The third group of challenges regard those which affect the individuals. To this extent, the theory of Adriaanse provides a clear overview on how personal and external motivation are important factors for individuals when implementing ICT in a company. Individuals compose teams, groups and each member's positive attitude towards change is fundamental when implementing BIM in a company. The team should have common goals, motivation, ability to collaborate, trust and the skills which are fundamental for the new practices. Moreover, the cultural aspects need to be taken into account when adopting technology and this

aspect is difficult to monitor, especially because of the differences from region to region and country to country. Figure 7 describes all the identified individual challenges.

4.3.1 Cultural aspect

Culture expresses the social ideals, values and beliefs that members of an organization come to share (Louis, 1980). Culture can have powerful consequences on individuals and organizations' performance. It can be defined as "a pattern of basic assumptions, invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration" (Schein, 1986). Organizational culture thus serves the leader of an organization through nurturing the value system created by him to both serving and incoming members. Organizational culture might be examined by the employees' capability to identify and accomplish the company goals and the level of awareness of employers in recognizing and rewarding good performance of employees (Cheung et al., 2010). Culture might be a challenge regarding BIM implementation, to the extent that for culture reason individuals of an organization do not want to change the way they are working or are not willing to embrace change. To this extend, the cultural aspect here refers to the way people work and are used to work inside an organization. The cultural aspect is difficult to measure because it depends from lots of factors, some of which are impossible to gather. At the same time, the cultural aspect needs to be considered important when analyzing the situation regarding BIM implementation inside the Italian construction sector, because of the traditional way of working characterizing the Italian construction sector. For this reason, culture has to be considered when implementing BIM inside an Italian design firm.

4.3.2 Individual drive towards change

Directly connected with culture is the individual drive towards change. It refers to the ability individuals of an organization have, to change their way of working, by adapting it to the new methodologies required after ICT implementation (Partridge, 2007). This challenge, when implementing BIM into a construction firm, can be translated into the ability of individuals to embrace change, by adopting the new way of working, with BIM, overcoming the traditional way of working (CAD) they were used to adopt. The reason why this challenge is difficult to overcome, reflect to the "fear" people have towards change, and their preference to keep on working in the same way during the years. The psychological reason of this fear will not investigated by this research, but, at the same time, is important to consider this challenge when implementing BIM. The individual resistance towards change is difficult to measure because of it psychological nature, but some recommendations can be provided on how can managers stimulate team members to adopt a positive attitude towards change (Chapter 6).

4.3.3 Knowledge and skills

The lack of knowledge and skills is perceived to be one of the main barriers to the implementation of BIM. BIM implementation itself requires knowledge and competences regarding several IT and software applications. However, there is quite some ambiguity regarding what BIM is and what it actually involves and many companies lack the competences to implement and use BIM. The lack of BIM professionals is usually due to a lack of inadequate training and education (Liu et al, 2015). When implementing BIM, new skills are required for the employees and the knowledge of software applications, new processes and data exchange methods are required by the companies. At the same time, it may happen that the labor market is not ready yet to provide all these experts and people with knowledge regarding BIM methods. For the reasons mentioned above, the lack of knowledge and skills can be considered one of the individual challenges which affect BIM implementation in a company.

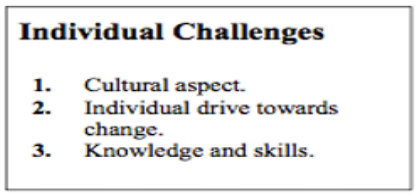


Fig. 7. Individual challenges.

4.4 Technological challenges

The last group of presented challenges, regards those related to the technology itself and the consequences to its implementation in a firm. Technological (or innovation) challenges, are a consequence of BIM's adoption from a technological and technical point of view. Several problems come up when implementing BIM within a firm, such as interoperability between the different software, the current IT infrastructure support which may be insufficient to sustain the innovation and the scalability of BIM models. All these challenges are explained below. Figure 8 summarizes the technological challenges.

4.4.1 Interoperability

BIM interoperability issues are also part of the strategic problems that AEC-FM companies face. This is principally due to problems of incompatibility with the information representation adopted by the software applications different disciplines are working with (Jardim-Goncalves, 2010).In a construction project, suppliers use different software BIM 3D softwares, such as Tekla and Bentley to build their aspect models, while architects use other softwares such as Revit, etc. In order to facilitate the integration of different aspects models (per discipline) and solve interoperability issues, the models are usually transferred into IFC. In the construction sector, the Industry Foundation Classes (IFC) standard is used to specify how the objects with attributes can be classified. The use of a common standard helps to avoid problems of communication, information exchange and to improve interoperability. However, this downgrades the information stored in the initial model and hampers collaboration between disciplines within the construction industry. The issue of interoperability might affect the collaboration between construction companies, because of the different standards used or because of misunderstandings and lack of communication between different disciplines.

4.4.2 Current IT infrastructure support

Before implementing BIM, a company uses a certain IT structure for all its projects. Consequently to BIM implementation, an organization needs to replace the current IT infrastructure support with the one required to allow the BIM cloud sharing and in order to have a high IT memory requirements for large and complex models. In most implementation cases has been revealed that the costs of adapting these systems are generally consistently lower than the one required to train staff and reach a good proficiency level of BIM. (Eastman, et al., 2011). The adoption of a more structured IT infrastructure support can be seen as a technological challenge, which many companies face with difficulties, and may require an external support in order to be implemented. For this reason, due to the large size of files and the amount of digital information shared, the implementation of BIM needs an IT structure powerful enough to support it.

4.4.3 Scalability of BIM models

The size of a BIM model depends on the accuracy and the level of detail the internal representations and parametric objects can have. Normally, due to a high level of detail, BIM models can have a really large size and for this reason there might be a slow response in terms of time for working on the model. The problem

which comes up is related to the memory for all the operations connected with BIM software, which is not large enough, so BIM projects need to be scaled. According to Underwood (2010), the file-based systems are normally slower for small projects, but their speed decreases very slow in accordance to the project size growth. The issue of scalability of BIM models can be considered the third technological challenge a company has to face with when implementing BIM.

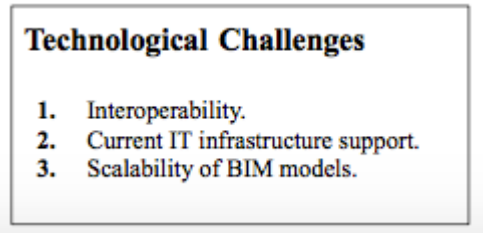


Fig. 8. Technological challenges.

5 A case-study approach – General Planning

While in the previous section a theoretical framework about the different challenges related to BIM implementation was developed, this Chapter aims to investigate, through a case-study, what are the practical BIM implementation challenges which an Italian design firm encountered when conducting the digital transition CAD-BIM. The company, *General Planning Spa* (GP), has recently started implementing BIM into the business processes and is currently facing several problems caused by the digitalization process. For this reason, it can be considered a perfect example of an Italian design firm as admitted by Loris Colombo himself, technical director of the firm.

5.1 Introduction

Founded in 1970 as the development and evolution of the Architecture & Fritz Batello Studio, General Planning is an Italian leading company of Engineering, Consulting and Design with over 40 years of experience in the implementation of major projects in many sectors (Corporate offices, Banks, Hospitals, Commerce, Industry, etc..). With an internal staff of 60 people including Architects, Engineers, and Technicians supported by Associated firms and external collaborators (up to 100 professionals in total), General Planning uses the most advanced tools available in the market and design methods in order to provide services of Integrated Coordinate Design, Construction Supervision, Project and Construction Management, working in different areas such as Offices, Laboratories, Hospitals, Space Planning, Industrial buildings, Corporate services and Residential buildings.
The company's goal is to achieve client loyalty providing a full consulting services and guided assistance in choosing the best solution, by being the only responsible interlocutor for the entire project. In order to achieve client's satisfaction, General Planning uses a method based on Integration and Organization of the whole project by constantly checking costs and times estimated. At the beginning of the definition of the intervention, General Planning acts as trustee consultant of the client providing administrative, final and executive design, integrating and coordinating the different technical specialties (architecture, structural works, installation works, equipment), assisting the Customer in the management of the procurement phase and directing the project execution from complete project management activities, general and specialized supervision works, time and cost control, to the handing over and the work testing. Finally, General Planning was the twelfth Italian design company by revenue in 2016.
An overview of the company's working methodology can be found in Fig. 9 below.

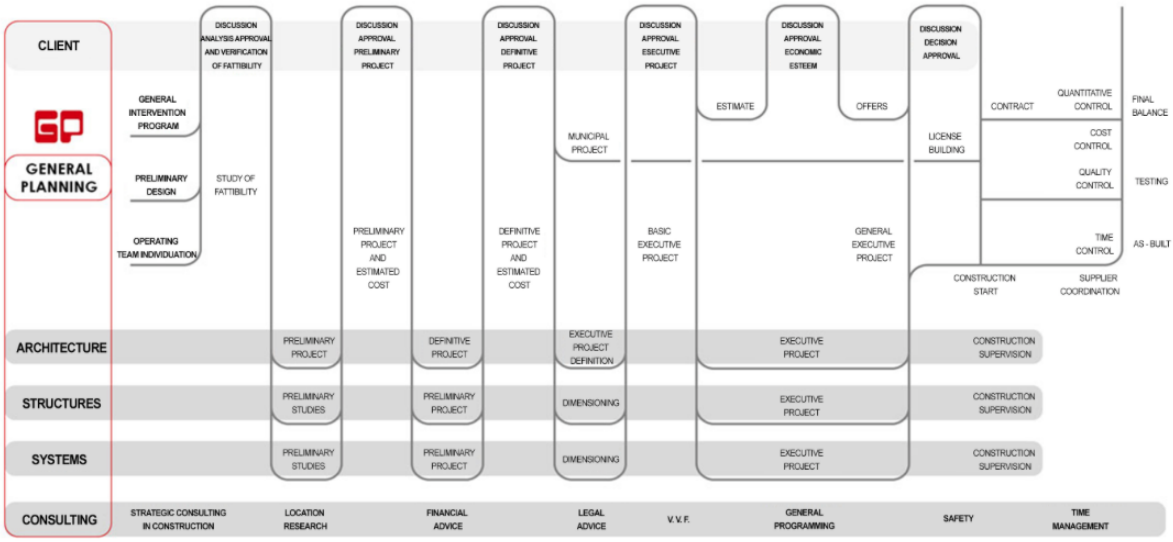


Fig. 9.General Planning working methodology, Integrated and coordinated design and Project management.

This case-study aims to either analyze the current BIM situation and design practices of the company, with a focus on the Design (CAD-BIM) Department, as it can be seen in the organizational chart (Appendix 2), and at the same time to find out what is the expected situation regarding the use BIM within the company in the next years. Moreover, *General Planning* can be considered a frontrunner in the adoption of BIM when comparing to the actual situation of the Italian construction market and for this reason the BIM implementation challenges of this case-study can be considered relevant and are mostly the same which other Italian design firms are facing or will face when implementing BIM within the organization.
General Planning's organizational structure can be divided into four main departments (Administration and financial control, human resources, engineering/design and Promotion/business development). The engineering department can be divided into: structures, installations, safety, architecture, project management and design (CAD-BIM). Particularly, as mentioned above, the focus was on the last mentioned sub-department, which is facing and is directly involved in the process of digitalization. However, other departments have been analyzed and different employees of the company have been interviewed in order to get a wider perspective of the available information at the company level. To this extend, the IT and cost management department were involved in the data collection phase of this research. Finally, the technical director himself, gave an important contribute to analyze the BIM implementation challenges from a management perspective.

The case-study has been used to answer to these sub-questions of the research:

1.2 What is the current and desired practice of BIM within an Italian design organization?

1.3 What is the opinion of experts of the organization about the challenges they faced with when implementing BIM?

The case-study structure can be divided into three main steps:

1. Actual design practices and BIM maturity level of the firm.
2. Desired BIM maturity level and company's BIM vision.
3. BIM implementation challenges within the organization.

The identified BIM implementation challenges can be considered as an example of what are the possible issues which can be encountered when an Italian design firm decides to implement BIM within its organization.

5.2Methodology

Two data collection methods were used for this research. The first data collection took place by conducting semi-structured interviews with employees, BIM managers, IT experts and directors of *General Planning*. In total more than 10 interviews were conducted, covering all the different topics which might help for the final result. The choice of conducting semi-structured interviews rather than classic ones, is given by the flexile structure of questions which might be asked with semi-structured interviews. In fact, while fixed questions aim to provide a direct answer to a specific topic, semi-structured interviews encourage the respondents to express their opinion, knowledge and opinion in a broader context, without a fixed scheme. For this reason, a large amount of information is gathered by letting the respondents free to express their opinion about the BIM implementation process within the company. The second half of data was gathered by conducting an on-site observation of the company, the way people work and how is the employees' approach when a BIM project has to be managed. The data collection took place in the period of June-August 2018.

The fixed part of the interview consists in the following questions:

1. Role and responsibilities. *What is your role within the firm?*

The answers to this question provides an overview of the different roles the respondents have within the firm, in what kind of projects they are involved and what is their daily working contribute for *General Planning*.

2. Company. *What are the general characteristics of the firm?* (The question was asked only three times, in order to avoid repetitions).
   Information such as the history, markets and general development of the firm are important to understand the context the firm is involved in a national level.
   Do you think General Planning is representative for the Italian construction sector or a frontrunner? Why?
   When implementing BIM, it is important to know the level of technological adoption and the position of the firm within the national construction market. Being a frontrunner means being one of the first firms involved in the implementation of BIM and as a consequence experiencing the challenges which derive from its adoption within an organization.
3. Current BIM situation. *Why and when did the company decide to introduce BIM into the practices?*
   In order to understand the current level of BIM adoption, it is important to get information about the first steps conducted when BIM was implemented within the firm, the decision which were made and when was it introduced in the ever-day practices.
   What is the current situation regarding designing practices (or the use of BIM) within your team/department/division?
   A direct question about the current design practices provides a starting point on how the actual level of BIM adoption within the analyzed departments of the company is.
4. Desired BIM situation. *What is the desired situation regarding the use of BIM within your team/department/division?*
   General Planning BIM maturity level's goal can be investigated with a question about the desired level of BIM in each of the departments and teams the respondents are part of.
   Is it there a consensual opinion formed around these intentions?
   Active motivation when implementing BIM plays a fundamental role. For this reason, this question aims to understand if it is there a consensual path to be followed and if all the actors agree in the decision-making process.
   What kind of benefits are expected from implementing and using BIM?
   This question aims to understand why BIM was implemented, what are the final goals and what kind of benefits are expected by its use in the next years in terms of costs, time, productivity, quality etc.
5. BIM implementation challenges. *What are the most important BIM implementation challenges playing by the firm?*
   While the theoretical framework is shown, it is important to know all the challenges and issues the company encountered when implementing BIM. By keeping this question open, other issues can emerge, even those which are specific for the case-study.
   What is the importance and how do these challenges affect the implementation process?
   The answer to this question provides a level of impact, based on the respondents' opinion, of how and to which extend these challenges affected the implementation process.

The interviews were recorded with mobile phones and listened again to write all the data in a word file. Afterwards, the data was analyzed to get the most important information for the case-study, and all the relevant information was reported into a separate file and grouped up in order to form the following BIM implementation challenges of the firm. A more detailed description of the research questions can be found in Appendix 4.

A list of the interviewed people is provided below (Table 10), with a description of the role and department as well. The number of individual interviews is provided, while two other interviews were conducted with two or more members of the list together.

Name	Role	Department	N. of interviews
A. Sandrelli	BIM manager	CAD/BIM	2
L. Colombo	Technical director	head of engineering	1
S. Versini	BIM coordinator	CAD/BIM	1
P. Facchetti	BIM specialist	CAD/BIM	1
M. Codini	IT support	IT	1
Walter Cola	Head of CM	cost management	1
A. Cristaldi	Quantity surveyor	cost management	1
E. Guasti	Quantity surveyor	cost management	1
S. Toini	MEP designer	installations	1

Table 10. Respondents' role, department and number of interviews.

5.3 BIM implementation history and actual BIM situation

The data collection started conducting interviews with the BIM manager of the company (2 years of experience within the firm), a BIM coordinator (few months of experience within the company) and a BIM specialist (with 20 years of experience in GP). The information gathered, were used as a starting point to understand the actual BIM maturity level of the firm, as well as the ambition and BIM goals for the next years. According to the BIM maturity model, which can be found in Fig. 11, there are several characteristics which need to be satisfied in order to assess the level of BIM capabilities for a design company. A managed 3D environment with an integration of all the combined models from all the different disciplines, as well as a link of the model to the project data and relevant software capabilities are necessaries to assess the BIM maturity level for either a company or a specific project.

General Planning started the first internal courses of BIM software about 5 years ago (2013). At the beginning, five members of the design team followed a BIM course about software and methodology. In 2014, the first pilot project, a small industrial building, was developed but without information, just as a 3D model. The real first BIM project was the Telecom Headquarter in Rome, in which external consultants helped GP with all the different and complex installations of the project. The first BIM project realized only by GP was the IEO hospital of Milan, third building. In this phase both CAD and BIM were used for different projects, and there was no BIM department into the company. Since mid-2017 all new projects of a certain dimension are in BIM (excluding small re-works previously done in CAD and with DWG file in the internal database). The BIM process management part started with hiring a BIM manager (Alessandro Sandrelli) in 2016 and later on two BIM coordinator with few more BIM specialists. In the same period, the model started to be used for quantities take-off and cost calculations (beginning of 2017). An overview of the most important steps regarding BIM implementation inside GP is provided in Appendix 3.

General Planning has a royal relationship with its clients, which are followed from the beginning till the end of each project. The company takes part in the maintenance phase because of the relationship built up with clients over the time. It may happen that clients ask for BIM, but since 2018 GP writes in the preliminary contract a document about the characteristics of the BIM model delivered. If requirements are not given, (BEP without EIR), the requirements of the client are predicted by GP.

Among all the disciplines, GP's BIM maturity level is between 1 and 2, as it is shown in Fig. 8. Architectural, Structural and MEP models are made with BIM till 1:50 level of detail. Precise and difficult details are still done with CAD because of their complexness and people do not have enough capabilities to

deal with them. Stratigraphies are trying to be imported in Revit. Moreover, steel details are made with CAD, even if the company is trying to go in deep about their design with Revit. MEP components are standards, not really detailed. These components are without brand and already exist in the market, no technical characteristics for MEP are in Revit, but in Word and in the contracts. Specialized Analysis is made with other software not with BIM. The energy calculations is made with other software and not using BIM. Finally costs calculations are either made via quantity take-off and Excel sheets. STR Vision software is not completely in the current practice of the cost management department, because of a less controlled quantities than what can be done in Excel, and because of a structured way of working for 20 years of the cost management department.
Even if BIM is used for different reasons and purposes, CAD is still important within the firm. For this reason, a BIM maturity level between 1 and 2 can be assessed in this stage of the digital transition to BIM.

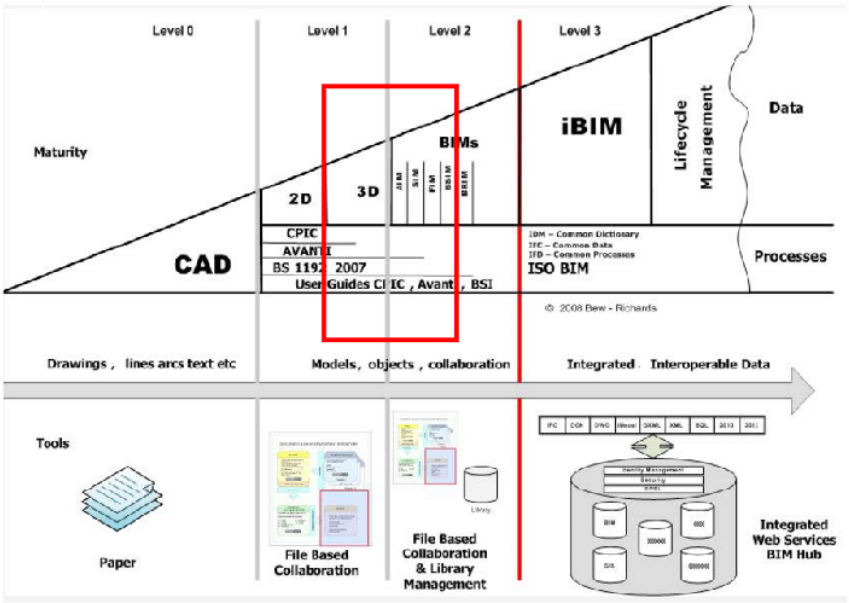


Fig. 11. Actual BIM maturity level.

5.4Desired BIM situation

When understanding what the actual BIM maturity level of the company is, it appears to be clear the importance of defining what is the goal in terms of BIM implementation for the next years. To this extend, interviews with the BIM manager and the Technical director were fundamental to understand the top management's vision and the company's ambition regarding future uses of BIM.
As mentioned in the previous chapter, GP started few years ago a process of internal training for five members of the design team about BIM software (such as Revit) and general BIM uses. However, not all the employees have a knowledge of software and processes related to BIM, so the average level of knowledge within the firm differs. In order to solve this issue, the company started in June 2018 weekly internal BIM courses, regarding the general BIM uses, BIM-related software and how those uses can be applied to the specific context of General Planning. To this purpose, the first short-term goal is leveraging the company's global knowledge of BIM, in order to create a common vision. According to the BIM manger's prevision, this resource leveling needs to be done before September 2018.

Secondly, some operational goals are planned to be reached in the short-midterm. The first operational goal, regards the structural calculation of the models which is not actually made with BIM. GP wants to entirely calculate the structural elements by using the BIM model and, to reach this goal, an effort will be made in the next months. The second goal regards the use of Visio software for cost calculation. Nowadays the cost

management department is managing the cost calculation either using Excel sheets and with the quantity take-off from the model. The goal is to use Visio for those calculations, without verifying the quantities and, as a consequence, lees time will be wasted. The third goal regards the creation of templates in Revit, which can be used for all the different facilities (hospitals, offices, residential buildings etc.) GP has an expertise on. Those templates, once created, reduce time consumption when starting a BIM project.

Lastly, some long-term goals emerged during the interviews with the BIM manager. The first one, is the use of Virtual Reality (VR) for clients. VR helps clients to understand with a direct visualization, how the project will be and is a great advantage from a marketing point of view. Secondly, in the next months GP aims to develop a common and shared data environment, in order to collect and manage information in the same BIM workplace, which can be used from different disciplines, locations and companies, at the same time. The third long-term goal, is the use of BIM for constructability, with Navisworks. The project management department of the company admitted that BIM has not been used yet for constructability, because of the lack of client's request. However, even if these goals are planned to be followed, the company does not have a clear idea yet about when the might be reached.

Short-term BIM goals	Long-term BIM goals
Leveraging the company's global knowledge of BIM	Use of Virtual reality (VR) for clients
Structural calculation with BIM	Develop a common and shared data environment
Visio software for cost calculation	Use of BIM for constructability
Creation of Revit templates	

Table 12. GP short and long-term BIM goals.

To sum up, GP's main goal is to move forward in the BIM maturity model, from a level between 1 and 2 to full level 2, as it can be seen in Fig. 13. To this extend, a more collaborative way of working needs to be developed and a wider BIM knowledge has to be acquired by all the employees. However, even if the company's BIM goal is well expressed, is not clear yet when the BIM maturity level 2 can be reached.

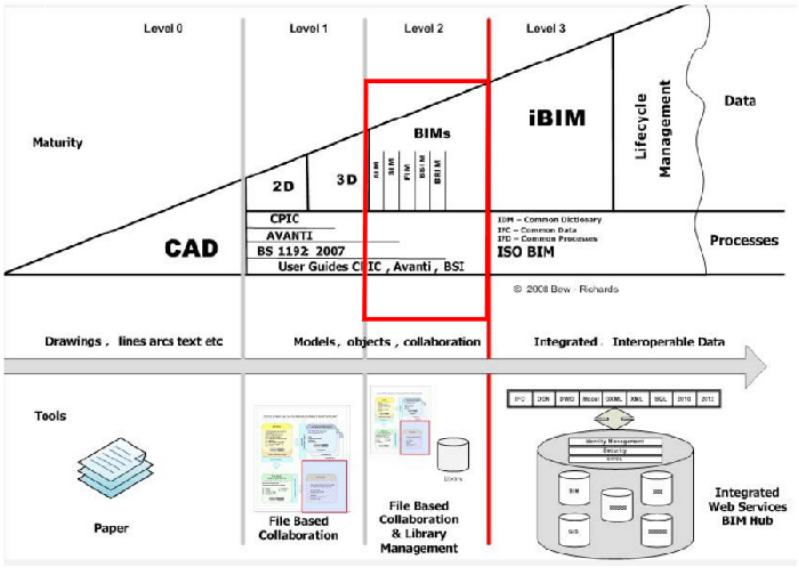


Fig 13. Desired BIM maturity level.

5.5 BIM implementation challenges

After analyzing the current and desired BIM maturity level of the company, the study goes further with an explanation of the BIM implementation challenges which GP is facing during the digital transition CAD-BIM. The theoretical framework was fundamental in this phase of the research for two reasons. First of all, it was used during the interview process, proving the respondents an example of which challenges were addressed by other design organizations which can be found in the literature. During the interviews, the respondents used the framework as a reference structure, however the challenges which came out (which can be found in the previous chapter) are more specific, adapted to the specific situation of the firm. The comparison between the challenges which came out from the literature and the case-study is provided as well in chapter 5.7. Moreover, as mentioned above, the structure of the theoretical framework constitutes a base for the identified challenges, which are still divided into environmental, technological, individual and organizational.
The identified issues have been organized into twelve challenges which can be connected to the challenges discovered via literature review. An example from the current (or past) practice of the case-study will be provided, when available.

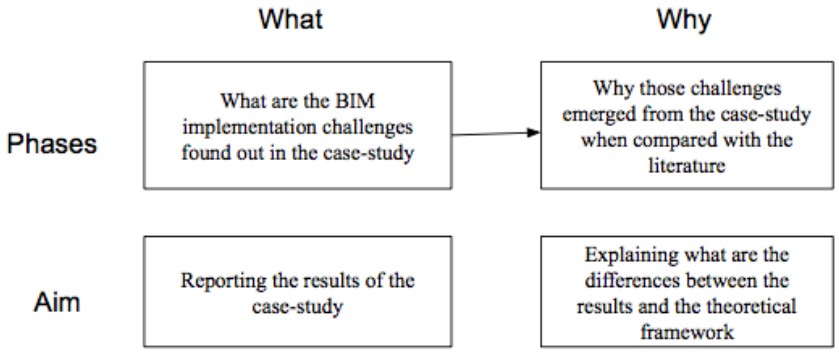


Fig 14. Phases followed in this part of the research, for chapters 5.5 and 5.6.

As it can be seen in Figure 14, this part of the research can be divided in two main phases. In the first phase (What), the challenges which came up from the case-study will be described (Chapter 5.5.1). The second phase can be considered a link between theory and practice, providing the "Why" the challenges which emerged from the case-study differ or are the same from those which emerged from the theoretical framework previously build up (Chapter 5.6).

5.5.1 Identified challenges

As mentioned above, twelve BIM implementation challenges emerged from the interviews within the company. This paragraph will describe the issues GP faced when implementing BIM. Figure 15 summarizes which challenges of the theoretical framework emerged from the case-study. The symbol "V" means the challenge of the theoretical framework is present in the case-study, the "X" means the challenge did not emerge during the case-study observation, while the "~" is used to indicate situations where the challenge is present with a different name (organizational structure and strategy which is expressed as "lack of all company's members direction to BIM in the case-study), or in case of the three individual challenges where they are not mentioned separately but all occur combined in the case-study in the challenge "overcoming the comfort of employees to change their working practice".

BIM implementation challenges of the literature	Presence of the challenges in the case-study	Case-study challenges' definitions
Environmental challenges		
Regulations and norms	V	Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM.
Common standards and information exchange	X	
BIM adoption at a national level	V	Lack of collaboration between companies, especially when data are not protected.
Level of clients' request for the use of BIM	V	Lack of clients' awareness about BIM advantages and request of BIM.
Organizational challenges		
Time necessary to adopt the new processes	V	High initial time to be invested to create templates, collaborative way of working and first projects with BIM.
High initial investment	V	High initial investment without assessing BIM economic advantages in the short-term.
Organizational structure and strategy	~	Traditional way of working is still followed without a clear BIM workflow.
Top management support	X	
Re-define the business model	X	
Assign responsibilities for BIM implementation	X	
Re-organization of teams	V	Lack of well-defined roles and responsibilities.
Data exchange within the firm	V	Information exchange and set up of information from the beginning.
Developing a collaborative way of working	V	Lack of all the company's members direction to BIM.
Promotion of the company's BIM capacity	V	Promotion of the company's BIM capacity
Contract change arrangements and costs	X	
Technological challenges		
Interoperability	V	Interoperability between different software version.
Current IT structure support	X	
Scalability of BIM model	X	
Individual challenges		
Cultural aspect	~	Overcoming the comfort of employees to change their working practice.
Individual drive towards change	~	
Knowledge and skills	~	

Table 15. Presence of the theoretical framework's BIM implementation challenges in the case-study.

A description of the twelve BIM implementation challenges encountered in the case-study is provided below:

1. Regulations and norms

The lack of public regulations about BIM is another challenge which affect its quick implementation into design firm. Currently, in Italy there is no regulations about BIM. From a European point of view, the art. 23, 50/2016, is an European directive which in Italy and Spain differs from France, UK and German. The "Decreto BIM" can be considered the first roadmap for BIM in public projects in Italy. It specifies that from 2025 only the model can be considered, without 2D design and any other document. Even if this goal will be necessary in the next years, it appears that the Italian construction market is not ready yet for this challenge. Moreover, no rule for Data exchange and responsibility of data (privacy and ownership) is provided or planned to be published in the next years. Finally, the UNI (first official European norms form BIM) are not

followed by Italian companies, which prefer the British or American standards. Based on the case-study results, the challenge can be re-defined as: **Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM.**

2. BIM adoption at a national level

Another BIM implementation challenge found out from the case-study regards a clear lack of collaborative way of working between all the companies involved in the construction process. Italian design firms, do not feel comfortable when sharing BIM files, as a consequence of challenge 2. To this extend, the collaborative BIM mindset still needs to be developed within the Italian construction sector. All the companies involved in the project should work in the same model and there should not be problems of data-sharing and collaboration. Based on the case-study results, the challenge can be re-defined as: **Lack of collaboration between companies, especially when data are not protected.**

3. Level of clients' request for the use of BIM

The first BIM implementation challenge regards the lack of clients' request for BIM use in a construction project. Italian public clients appears not to have enough knowledge to ask for BIM adoption, and a common question General Planning finds out from clients is "How do I do it with BIM?". Clients should request and define the specifications which are going to be followed by the firm during the design. However, this lack of knowledge emerges especially when clients ask for BIM just for the 3D model without information, when they do not understand the future benefits and advantages for its use, or when they do not have an idea about the requests/specifications which should be provided during the first phases of a project. Based on the case-study results, the challenge can be re-defined as: **Lack of clients' awareness about BIM advantages and request of BIM**.

4. Time necessary to adopt the new processes

It is well-known BIM implementation requires time. A huge effort has to be made, especially in the previous phases of the digitalization CAD-BIM process, to create a BIM collaborative vision among employees, templates which can be used for projects among the same disciplines, Revit families, materials etc. It is common practice that a design firm implementing BIM is at the same time working on other projects which do not regard and are not affected by BIM implementation, but are normally made in CAD. For this reason, what happens is an overlapping period between CAD projects and pilot BIM projects. GP faced the same issue, and the company has now a position in the digitalization process where it is not possible to come back, because of the amount of time and money the company invested, but at the same time is not possible yet to predict when the payback period will be. This challenge generates fear among the top management and a strategy should be taken in order to understand how much time (and money) is still required to definitely switch to BIM. Based on the case-study results, the challenge can be re-defined as: **High initial time to be invested to create templates, collaborative way of working and first projects with BIM.**

5. High initial investment

From the learning curve, it can be understood as the economic impact of BIM cannot be seen in the short term. Indeed, time, resources and money have to be invested especially in the first phases of the BIM implementation process in order to see relevant results in the mid-long period. To this extend, GP provides a great example of an Italian design firm with strong management support to BIM implementation, which invested a lot to reach a certain level of BIM use. GP invested in laptops, internal courses, software and Autodesk licenses to support BIM implementation. The return on the investment in terms of time and costs is difficult to be predicted by the top management of GP and, especially in this transitional phase, the lack of a predictable cash-flow adds pressure on the strategical decisions of the firm. Based on the case-study results, the challenge can be re-defined as: **High initial investment without assessing BIM economic advantages in the short-term.**

6. Organizational structure and strategy

Digital transition within the case-study is still an on-going process. From a process point of view, if the traditional process is still followed for all the new projects, the real importance of BIM is not correctly understood. The strategy of the firm has to be aligned with the new BIM goals. While a BIM implementation plan has to be developed for all the new projects, in order to understand what the BIM goals are, and how can be reached, a BIM workflow can help the company to have clear objectives about the BIM implementation steps which have to be followed and what is the "example process" of a BIM project for the specific firm. Following the traditional way of working inside and outside the firm does not allow a correct application of BIM methodologies within the working procedures currently used by GP. Based on the case-study results, the challenge can be re-defined as: **Traditional way of working is still followed without a clear BIM workflow.**

7. Re-organization of teams

When implementing BIM, new roles have to be assigned or new people have to be hired in order to fulfill the lack of BIM competences in terms of operations and processes. After the creation of a BIM department, professional figures such as BIM managers, BIM coordinators and BIM specialists can be considered the baseline from which building on an organizational structure in a design firm where BIM is implemented. However, in the case of GP it was noticed that, even if a specific role was assigned to a specific person, responsibilities not always correspond to the main role's function. For instance, it is common to see the BIM manager working with CAD drawings or the BIM specialists not led by a BIM manager during the design. In the case of GP, importance is mainly given to the design, while the biggest issue is the management of the BIM process. The presence of only two BIM coordinators and one BIM managers, in a period where the amount of BIM projects is great, has created a sort of confusion about what the responsibilities are and how the process can be managed and followed. Based on the case-study results, the challenge can be re-defined as: **Lack of well-defined roles and responsibilities.**

8. Data exchange within the firm

Information exchange allows all different stakeholders to know exactly which information are needed in the different phases of a project. In GP, when a project is started information are asked by the BIM department (both verbal and written) and when something is missing during the process, internal phone calls are made or small meeting are set up. However, the internal structure of the firm (divided into three different floor, with external stairs to reach each floor) does not allow a perfect information exchange. The Design-BIM department is split up into two different floors because of its different goal (the first one is for CAD and the second for BIM), while a unique BIM department should exist with easy communication between different department. The lack of clear Written information from the other departments about is a challenge the BIM department is facing in this phase of the BIM implementation process. Based on the case-study results, the challenge can be re-defined as: **Information exchange and set up of information from the beginning.**

9. Developing a collaborative way of working

All the company's members need to be aligned to the direction of BIM. This challenge is a consequence of challenge 6, but it refers more to the cohesion and alignment of the employees than to the resistance to change. In GP, while the top management's perspective "Pro-BIM" is clear, some employees still do not get the advantages and are not well informed about the company's future goals in terms of BIM. This misalignment is creating a rift within the company, from people who are informed about the process GP is undertaking, to employees who still do not have clear what is the company's idea about BIM and what is the plan for its implementation in the next years. This issue, united with the consequences of challenge 6, can be considered an important barrier affecting the digitalization process inside the firm. Based on the case-study results, the challenge can be re-defined as: **Lack of all the company's members direction to BIM.**

10. Promotion of the company's BIM capacity

Digitalizing a design construction company requires a high effort in terms of costs, time and resources. However, especially in a period where the market is not ready yet to BIM implementation, the company's effort should be translated from an initial issue to a competitive advantage in the market. GP shows a weak point in terms of marketing and advertising. Even from the Website it can be noticed as the use of BIM is nor well-promoted as one of the most important advantages the company can offer to clients. The promotion of the firm's capabilities and the seeking for new opportunities is left to the "managing the clients" department, with the 3 members of top management directly involved in this activity. Without promoting the company's strengths and BIM successful uses in past projects it might be ambitious, if not impossible, for clients to understand what GP can really offer in terms of BIM benefits. Based on the case-study results, the challenge keeps being: **Promotion of the company's BIM capacity.**

11. Interoperability

Interoperability regards problems of incompatibility between different software, file and information-exchange. Interoperability's issue is not excluded from the situation of GP. Autodesk Revit 2018 and 2019, Navisworks and STR Vision (for cost calculations) are the BIM software currently used by the firm. Due to the not advanced state-of-the-art of BIM implementation, GP has not experienced huge problems of interoperability between different software, but the main challenge regards the use and exchange of Revit file between different version of the software. Indeed, when opening a Revit 2018 file with a 2019 software version, the file is compromised and is not possible to open it again with older version of Revit. This problem has been partly solved by installing different Revit versions in each laptop but it causes delays, hard-disk space use and possible mistakes. Based on the case-study results, the challenge can be re-defined as: **Interoperability between different software version.**

12. Cultural aspect, Individual drive towards change, knowledge and skills

People are resistant to change. When BIM is implemented within a design firm, the cultural aspect and employees' resistance to change need to be considered. AutoCAD designers (with 20/30 years of experience) are used to the way they work and, especially when the ages of experience are relevant, a change in the current working practices is seen as insurmountable obstacle. For those reasons, the comfort of designers and other members of the firm to change the current working practices is not easy to be overcome. Within GP, an example can be found within the design department, where some people still use CAD and prefer to use it over BIM, without understanding the advantages BIM can give to the all process and in the cost management department. This challenge is a consequence of either the Italian traditional way of working (cultural aspect), the individual drive towards change and the lack of knowledge people have on using new BIM software and tools (such as Revit). For this reason, the three individual challenges of the theoretical framework can be combined in one challenge for the case-study: **Overcoming the comfort of employees to change their working practice.**

In Appendix 5, the level of challenges' impact on the BIM implementation process can be found as well.

5.6 Comparison with the theoretical framework

Once identified all the challenges which affected the implementation of BIM in the case-study, those issues can be compared with the theoretical framework previously developed. As it can be seen from the results, the challenges which emerged are the same, differ or are more specific, in comparison with the theoretical framework. This fact can be explained as it follows: the challenges which emerged from the literature are broad and refer to a generic context of a design firm implementing BIM. In fact, by analyzing a generic situation of a design firm implementing BIM the challenges' definitions are kept more generic (Interoperability, regulations and norms, cultural aspect etc.). On the other hand, the results of the case-study provides an overview of which challenges might emerge from a specific context such as the one reviewed

during the case-study. Indeed, the challenges analyzed from the literature, came up from different countries, regulations, cultures and organizations, while the case-study is unique and its results describe the criticalities related to BIM adoption which are part of a specific situation (the Italian construction sector). For this reason an explanation of why the challenges differ, keep being the same or are more specific is provided below as well. A red definition is provided to the challenges which did not emerge from the results.

5.6.1 Environmental challenges

Environmental Challenges	
Challenges of the Theoretical framework	**Case-study results**
Regulations and norms	Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM
Common standards and information exchange	Did not emerge. As a consequence of a delay in the publication of norms about common standard and information exchange, the largest design firms own the market by deciding common standards.
BIM adoption at a national level	Lack of collaboration between companies, especially when data are not protected
Level of clients' request for the use of BIM	Lack of client awareness about BIM advantages and request of BIM

Fig. 17. Differences between the environmental challenges found out in the literature and the case-study results.

First of all, a comparison between the environmental challenges is provided.
As it can be seen in Figure 17, three environmental challenges emerged from the case-study, which can be compared with the findings of the literature:
1. The challenge "lack of regulations and norms" is analyzed in the specific context of the Italian construction industry and for this reason is not kept broad, but it specifically refers to the regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM. For this reason, the challenge is the same, but the definition is extended, due to the lack of specific rules regarding BIM implementation in Italy.
2. As it can be seen from the results, the common standards and information exchange is not included as a relevant challenge for the case-study. This can be explained as it follows: the lack of common standards is not directly included as a challenge because it can be considered a consequence of the lack of regulations and norms about BIM. Indeed, if no regulation about common standard and information exchange has been published, a consequence is that the largest design firms own the market by deciding common standards. Those standards are proposed in contracts to firms with less power or experience in a BIM project, with few firms getting more power inside the market.
3. The challenge BIM adoption at a national level is translated in the case-study into "lack of collaboration between different firms, especially when data are not protected". This lack of collaboration emerged especially when companies with a different BIM maturity level have to collaborate on a single BIM project, generating lack of trust for reasons related to either the use of software (in case of Revit all the families, objects, parameters, templates, materials etc.). BIM adoption at a national level was difficult if not impossible to measure during the research, because it required a survey or interviews through the all Italian territory to understand what is the BIM maturity level of several Italian construction firms. For this reason, even if the BIM adoption at a national level was not directly measured, this challenge is strictly related to the BIM maturity level between Italian companies and the more BIM is adopted within Italian firms, higher is the level of collaboration between different firms on a BIM project.

4. The lack of client awareness about BIM advantages and request of BIM is still one of the most relevant challenges of the framework. This challenge is mentioned in the theoretical framework as "level of client's request for the use of BIM" but in the case-study it emerged as the lack of request is a consequence of the lack of awareness Italian clients have about BIM benefits and advantages for the future. For this reason this issue is stated with the more specific definition "lack of client awareness about BIM advantages and request of BIM.

5.6.2 Technological challenges

Technological Challenges	
Challenges of the Theoretical framework	**Case-study results**
Interoperability	Interoperability between different software version
Current IT infrastructure support	Did not emerge. Strong IT system implemented
Scalability of BIM models	

Fig. 18. Differences between the technological challenges found out in the literature and the case-study results.

1. From the technological challenges which came up from the theoretical framework, as it can be seen in Figure 18, only the issue of interoperability slightly affected BIM implementation in GP. However, as mentioned in Chapter 5.5, due to GP has not experienced huge problems of interoperability between different software, but the main challenge regards the use and exchange of Revit file between different version of the software. Indeed, when opening a Revit 2018 file with a 2019 software version, the file is compromised and is not possible to open it again with older version of Revit. For this reason, the broad challenge "Interoperability" of the theoretical framework is adapted to the specific context of the case-study and is extended in "Interoperability between different software version".
2-3. The other two challenges of the theoretical framework, the scalability of BIM models and IT infrastructure support cannot be considered relevant challenges for the case-study and for this reason have not been included in the results. This is a result of the strong IT system implemented by the company and the high amount of resources (time and money) invested to support BIM implementation. Additionally, the company's attitude aiming to a constant improvement of the internal IT capabilities limit the emerging of new challenges related to the technological aspects of BIM implementation and for this reason no new technological challenges were noticed during the case-study observation.

5.6.3 Individual challenges

Individual Challenges	
Challenges of the Theoretical framework	**Case-study results**
Cultural aspect	Overcoming the comfort of employees to change their working practice
Individual drive towards change	
Knowledge and skills	

Fig. 19. Differences between the individual challenges found out in the literature and the case-study results.

Individual challenges always refer to a cultural aspect which affect people's difficulty to overcome the comfort to change the working routine. The main individual challenge which emerged from the case-study can be described as "overcoming the comfort of employees to change their working practice". Indeed, inside GP, almost all the designers seem to show difficulties in overcoming the comfort to change their working practice. For this reason, this challenge is delaying BIM implementation, even if the company is trying to invest in trainings in order to build up a BIM maturity. When comparing this issue with the challenges which emerged from the theory, it can be noticed as it is a mix of the cultural aspect, individual drive towards change and knowledge/skills which emerged from the literature review. The fear to change, highly connected with the challenge "Individual drive towards change" is also a consequence of the Italian culture inside the construction industry, which follows a traditional way of working, difficult to overcome. Moreover, the knowledge and skills required to apply the new working methodologies, can be considered another obstacle which is delaying BIM implementation, because designers might be "lazy" to change their working practices by adopting new ones. For this reason, the issue emerged from the case-study, can be considered as a mix of the three factors encountered in the literature review (the cultural aspect or the Italian traditional way of working, individual drive towards change as well as the employees' skills and knowledge about new software) and perfectly describes in one sentence the human factors which are delaying BIM implementation in an Italian design firm.

5.6.4 Organizational challenges

The organizational challenges are those which changed the most when comparing the theoretical framework with the results of the case-study. This Chapter aims to analyze which differences can be found out from the comparison between them and why some challenges differ or are not part of the case-study.

All the results, which are described below, can be seen in Figure 20.

Organizational Challenges	
Theoretical framework	**Case-study results**
Time necessary to adopt the new processes	High initial time invested to create templates, collaborative way of working and first projects with BIM
High initial investment	High initial investment without assessing BIM economic advantages in the short-term
Organizational structure and strategy	Lack of all the company's members direction to BIM
Top management support	Did not emerge. High effort of the top management in promoting and stimulating the use of BIM inside the firm.
Re-define the business model	Did not emerge. Business model re-definition due to BIM adoption inside the firm has been considered a solution and not a challenge of the digitalization process
Assign responsibilities for BIM implementation	Lack of well-defined roles and responsibilities
Re-organization of teams	
Data exchange within the firm	Information exchange and set up of information from the beginning
Developing a collaborative way of working	Traditional way of working is still followed, without a clear BIM workflow
Promotion of the company's BIM capacity	Promotion of the company's BIM capacity
Contract change arrangements and costs	Did not emerge. Design companies are trying to develop contracts based on their needs, producing either the EIR and BEP for clients. This might appear as a future challenge

Fig. 20. Differences between the organizational challenges found out from the literature and the case-study.

1. The time necessary to adopt the new processes is present in both the framework and the case-study results. BIM implementation is a long process which requires several actions. For this reason, the challenge's definition is extended in the case-study, by defining that the time should be invested especially in the first phases of the project to create templates, a collaborative way of working and the first projects with BIM. As explained previously in the research, the choice of changing the definition is given by the more specific context which the case-study refers to, which provides a more defined explanation of the challenge.
2. For the high initial investment, a similar description of the initial time invested can be provided. As previously described, an extension of the definition is given, as in the case-study the main problem was the high initial investment without assessing the economic advantages for the future. Indeed, the top management team was not against the BIM-related investment, however, it created fear because of the lack of an existing long-term view in terms of the benefits the use of BIM might provide to the firm itself.
3. The third challenge of the theoretical framework is "organizational structure and strategy". Even if this challenge did not directly come up from the case-study, a "lack of all company's members direction to BIM" emerged from GP. This challenge can be considered a consequence of the BIM strategy of the firm, which do not consent an easy alignment of the employees to the BIM direction. This challenge can be influenced by individual and human factors as well (such as the individual drive towards change), however it has been proved how setting up a correct BIM strategy helps on defining the path to be followed during the implementation process.
4. The top management support cannot be considered a relevant challenge in GP, due to the high effort of the top management in promoting and stimulating the use of BIM inside the firm. This challenge might emerge as found out in the literature in other design organizations, but in case of GP did not influence the BIM implementation process but it can be considered an advantage "pro-BIM".
5. The re-definition of the business model did not come up from the case-study as well. This fact can be described as it follows. Even if it was found out to be a challenge from the literature which affects BIM implementation in a design firm, during this research the re-definition of the business model due to BIM adoption inside the firm has been considered a solution and not a challenge of the digitalization process. This change of view can be explained when providing an explanation of what developing a business model for BIM is, in Chapter 6.2.1.
6-7. Challenges 6 and 7 of the theoretical framework refers to "assigning the responsibilities for BIM implementation" and the "re-organization of teams". Those two challenges emerged in the case-study, as a lack of well-defined roles and responsibilities inside the firm. Those roles regard who is responsible for the BIM implementation process (Challenge 6), and how can the new roles be inserted in the organizational context in terms of teams and departments (Challenge 7). For this reason, the challenge "lack of well defined roles and responsibilities inside the firm includes either challenge 6 and 7 of the theoretical framework, and this new definition acquires importance within the BIM implementation process because roles have to be assigned to both conduct the implementation process and to approach the BIM methodology in the new projects the firm will get involved.
8. The exchange of data within a firm appeared to be an organizational challenge from the literature review. In case of General Planning, the main problem related to exchange within the firm was about the information sharing between employees and set up the information from the beginning. This change of the challenge's definition is given by the importance information exchange has in a BIM process. Before sharing files and data, information has to be set up, especially at the beginning of a BIM project, and for this reason if the problem of information exchange is overcome, data sharing becomes easier.
9. The problem of creating a collaborative way of working is still present in the case-study, however a definition of "traditional way of working is still followed without a clear BIM workflow" is preferred. This is a consequence of the great importance the creation of a BIM workflow has in the BIM implementation process. The choice of changing definition is given by the amount of times the creation of a BIM workflow emerged to be a challenge during the interview processes. It has to be noticed how a BIM workflow can speed up the BIM process and increase the collaboration inside the firm. Indeed, the creation of a BIM

workflow is the first step to overcome the traditional way of working within a design firm and for this reason this definition is more appropriated.
10. The promotion of the company's BIM capacity of a firm did not change from the theoretical to the case-study results. This is because a firm implementing BIM has to promote its BIM capabilities to clients, future customers and other firms in order to get the best benefits from the use of BIM. This challenge may be solved by created a marketing department, as it is described in Chapter 6.
11. The challenge "contract change arrangements and costs" is not present in the results of the case-study. That is because contracts in the Italian construction market are not BIM-related yet. Design companies are trying to develop contracts based on their needs, producing either the EIR and BEP for clients. However this might not be considered a challenge but an advantage for the design firm because of the possibility to get an advantage in the market and get a leadership position in the sector. For all the reasons above mentioned, this challenge cannot be considered part of the case-study. For this reason, even if it did not come up in the case-study, this challenge might be considered relevant in a future perspective.

5.7 Conclusion of the case-study

This chapter aimed to either analyze the current and expected BIM situation and design practices of an Italian design company and at the same time to find out what are the challenges the company had to face, or it is still facing, while conducting the digital transition CAD-BIM. To this purpose, a case-study research method has been chosen and General Planning Spa was selected as a firm. The results of the case-study aimed to provide an answer to the following research questions:

1.2 What is the current and desired practice of BIM within an Italian design organization?

1.3 What is the opinion of experts of the organization about the challenges they faced with when implementing BIM?

While conducting the interviews, the research questions found an answer to both the problems which were asked. The company's current BIM situation was found out to be between level 1 and 2, aiming to grow up till completely reaching BIM maturity level 2. The future and current design situation of all the different disciplines was investigated during the data collection period. It emerged the company is deeply involved in the digitalization process, but a lot of work has still to be done in order to adapt the traditional way of working to the BIM procedures. Moreover, form the interviews with employees, the technical director and the BIM manager of the firm, several BIM implementation obstacles came up which have been compared with the theoretical framework previously developed. The most important results are the strong top management support to BIM implementation, the lack of a clear BIM workflow and well-defined roles and responsibilities during a BIM project, the strong IT system which avoided several technological challenges, the lack of regulations regarding BIM models' privacy and ownership which affects collaboration between different Italian firms, the lack of clients' request about BIM use in construction projects and the overall traditional way of working (cultural aspect) which is delaying the digital transition.
Due to the relevant position GP has in the Italian construction market (12^{th} design company by earnings in 2016) the challenges affecting BIM implementation inside the firm can be considered a great example of the obstacles all the Italian design firms might find when deciding to implement BIM in the organization.
To this extend, General Planning can be considered as a reference point in the Italian construction sector, one of the first design companies which decided to adopt BIM. As a consequence, the results of this case-study can be used by other Italian design firms which are facing or planning to face the digital transition as an example of what re the problems which need to be avoided when implementing BIM.
While in this chapter the problems regarding BIM implementation were identified, the next one will focus on what needs to be done in order to solve these challenges and correctly implement BIM inside an Italian design organization.

6.Overcoming the challenges and recommendations

Chapter 5 provided an analysis of the current and expected BIM situation and design practices of an Italian design company and an overview of the encountered challenges during the digital transition CAD-BIM. This Chapter logically follows the previous one, finding out what are the possible recommendations which can be provided to a generic Italian design company encountering the same BIM implementation challenges which came out from the case-study. Overcoming the implementation challenges is the first step to be conducted to correctly implement BIM within an organization. This paragraph introduces the second phase of the research, using a different research methodology to answer to the second main question of the graduation project. The main question to be answered is:

> *What are the possible strategies and recommendations needed for an Italian construction company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?*

While Chapter 5 aims to find out what the BIM implementation challenges are and, according to Verschuren (2010), it can be seen as the diagnosis of the causes for a practice-oriented research, this phase of the study corresponds to the design of a plan to overcome the previously identified issues and at the same time providing recommendations to similar Italian design firms facing the same BIM implementation challenges.
Moreover, an overview of what kind of changes are necessary in terms of people (change management), organization (organizational structure) and ICT structure (software and interoperability) will be provided when explaining which actions have to be conducted to successfully implement BIM.
First of all, the methodology which has been used during this stage of the research, the interview questions and the sub-questions to be answered are exposed in Chapter 6.1.
Chapter 6.2 shows what are the possible recommendations addressing to the BIM implementation problems found out during the case-study and, when present, a practical example of how the specific challenge has been faced by GP during the months of research is provided to the reader.
Finally, Chapter 6.3 explains how the actions to be undertaken can be sequenced to build up a BIM implementation roadmap for an Italian design firm.

6.1 Methodology

This Chapter aims to explain what kind of methodology has been followed during Phase 3 of the research. The main goal of this phase was to answer to the three sub-questions developed in the research proposal, which automatically answer to the main questions Q2. The sub-questions to be answered are:

2.1 *What kind of recommendations can be provided for an organization to overcome the challenges identified in q.1.2?*
2.2 *What kind of change management is it necessary in the organizations (people and managers) and from an ICT perspective to facilitate and apply correctly the BIM methodology into Italian construction companies?*
2.3 *What is the sequence of actions which can be followed by an Italian design firm to correctly implement BIM into its ever-day working routine?*

Two type of data collection method were used during this phase of the research. In the first stage, semi-structured interviews took place with BIM implementation experts, Professors or PhD candidates of prestigious Italian universities (such as the Polytechnic of Turin and Polytechnic of Milan), digital transformation experts and BIM professionals who live in the area between Turin and Milan, north of Italy. The choice of semi-structured interviews is the same explained in the previous Chapter, because of the flexibility the structure of questions has. Again, the set of questions is composed by a fixed and an open part, letting the respondents more freedom to express their opinion. In total, 8 interviews were conducted in the

period of July-August, as it can be seen in Table 22, where names, roles, expertise and number of interviews is shown.

As conducted in the case-study, the interviews were recorded with mobile phones and listened again to write all the data in a word file. Afterwards, the data was analyzed to get the most relevant information to answer to the research questions.
In the second stage a literature review has been conducted to find out what are the best approaches to overcome the identified BIM implementation challenges, in order to understand what other design companies did in similar circumstances or what needs to be undertaken to successfully implement BIM in an organization in terms of people and change, skills, IT and organizational structure.

Name	Role	Expertise	N. of interviews
Ing. V. Villa	Professor and BIM consultant	BIM implementation	2
Arch. G. M. Di Giuda	Professor and BIM expert for the Italian market	BIM regulations and future norms	1
M. Bonanomi	PhDresearcher	Digitalization in the Italian construction sector	2
Alberto G.	Digital expert	Change management	1
Giacomo B.	BIM manager	BIM implementation	1
Chiara R.	BIM implementationconsultant	BIM implementation	1

Table 22. Respondents' role, expertise and number of interviews (for reasons of privacy some surnames cannot be provided).

The fixed part of the interview consists in the following questions:

1. Roles and expertise. *What is your role and expertise?*
   The answer to this question provides an overview of the different roles the respondents have and in which field they focused their expertise.
2. BIM implementation. *How are you involved in BIM implementation?*
   The level of knowledge about the topic was one of the reasons why the respondents were selected among different experts.
3. Recommendations to the challenges. *Given the developed framework, how can an Italian design firm overcome the most important issues encountered when implementing BIM into the firm?*
   This question helped the respondents to give their opinion about what has to be done to overcome the most important BIM implementation challenges encountered in the case-study.
4. Changes in the organization, ICT structure and change management.
   What kind of changes are necessary in a design organization in terms of people and managers (change management), when implementing BIM?
   This question aims to find out what are the possible solutions in terms of change management and re-organization of roles and responsibilities which can help an Italian design firm during the digitalization process CAD-BIM.
   What kind of changes are necessary from an ICT perspective (not only from a software prospective) and licenses in order to make it worth the implementation of BIM?

This question aims to find out what are the possible solutions in terms of ICT structure, software and interoperability to e considered when adopting BIM inside an organization.

5. Changes in the Business model. *What kind of business model can be defined when implementing BIM and how can be considered a correct business strategy for a design firm which is conducting the digital transition CAD/BIM?*
   The answer to this question provides an overview of what kind of business model needs to be adopted by a firm which is implementing BIM.
6. BIM implementation roadmap. *Which steps are necessary in order to implement BIM into a design firm, which has never worked with it before?*
   This question aims to find out what are the most important actions which have to be undertaken by a firm which is implementing BIM and how the different steps can be ordered in a BIM implementation roadmap for an Italian design firm.

The questionnaire which was used when conducting the interviews can be found in Appendix 6.

6.2 Recommendations addressing the BIM implementation challenges

BIM implementation challenges' solutions and possible actions to be undertaken	Contextual/organizational level	Addressed challenges
Development of new regulations about BIM models' privacy and BIM process	contextual	1. Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM. 2. Lack of collaboration between companies, especially when data are not protected
Stimulating the clients' BIM request in construction projects	contextual	3. Lack of clients' awareness about BIM advantages and request of BIM.
Developing a feasibility study for BIM	organizational	4. High initial investment without assessing BIM economic advantages in the short-term; 5. High initial time to be invested to create templates, collaborative way of working and first projects with BIM.
Set up the BIM strategy	organizational	9. Lack of all the company's members direction to BIM
Developing a business model for BIM	organizational	3. Lack of collaboration between companies, especially when data are not protected 5 High initial investment without assessing BIM economic advantages in the short-term
Developing a BIM workflow	organizational	6. Traditional way of working is still followed without a clear BIM workflow
Developing roles and responsibilities inside the BIM workflow.	organizational	7. Lack of well-defined roles and responsibilities.
Creation of a marketing department	organizational	10. The company's BIM capability is not well promoted
Forming the BIM implementation group	organizational	5. High initial time to be invested to create templates, collaborative way of working and first projects with BIM
Trainings of resources and employees – human resource development plan	organizational	12. Overcoming the comfort of employees to change their working practice
Developing collaboration and procedural protocol	organizational	8. Information exchange and set up of information from the beginning.
Developing the technical resource plan	organizational	11. Interoperability between different software

Table 21. BIM implementation actions, recommendations and addressed challenges.

As a consequence of the BIM implementation challenges described in Chapter 5, the question to be answered still remains what needs to be done and which actions need to be undertaken to overcome and provide solutions to the identified challenges. From the interviews and the literature review, several possible solutions emerged to be appropriate when a design company has to face BIM implementation and the digitalization process inside the organization. The actions have been divided into two different level, contextual level if the actions have to be conducted by external actors, such as the government, public or private clients, and organizational, if the company itself is the responsible party for those actions. All the actions, as it can be seen in Table 21, are presented with the addressed challenges, and with practical example from the interviews, when available.
Each action described, aims to solve at least one the BIM implementation challenges found out in the case-study, even if some solutions address to more than one issue. In this chapter a theoretical solution is provided, in order to be used as a theoretical guideline for a generic Italian design firm facing the same problems, while an example on how the challenges has been initially or will be addressed by GP is provided as well. As a consequence, this chapter can be considered important for either theoretical and practical purposes, in case of an Italian design firm implementing BIM inside its organization.

6.2.1 Contextual level actions

As mentioned above, contextual or environmental level actions, are those which can be undertaken externally from the firm. Specifically, in the Italian construction sector, two main actions recommendations can be provided, which are the development of new regulations about BIM models' privacy and processes and the stimulation of the clients' request for BIM in construction projects. A description of the proposed recommendations and the addressed challenges is proposed below. The numbers mentioned before each challenge refer to the numerical order those are proposed in the case-study Chapter.

A. Development of new regulations about BIM models' privacy and BIM process
Addressed challenges:
1. Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM.
2. Lack of collaboration between companies, especially when data are not protected

One of the main problems which are delaying the digital transition CAD-BIM in the Italian construction sector, is the lack of existing regulations about BIM processes in a construction project. Specifically, it appears to be evident the lack of rules about "who is responsible for what" in a BIM model, and which party is going to keep the privacy of the model when the project is over. This challenge generates a lack of trust among companies who collaborate each other. To this extend, the main recommendations which can be provided came up from the interviews with BIM regulations experts and are related to the development of new regulations and rules about BIM models' privacy and collaboration between companies within a BIM process. Those rules have to be published by the government in the next years to stimulate the adoption of BIM in the Italian construction market.
In Italy, the first regulation about BIM was the *"Decreto N. 560, 1 December 2017"*, which can be considered a roadmap for BIM implementation in Italian public projects (Ministro delle Infrastrutture e dei trasporti, 2017). It can be found in page 2 of this research. As a consequence of this regulation, from 2025 on, only the model can be considered for all the information needed, as it becomes part of the contract. According to the main Italian BIM regulations' experts , such as Professor G. M. Di Giuda, the *Decreto BIM* is kind of ambitious considering the actual situation of the Italian construction sector, and it is possible the norm will be delayed if the standards cannot be reached by the majority of Italian construction, design and engineering companies. From an European point of view, the ISO norms have been published in the last years, about the adoption of BIM in different European countries. However, the European directive shows

differences between Germany, UK and France, explaining clearly the word "BIM" and other countries such as Italy and Spain where the same concept is explained in terms of digital system. Even if those rules show a clear direction pro-BIM of the European and Italian government, it seems to be evident how new regulations have to be published in the next years about BIM models' privacy and collaboration methods within a BIM project, because of the spreading BIM is having in the construction sector.

BIM regulations	Date/goal of publication
"Decreto BIM" N. 160	1 December 2017. Roadmap for BIM implementation in the Italian construction sector.
European ISO	Published in the last years but not followed by Italian companies
Regulations about BIM models' privacy and ownership	Not published. No actual plan to publish them

Fig.22. BIM regulations for the Italian construction sector.

B. Stimulating the clients' BIM request in construction projects

Addressed challenges:

3. Lack of clients' awareness about BIM advantages and request of BIM.

As emerged from the case-study observation, one of the main problems which is affecting and delaying BIM implementation in the Italian construction market is the lack of capabilities and knowledge public clients have to deal with a BIM process. From the experience of GP, only in few cases a client required BIM with a complete and well-defined Employer Information Requirement (EIR). In all the other cases, the design company itself, in this case General Planning, took the responsibility to develop a document with the BIM requirements, according to what the company can provide as a service to the client. As it can be understood, the method above mentioned cannot led to a correct BIM use, because the design company either writes the requirements (EIR) and the intended way on how those requirements can be met (BEP). For this reason, public clients have to be trained to correctly manage a BIM process and, as a consequence, increase the request of BIM in construction projects. Trainings about how to deal with BIM processes can be considered a possible solution to solve this issue.

Steps of a well-defined EIR by public clients	What must be included in each section
1. Scope and purpose of the project	The project's aim, project stages
2. BIM goals and uses	Different uses of BIM and BIM goals for all the phases of the project
3. Roles and responsibilities	BIM team names, roles, training requirements and responsibilities
4. Competence assessment	Evaluation of the competences
5. Technical requirements	Software formats, system performance, volumes, zones and areas, naming conventions, coordinates, standards and guidance documents, compliance plan
6. Specific modeling requirements	Specific requirements of the 3D model
7. Information management requirements	Discipline models, level of development, asset information requirements
8. Collaboration requirements	Information exchange, coordination, clash prevention and detection, health & safety, workshops
9. Sharing requirements	common data environment, collaboration process, publishing process, security requirements

Fig 23. Table of content of a well-defined EIR for public clients.

To this purpose, a practical example of an Italian BIM project, where the public client was assisted during all the bid process, is the Galiera Hospital of Genova. This example came up during the interviews. GP took part to the selection process for this project, even if they could not succeed on winning it. In case of the Galiera Hospital project, public clients developed in collaboration with BIM experts a well-structured EIR, which can be used as an example for other Italian BIM projects. The table of contents of the EIR used in this project can be considered an important example for other Italian public clients and for this reason it can be provided in Figure 23.

6.2.2 Organizational level actions

The second level of actions regards the activities which can be undertaken by the firm itself and are not outside from its decisional power. Organizational level actions have been defined as those activities which consent a design firm to leaner implement BIM and are decisions which can be made from the inside of the company. Specifically, ten main recommendations can be provided in this chapter. The activities, which are described below, can be divided into four groups. Developing a feasibility study for BIM, setting-up the BIM strategy and developing a business model for BIM are those strategic activities a company has to undertake. The following group is related to the BIM workflow, with its creation and the development of roles and responsibilities inside it. The third group regards the creation of new groups inside the company, such as the formation of the BIM implementation group and the creation of an internal marketing department. The fourth group is about resources, collaboration and IT, including the training of resources and employees, Developing collaboration and procedural protocol and the development of the technical resource plan.

C. Developing a feasibility study for BIM

Addressed challenges:

4. High initial time to be invested to create templates, collaborative way of working and first projects with BIM.
5. High initial investment without assessing BIM economic advantages in the short-term;

A literature review can be conducted to understand what does it mean developing a feasibility study for BIM. According to Hoagland (2000), a feasibility study can be developed, in an objective and rational way, to uncover the strengths and weak points of a new idea, opportunities which are present in the correlated environment, to assess the cost which is required in order to get the expected result and finally what are the forecasts in term of success once the idea is followed. In order to assess the feasibility of an investment, such as the implementation of BIM, a comparison between the required costs and the value which can be obtained from the investment has to be conducted. The feasibility study has to be conducted by people inside the organization or external consultant who have knowledge about possible investments for innovations and what are the possible benefits from that investment. In order to conduct a feasibility study for BIM, two actions have to made at the company level, as described in Table 24.

The two stages a company has to follow to conduct a BIM feasibility study	
Stage 1: An assessment of the strong/weak points, opportunities, main benefits for the organization in the future, why BIM is crucial for the organization and what the company can get, not only from an economical point of view, with its implementation inside the firm	Stage 2: A trade-off between the advantages, benefits and disadvantages encountered in the previous stage and the money which need to be invested for BIM implementation. In this step an assessment of the investment's feasibility is made, in order to understand if the benefits overcome the economical lost for the firm

Table 24. Stages to conduct a BIM feasibility study.

As output of these two actions, the potential success of BIM in the organization might emerge. During the feasibility study several information has to be collected, such as market conditions, implementation cost evaluation, current and future value of BIM for the company.
From a practical point of view, even if the economic advantages of BIM are difficult to predict in the short period, a learning curve can be done by Italian design companies in order to assess if the time and money invested can be earned in the future.

D. Set up the BIM strategy
Addressed challenges:
9. Lack of all the company's members direction to BIM

Consequently to the feasibility study, the organization should work together in order to create a common vision which correlate the business strategy of the firm with the current and expected development of BIM technology. The strategy should state in a clear and realistic way how to solve all the principal problems regarding BIM implementation, for example forming a set of principles which can be used during the different stages of BIM adoption regarding interoperability between BIM software, communication exchange methods and setting up the most important milestones of what has to be achieved during the BIM implementation process. The BIM strategy development should be a top management decision, because of the importance this strategic choice has on the future of the firm.
When analyzing this aspect during the interviews with the BIM implementation experts, it emerged that a BIM strategic report should be developed focused on the effectiveness of the implementation process based on the specific situation of the involved organization. There is no possibility to develop a common strategy for all the design firms involved in the implementation process because of the unique situation each organization has to face. Therefore, the focus of this strategy should be on the development of an approach the company has to follow to implement the technology in a way that better fits their needs and can provide the best benefits in a future perspective. Even if each company has to align a different business strategy to BIM direction, different guidelines can be used as a starting point for an organization, such as the US National BIM Standard and the UK BSi Standard Framework and Guide to BS1192.

E. Developing a Business model for BIM
Addressed challenges:
5. High initial investment without assessing BIM economic advantages in the short-term
3. Lack of collaboration between companies, especially when data are not protected

BIM implementation causes several issues to organizations which have not already aligned the business strategy in favor of BIM adoption. A change in the business model is required from each department to follow the company's BIM strategy previously set up and encompass BIM. The literature provides examples of what has to be changed in the business model to adapt it to BIM. The principal elements of the business model, key partners, key activities, resources, cost structure, value proposition, customer segments and relationships, revenue streams have to be re-defined according to the needs of the new working methodology (Osterwalder et al., 2010). Several aspects of the model change as a consequence of BIM implementation, such as the development of a marketing strategy for BIM, the development of new knowledge and skills among employees, the use of different contract types when collaborating with other firms and the re-definition of the organizational structure according to BIM. When re-defining the business model, a cost evaluation has to be conducted which can help to assess the return of the investment for BIM implementation. Moreover, a change in the relationships with other companies, stakeholders and clients is necessary, as consequence of interoperability between different firms and evaluation of the BIM maturity level each firm has reached in the collaboration period. For this reason, contractors and sub-contractors will be selected as partners for a project by a design company only when the BIM maturity level between the

firms is similar and not a large amount of time has to be invested to leverage the BIM capabilities of different companies collaborating in the same project.
Moreover, the internal resources and key BIM activities should be defined as well when modifying the business model. The company's organizational structure has to be changed according to the BIM needs. New resources have to be introduced when a lack of BIM knowledge and skills appears to be relevant.
The creation of a BIM portfolio can be seen as an instrument to amplify the marketing power of a firm. The changes required in terms of marketing are described in the "creation of a marketing department paragraph".

F. Developing a BIM workflow
Addressed challenges:
6. Traditional way of working is still followed without a clear BIM workflow

A workflow consists of a sequence and progression of steps (tasks, events, interactions) that comprise a work process, involve more than one person and create or add value to an organization. Having a well-structure workflow, gives to all the company's employees a clear structure of which activities can occur concurrently or are dependent each other. In the case-study, it appeared evident as the lack of a BIM workflow created uncertainties in which activities had to be performed in all the stages of a BIM process. For this reason, during the interviews it became relevant to understand how the workflow might be built up. In case of GP, a BIM workflow was developed in the month of September by the researcher and the BIM manager of the firm. This workflow can be used as a practical example of how a BIM process should be structured in an Italian design organization which is approaching the digital transition CAD-BIM. As it can be seen in Appendix 7, the workflow shows different activities divided into four phases, which are respectively the BIM implementation plan, the preliminary design, the definitive design and the executive design. All the workflow's steps can be found in Appendix 7.

G. Developing roles and responsibilities inside the BIM workflow.
Addressed challenges:
7. Lack of well-defined roles and responsibilities.

This recommendation came up as well from the interviews with change management and BIM experts. When working with BIM, new roles and responsibilities have to be developed inside the firm. Roles such as BIM manager, BIM coordinator and BIM specialist will replace traditional and existing roles inside a firm.
A whole process of change management is required when IT is implemented inside a company, and BIM is not an exception. Furthermore, a new organizational structure have to be developed to improve coordination between the departments of the company. When developing those roles inside the firm, two possible paths can be followed: the first one regards the possibility to offer trainings among the current employees, while the second is hiring new employees with the needed knowledge and skills (This part is described in Sub-Chapter – trainings of resources and employees). The implementation of BIM causes the creation of a new department inside an organization, which for the transition period can co-exist with the CAD Department.
All the major changing for the organizational structure of a firm trying to implement BIM can be summarized in Table 25.
Change management is a process and, for this reason, there might a need of months if not years to elaborate and develop a correct organizational workflow for the specific situation of the firm. Even if a general example of BIM organizational structure might be provided, it has to be adapted to the specific situation of each firm and, for this reason, most companies refer to external consultants to help them developing the correct organizational structure for BIM implementation. This paragraph partially provides an answer to sub-question 2.2 about what kind of change management is necessary when a design company implements BIM inside the organization.

Changes in the organizational structure of a design firm implementing BIM
1. A new department, even called BIM department will slowly replace the CAD department
2. New roles such as BIM manager, BIM coordinator and BIM specialists will appear on the organizational structure
3. Introduction of A system engineering department, with the responsibility to manage collaboration between different departments (cost calculation, accounting, MEP, structural, architectural etc.).
4. New roles such as system engineers can be developed as well, even if in case of small-medium size firms there might be the need to set up this department with one or two members of each department with a double role, such as BIM specialist-system engineers. Those people have to manage the collaboration for all the BIM processes of the firm and, for this reason, there might be a need to meet weekly to assess the progresses in a project
5. All the developed roles inside the firm have to be aligned with the developed BIM workflow. Responsibilities have to be assigned to all the firm's members in order to complete all the available succession of task of the BIM workflow. The alignment between responsibilities and the tasks of the BIM workflow is a crucial step for a correct BIM implementation process

Table 25. Changes in the organizational structure of a design firm implementing BIM

H. Creation of a marketing department

Addressed challenges:

10. The company's BIM capability is not well promoted

As emerged from the interviews, a marketing campaign can be developed to show and better promote the BIM capabilities of the firm. Marketing can be internal, conducted for the members of the organization, to become aware of the new working methodology and all its advantages, or external when the BIM capabilities of the firm are promoted in the construction market. In the case-study, the internal marketing has been conducted by showing with internal meetings and courses what are the benefits which can be got by using BIM and, at the same time, what has to be done inside the firm to reach a certain BIM maturity level. However, a problem which emerged in GP is the lack of a well-defined external marketing campaign, to promote and show to clients, stakeholders, users or other firms the BIM level reached by the firm itself. In order to overcome this obstacle, a marketing department can be created inside the firm, with employees specialized in marketing through the website, social media, brochures and all the possible marketing instruments. Those department, normally composed by one or two employees, has the goal to increase the firm's brand inside the construction sector, to get more projects, increase earnings and improve the reputation of the firm. All the advantages to create a marketing department are described in Table 26.

Advantages for the creation of a marketing department for a design firm implementing BIM
1. Increasing the firm's brand inside the construction sector and being an example for other companies facing the digitalization process
2. Getting the possibility to earn more projects
3. Getting an increase in the long-term earnings
4. Improve the reputation of the firm. Being well-recognized from public and private clients

Table 26. Advantages in the creation of a marketing department for a design firm implementing BIM.

I. Forming the BIM implementation group

Addressed challenges:

5. High initial time to be invested to create templates, collaborative way of working and first projects with BIM

When adopting a new working methodology inside an organization, there should always be a leading group inside the company in order to advice, arrange and take the responsibility to lead all the implementation process. The main goal of the implementation group is to identify what are the leanest paths, from a strategical and organizational point of view, when implementing ICT inside a company. In case of a design firm implementing BIM, the responsible group should be composed by few people from each department. This group should be supported by the top management to develop a common BIM implementation plan for the firm. First of all, there should be defined what are the needs for each department and which information extracted from the model are needed by each group. Secondly, the group should collaborate to find out how can those information be provided to the correspondent group. Thirdly, the implementation group should work together to elaborate the BIM implementation plan for the company, defining what are the general needs and BIM goals for the future. According to the results of the interviews, the people involved in the implementation group should have important characteristics, such as a positive attitude towards BIM, dedication for the transformation process, and great leadership skills. Moreover, a deep knowledge of BIM and all the practices necessary to successfully implement it is considered an essential element in this phase. The created group should consists of at least one person from the tactical level and one from the operational level, such as a BIM coordinator, with knowledge of BIM software, processes and availability to collaborate with the rest of the company during all the stages of BIM implementation. Finally, internal incentives can be proposed as a motivation for the successful achievement of the BIM implementation's goals.

J. Trainings of resources and employees – human resource development plan

Addressed challenges:

12. Overcoming the comfort of employees to change their working practice

When BIM is implemented in a design firm, new knowledge and skills are required by the employees to correctly use the new software. For this reason, according to the results of the interviews, two possible paths can be followed. The first one regards the possibility the company has to hire new professional figures, such as BIM coordinators, BIM managers or BIM specialists, in order to overcome the lack of BIM capabilities inside the firm. The second possible way to increase BIM competences is to promote trainings among resources and employees about what BIM is, what are the main benefits for its use and how can the main BIM-related software be used. In order to establish how the new capability is built up inside the firm, there is a need to create a human resource development plan. This plan should start with an analysis of the current skills of the employees inside the organization and the potential which can be developed with trainings. Afterwards, the trainings among employees should start, and those might regard all the levels of the organization. Finally, a process of leveraging is necessary because of the different level of capabilities developed inside the organization. From the results which came out from the case-study, GP is now facing phase 3, aiming to leverage the BIM capabilities of the employees. The required BIM knowledge can be developed through BIM courses. The learning process shows a loss of productivity of employees in the first stages, while the new way of working needs to be correctly practiced and understood. From a study of Autodesk (2012) is has been shown as the time required for an employee to reach the same level of productivity he had with CAD, is stated to be 3-4 months. On the other hand, BIM courses have an high impact as cost for the organization, and that's a reason why some design firms prefer to hire new resources instead of trainings the existing ones.

K. Developing collaboration and procedural protocol

Addressed challenges:

8. Information exchange and set up of information from the beginning.

As emerged from the interviews, BIM implementation requires a change for a firm from the traditional way of working to a more collaborative and integrated approach. Indeed, in a BIM project all the involved parties collaborate each other on a common parametric model, which can create difficulties. For this reason, there is a need to develop a collaboration and procedural protocol, to provide a structured plan for BIM use in all the projects, describing responsibilities, deliverables, level of detail and model management. In order to develop it, the goals and requirements for BIM have to be set up and as a consequence the specifications can be drawn for structuring the collaborative and integrated process. The protocol can be used not only when collaborating between different disciplines inside the same firm, but when managing the collaboration among different firms in the same project. To this extend, the protocol should help to determine who is responsible for errors in the model at each phase of the project and who has the control of the updated file and is authorized to change the model. Several documents can be provided as guidelines of procedural protocols for an organization trying to implement BIM, such as the Project execution planning guide developed by the Pennsylvania State University (CIC, 2010), the Autodesk Deployment Plan (Autodesk, 2010) and the standard protocol for use in projects using BIM (Beale and Company, CIC/BIM Pro, 2013).

L. Developing the technical resource plan

Addressed challenges:

11. Interoperability between different software

Most important requirements for BIM solutions (Khemlani, 2007)	
1. Full support for producing construction documents in order not to use another drafting application	6. Ability to work on large projects
2. Smart objects, which maintain connectivity and relationships between them	7. Multi-disciplinary capability that serves architecture, structural engineering and MEP
3. Availability of libraries of objects	8. Ability to support preliminary conceptual design modeling
4. Ability to support distributed work processes, with multiple team members working on the same project	9. Direct integration with energy analysis, structural analysis and MEP
5. Quality of help and supporting documentation, tutorials and other learning resources	10. Compatibility with Industry foundation classes (IFC)

Table 27. Most important requirements for BIM solutions (Khemlani, 2007).

BIM implementation requires a strong IT structure to support all the software and tools required for the new processes. A technical resource plan has to be developed by the BIM implementation team with support of IT specialists at the same time with the changes in people, roles and responsibilities presented in paragraph 5. The basic requirements to support BIM implementation are: software and 3D modeling/visualization tools, an adequate hardware resource, the creation of project data database and object library. An analysis of the company's current IT structure is necessary before developing the technical resource plan. Once deciding internally to the firm which BIM software are going to be used, interoperability issues need to be solved between the software solutions used by different disciplines of the organization and with external partners. It is very important to consider the requirements of the downstream processes.

Khemlani (2007) collected in a survey the most important requirements for BIM solutions, which can be used as a basis for the technical resource plan. Those requirements are summarized in Table 27.

IFC is currently used in the Italian construction sector, as a standard allowing interoperability. However, it has been proved how IFC files limit BIM models and do not contain all the information required. For this reason, collaboration between different firms with IFC files might be difficult.
All the Software implemented inside the firm have to be interoperable between them. To this purpose, a simulation of the BIM process can be conducted to test all the compatibilities, results and skills of the team members. For instance, a small portion of a current project can be tested, to understand what are the possible issues which may be encountered during the process.
To complete the technical resource plan, an analysis of the current software and hardware resources compliance with BIM requirements have to be done, and at the same time an identification of the software solutions which allow a high interoperability and compatibility with the current software of the firm and the designers skills. This question provides and answer to sub-question 2.2 about what kind of IT structure are necessaries when implementing BIM inside an organization.

6.3 A possible BIM implementation roadmap for an Italian design firm

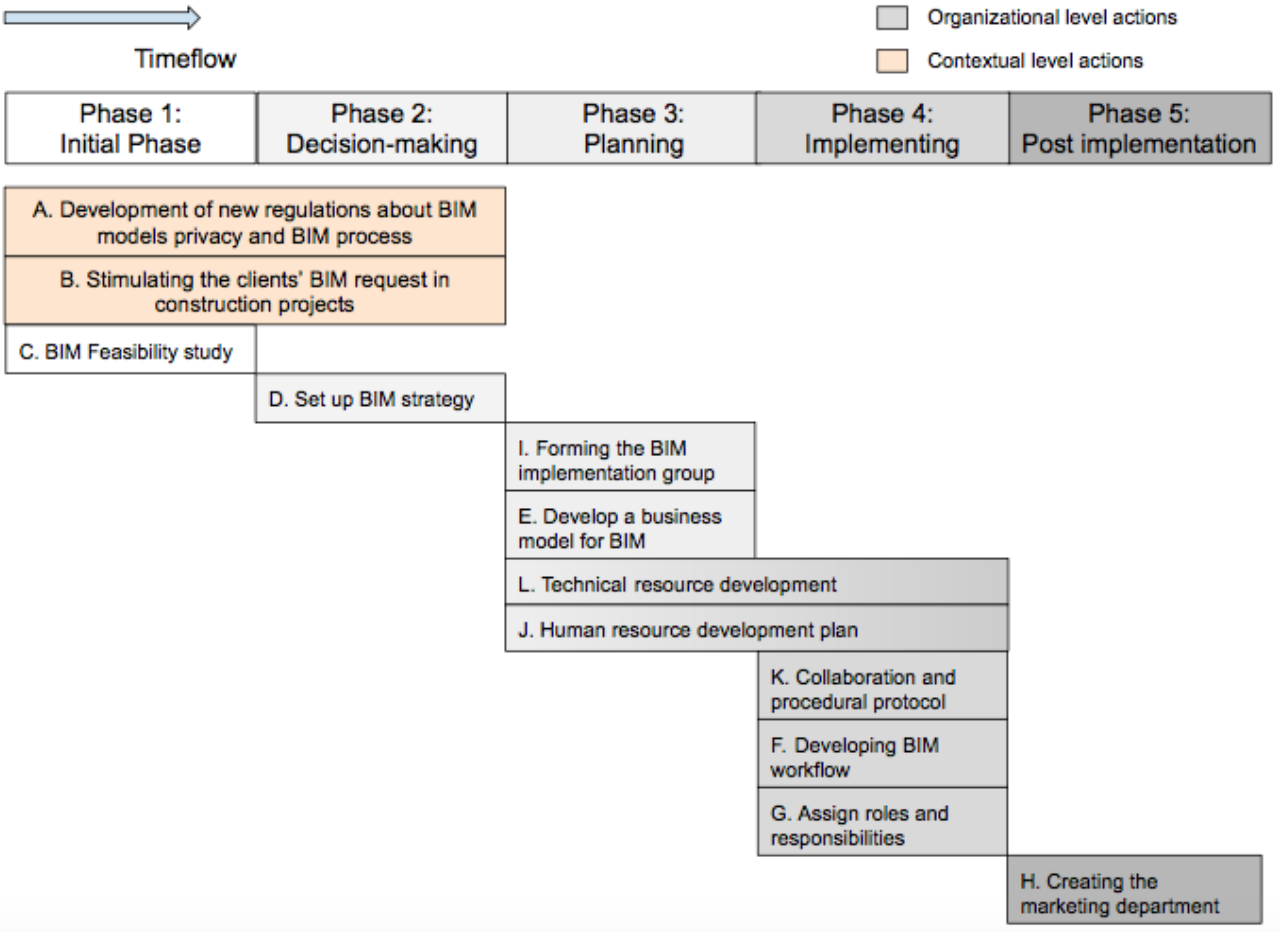


Fig. 28. BIM implementation roadmap for an Italian design firm.

Chapter 6.2 described all the possible actions and recommendations which can be provided to an Italian design firm trying to implement BIM inside the organization. Those actions can be sequenced in order to build up a BIM implementation roadmap which can be used for practical purposes. The proposed sequence of actions is a consequence of either logical thinking (for example the creation of marketing department might follow the feasibility study for BIM), either the results from the interviews. Indeed, the interviews helped to understand which phases The sequence of steps provided can be considered an example for a design firm on which actions have to be followed when implementing BIM, but it is not limited to itself and each company should arrange it to its specific and current situation.

The actions presented in Chapter 6.2 have been divided into five main phases. Each phase represents a step which a design firm has to follow in order to correctly implement BIM inside the organization. The phases which have been encountered to be important in a BIM implementation roadmap are:

- Initial or preliminary phase;
- Decision-making phase;
- Planning phase;
- Implementing phase;
- Post implementation phase.

An overview of the BIM implementation roadmap can be found in Table 22.

Phase 1 consists on the BIM feasibility study in order to assess whether BIM implementation can provide benefits to the company or not. In this phase, a top-down approach is generally followed, with the top management team who assess BIM feasibility inside the organization for either costs and time required for its implementation comparing with the long-term benefits which can be obtained by the firm in the future.

Phase 2 or the decision-making phase, consists on the decision-making. The company starts a set of meetings at the strategic level to discuss strategic issues of BIM and its implementation and to get consensus over the employees and the top management in order to develop a strategy for BIM implementation. Specifically, in this phase the company decides which strategy is the best to be followed in order to avoid mistakes during BIM adoption.

Phase 3 represents the planning phase, in which a real plan for BIM implementation is developed. Here, the BIM implementation group is built up, which function is to support BIM implementation during the all process. In this phase the top management collaborates with the BIM implementation group to create a business model that supports BIM adoption and is aligned with the strategy of the firm itself. Based on the business model, the implementation group develops a set of goals within the process, and contribute to the development of a human resource plan and a technical resource development plan. Those plans are fundamental steps in BIM adoption, to understand which actions have to be conducted in terms of resources development and IT structure to enable BIM use inside the firm. The human resource development plan and the technical resource plan are developed in this stage, but can be considered processes which continue over the all implementation.

Phase 4 represents the most important part of the roadmap, because it regards the implementation itself. In this stage, the plan developed in the previous phase is implemented inside the firm. Specifically, the technical resource development and the human resource development are carried out. At the same time, the collaboration and procedural protocol is developed to stimulate collaboration on BIM projects. Moreover, this phase regards all the activities concerning the BIM workflow and assigning roles and responsibilities inside it. This phase represents the core of the all BIM implementation process and for this reason its activities require more attention when undertaken.

Phase 5, the last step in the BIM implementation roadmap, regards activities which follow the implementation process, such as the creation of a marketing department which do not affect BIM implementation inside the firm, but are a direct consequence of it. Indeed, without the creation of a marketing department, the firm cannot share its capabilities with clients and other companies in a profitable way.

The proposed BIM implementation roadmap is an example of which activities can be undertaken to correctly and successfully implement BIM inside an organization. However, as mentioned above, each company should reflect on a personalized roadmap, depending on the current BIM situation of the firm and what are the goals to be reached in mid-long term.

When proposing a sequence of activities which an Italian design firm might follow when implementing BIM, an answer to the sub-question 2.3 is provided.

6.4 Conclusions of chapter 6

This Chapter, as a consequence of Chapter 6, aimed to find out what are the possible recommendations which can be provided to a generic Italian design company encountering the same or similar BIM implementation challenges which came out from the case-study. To this purpose, in the first phase semi-structured interviews with BIM implementation experts, Professors or PhD candidates of prestigious Italian universities, digital transformation experts and BIM professionals took place, while in the second phase a literature review was carried out to find out what are the best approaches to overcome the identified BIM implementation challenges. The main question to be answered is:

What are the possible strategies and recommendations needed for an Italian design company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?

Specifically, the research question was divided into three sub-questions which were answered in this chapter. Those sub-questions are:

- *2.1 What kind of recommendations can be provided for an organization to overcome the challenges identified in q.1.2?*
- *2.2 What kind of change management is it necessary in the organizations (people and managers) and from an ICT perspective to facilitate and apply correctly the BIM methodology into Italian construction companies?*
- *2.3 What is the sequence of actions which can be followed by an Italian design firm to correctly implement BIM into its ever-day working routine?*

To provide an answer to the research question, the chapter was divided into two sections. First of all, an overview of all the recommendations and actions which can be undertaken to overcome the BIM implementation challenges found out in the previous chapter was provided. Those actions were divided into contextual level actions, referring to the context and external actor, such as the government, public or private clients, and organizational, if the company itself is the responsible party for those actions.

Two contextual level actions were found out, which are the development of new regulations about BIM model's privacy and the BIM process in general inside the Italian construction market and the stimulation of the client's BIM request in construction projects.

For the organizational level, ten actions can be undertaken to overcome the challenges. In particular, developing a feasibility study for BIM, setting up a BIM strategy, developing a BIM workflow, addressing BIM roles and responsibilities, creating a marketing department, creating the BIM implementation group, developing a business model for BIM, creating a collaboration and procedural protocol and a technical resource plan are considered to be the best actions to be conducted by an Italian design firm trying to overcome the above mentioned challenges. Moreover, while describing the recommendations, an overview of what kind of changes are necessary when implementing BIM in terms of people (change management), organization (organizational structure) and ICT structure (software and interoperability) were analyzed as well.

In the second section, an answer to the sub-question 2.3 is given, by sequencing all the steps which were described in the previous part of the chapter. As a consequence, a roadmap for BIM implementation which can be used for practical purposes by an Italian design firm is proposed. The roadmap was divided into five phases which are: the Initial or preliminary phase, Decision-making phase, Planning phase, Implementing phase and Post implementation phase. The roadmap, proposed in Table 22, is a result of the research which can be used as a practical example by Italian design firms, however each company should reflect on a personalized BIM implementation path, depending on the current BIM situation of the firm and what are the goals to be reached in mid-long term.

7. **Discussion and limitations**

This research extends and can be integrated to the literature regarding BIM implementation in construction companies. Specifically, the challenges regarding BIM implementation encountered by a design firm with a relevant presence in the Italian construction sector were analyzed through the research. Several reflections can be made on the results of this study, when comparing to the existing literature about the same topic.

From a broader perspective, previous researches were conducted on the past about BIM implementation challenges for an organization. Theories such as Arjen Adriaanse's framework about ICT adoption into construction companies (Adriaanse, 2007), the innovation diffusion theory (IDT) (Rogers, 1995), the technological organizational and environmental framework (TOE) (Tornatzky et al. 1990) have been used as a baseline for the theoretical framework developed in phase 1 of the study. The IDT theory explains how, why and at what rate an innovation spread through cultures, operating at the individual and organizational level (Straub, 2009). The Technological, Organizational and Environmental (TOE) framework, developed by Tornatzky et al. (1990), differs from the other theories related to the adoption of technology at individual level and its focus is mainly on the implementation of technological innovation at the organizational level (Oliveira and Martins, 2011). The theory described with the TOE framework consisted an example of which challenges might influence BIM implementation in Italian design companies, specifically because it includes the environmental and external context which needs to be considered when studying the Italian construction sector. Accoridng to Adriaanse et al. (2009) personal and external motivation, knowledge and skills, acting opportunities have to be considered important factors when implementing ICT in construction companies.

The problem of identifying the challenges regarding BIM implementation inside a design firm was investigated by previous researches (Vass and Gustavsson, 2017) (AL-Btoush and Haron, 2017) (Hatem et al., 2018). These studies stated how challenges regarding the technological (interoperability), organizational (initial cost, time required, re-organization of team, new roles, data exchange and collaborative way of working), individual (resistance of people towards change) and environmental (regulations and norms, lack of clients request, common standards and information exchange) aspects of BIM implementation inside design firms were found out by previous researches as well. Moreover, the case-study method has been used as favorite method of research in many cases (Vass and Gustavsson, 2017) (AL-Btoush and Haron, 2017), because of the immediate source of data a the observation of a design company might offer.
Design companies are the first involved in the construction process for BIM implementation. However BIM implementation challenges influenced all the firms involved in the supply chain, such as contractors and suppliers. Bosch-Sijtsema et al. (2017) explains how the lack of clients awareness about BIM affects BIM implementation among contractors as well. Moreover, as a result of this research it can be seen as challenges such as "lack of collaboration" between different firms, and "lack of regulations about common standards" and ownership of the model are delaying BIM implementation in Italian construction projects because all the firms involved in a BIM project (suppliers, contractors, design firms) do not trust each other on sharing relevant data, while with the use of IFC files important information are lost.

However, the BIM implementation process refers to a socio-technical view in which it does not only consider the implementation of technology but also the socio-cultural environment that provides the context for its implementation (Arayici et al. 2011). To this extend, the specific context of the research (the Italian construction sector) explains why some environmental challenges such as "BIM adoption at a national level" and "regulations and norms" are delaying more BIM implementation in Italy than in other European countries such as Norway, Sweden, Finland (COBIM, 2012), UK (AEK BIM technology protocol, 2015) Netherlands, France (Guide Methodologique, 2016) and Germany (Egger et al., 2013). This can be explained as a consequence of the Italian traditional way of working (cultural aspect), lack of strong governmental position "pro-BIM" and people's resistance to change. Those aspects explains why challenges of the

theoretical framework such as “Lack of regulations and norms”, “BIM adoption at a national level”, “cultural aspect” and “Developing a collaborative way of working” emerged from the case-study. The most important aspect is the use of different, more specific definitions for the case-study challenges because those are adapted to the Italian context, while the results of previous researches explain general BIM implementation challenges which might be encountered by a design/construction firm. An example can be provided by the change of the theoretical framework “Regulation and norms” which was found in previous studies as well (Hatem et al., 2018), but in this context is re-phrased in “Lack of regulations about BIM models’ privacy, collaboration and in general how to deal with a construction process with BIM”, adapted to the context in which the research was conducted. From the challenges which came up from the case-study, it is relevant to observe the interconnection and overlapping between different issues. An example can be provided by the organizational challenges which are affected by individual issues as well. To this extend, the challenge “lack of all company’s members direction to BIM” can be influenced by individual and human factors as well (such as the individual drive towards change). The interconnection between different challenges has been considered in previous researches as well (Adriaanse et al. 2009) and it was confirmed by this research as well.

The case-study method appears to generalize the results of a single firm to the broader Italian construction sector, while some differences might emerge from similar studies. Moreover, it can be noticed how the IT structure of a company differs from others, and this challenge has to be related to the specific situation of the case-study.

The BIM implementation roadmap development for an Italian design firm, can be connected to previous researches about European (Khosrowshahi and Arayici, 2012) and not European (HKCIC, 2014) countries with an higher BIM adoption. Indeed, those studies aimed to propose the sequence of actions which can be performed in order to achieve a lean BIM implementation inside design firms. The result of this study is similar to the previous researches for the organizational level actions (Khosrowshahi and Arayici, 2012), while the contextual level actions are those which differ the most when comparing the results of this research with precious studies. In specific, the development of new regulations hat to be considered to the selected context of the country and in Italy the lack of regulations about models’ privacy emerged to be an obstacle to BIM adoption at a national level. Moreover, the BIM implementation roadmap presented in Chapter 6 has to be adapted to the specific context of the firm: for example small design firms cannot follow all the steps (such as the creation of a marketing department, or the creation of a BIM department), but it can be stated as this roadmap can be applied by Italian design firms with a similar size and dimension to the case-study of this research.

The analysis of BIM implementation challenges for an Italian design firm can be considered relevant, as in the literature no example about similar researchers can be found. In fact, even if similar researches have been conducted in other countries, BIM is partially a new theme for the Italian construction industry and for this reason this research reached its goal to provide a guideline of what the challenges an Italian design organization has to face when implementing BIM are, and what can be done in practice in terms of steps (or actions) to overcome the above mentioned challenges.

7.1 Limitations of the research

Unavoidably, the research had some limitations. Three main limitations were found out from the research.
1. First of all it has to be mentioned how there might be challenges which did not emerge from the literature or were not taken into account during phase 1 of the research. This issue can be considered a consequence of the large amount of papers regarding BIM implementation which can be found in the literature, fact which leads to multiple challenges from different researchers.

2. Secondly, three limitations emerged from the case-study, which are analyzed in paragraph 5.7.1. Specifically, those limitations are:
- The context in which the research is conducted (the Italian construction sector), which reflects the challenges of a specific country in a specific historical period. All the challenges presented in the theoretical framework were found out through researches in other countries, fact that needs to be mentioned when comparing it with the framework developed in the Italian context. The context of the research affected the environmental and individual results as those depends on the environmental situation of the country and individual aspects.
- The choice of General Planning as case-study for the research, because of the different findings which the same research in another Italian organization might have, and its location in the region of Milan, European and Italian economic capital, where IT adoption is more stimulated than other Italian regions (such as the South of Italy). This limitation can be seen in the technological challenges which emerged from the case-study.
- The dimension of the firm selected as case-study influenced the way BIM implementation challenges are perceived, because a company of 50-60 employees has a different organizational structure and follows different project workflows when compared with a 200 employees firm. The firm's size, structure and dimension influence the organizational challenges which come up from the research.
For all the reasons mentioned above, it appears to be clear why these challenges emerged rather than others, and why there are some differences between the found out issues and those collected from the literature.
In conclusion, even if the theoretical framework can be considered a basis for the research, slight differences appear from its comparison with the developed framework, even if it does not appear the theoretical framework was incomplete or with some missing parts. In fact, those differences can be considered a consequence of either the context in which the research was conducted and the case-study selection (region and size of the firm).
All the limitations part of the case-study can be found in Figure 29.

Case-study Limitations	Challenges influenced by the limitation
Context of the research – Italian construction sector	Environmental challenges Individual challenges
Specific Italian region (Milan) and choice of a frontrunner Italian company for BIM adoption	Technological challenges
Firm's size, structure and dimension	Organizational challenges

Fig. 29. Limitations of the case-study results and related challenges.

3. Finally, it has to be mentioned as the BIM implementation roadmap developed in phase 3 of the research is just an example of activities which can be undertaken by an Italian design firm implementing BIM inside its organization, while it has to be adapted to the current and specific situation of the firm. To this purpose, different activities can be proposed which do not aim to solve the challenges but are still useful for BIM implementation. Those activities have not been included in the research because of its different purpose to provide recommendations and solutions to the identified challenges.
To sum up, even if the research had some limitations, it can be seen as the main objective of the research has been reached and its results might be used by future researchers about BIM implementation challenges, as well as by practitioners, such as construction companies facing the digital transition from CAD to BIM.

Main limitations of the research
1. Some challenges might not have emerged during the literature review
2. Case study limitations: - Context of the research – Italian construction sector - Specific Italian region (Milan) and choice of a frontrunner Italian company for BIM adoption - Firm's size, structure and dimension
3. The BIM implementation roadmap has to be adapted to the specific situation of each design firm

Fig. 30. Main limitations of the research.

8. General conclusions of the research

This Chapter aims to provide a general conclusion for the all research. The objective of this research was to provide to Italian companies involved in the construction industry an overview about the obstacles, problems and challenges related to BIM implementation and how can those problems be overcome by explaining which actions and recommendations can be undertaken to successfully implement BIM inside an organization.

In specific, two main research questions were answered, while conducting the research:
1. What are the obstacles, problems and challenges which an Italian design firm might encounter during BIM implementation?
2. *What are the possible strategies and recommendations needed for an Italian design company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?*
To provide an answer to the two research questions, different steps have been followed during the research, each one logically connected with the previous and the following one.

8.1 Main conclusions

The research project have been divided into three main parts. Phase 1 and 2 aim to answer to the firs main question of the study, while question 2 will be answered by the third phase of the research.

1. What are the obstacles, problems and challenges which an Italian design firm might encounter during BIM implementation?
In the first part, Chapter four, a literature review was carried out to collect all the challenges related to the adoption of BIM into a theoretical framework, which can be used as a baseline for the following section (Chapter 6). The results of the literature review shows as the challenges can be divided into four main groups: environmental, organizational, individual and technological. This section aims to provide an answer to the first sub-question of the research and, at the same time, to build up a theoretical framework which will be compared with the results of the case-study. As results of the literature review, as it can be seen in Appendix 1, four environmental challenges were identified (regulations and norms, common standards and information exchange, BIM adoption in a national level and level of client's awareness for the use of BIM), which affect an organization externally, while three individual challenges (cultural aspect, individual drive towards change, knowledge and skills), three technological challenges (interoperability, current IT infrastructure support and scalability of BIM models) and eleven organizational challenges (time necessary to adopt the new processes, high initial investment, organizational structure and strategy, top management support, re-define the business model, assign responsibilities for BIM implementation, re-organization of teams, data exchange within the firm, developing a collaborative way of working, promotion of the company's BIM capacity, contract change arrangements and costs) were identified as problems a firm needs to face internally.

In the second phase of the research, a case-study research method has been used, to analyze the current and expected BIM situation and design practices of an Italian design company and at the same time to find out what are the challenges the company had to face, or it is still facing, while conducting the digital transition CAD-BIM. The selected firm, General Planning Spa (GP), can be considered a frontrunner for the adoption of BIM in the Italian construction sector, as one of the first design companies which decided to adopt BIM inside the organization. Moreover, because of the relevant position GP has in the Italian construction market (12^{th} design company by earnings in 2016), the challenges affecting BIM implementation inside the firm can be considered a great example of the obstacles all the Italian design firms might find when deciding to

implement BIM in the organization. The case-study aimed to answer to the sub-questions 1.2 and 1.3, providing an overview of the current and desired BIM situation of GP and explaining which BIM implementation challenges emerged from the case-study. It emerged that the company is deeply involved in the digitalization process, but a lot of work has still to be done in order to adapt the traditional way of working to the BIM procedures. Moreover, it has been noticed as the actual BIM maturity level of the company is between 1 and 2, while the desired one is the BIM maturity level 2.
Several BIM implementation challenges came up from the case-study observation and from the interviews with the employees. Specifically the twelve BIM implementation challenges are: (1) Lack of client awareness about BIM advantages and request of BIM, (2) Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM, (3) Lack of collaboration between companies, especially when data are not protected, (4) Traditional way of working is still followed without a clear BIM workflow, (5) Lack of well-defined roles and responsibilities, (6) Overcoming the comfort of employees to change their working practice, (7) High initial investment without assessing BIM economic advantages in the short-term, (8) Lack of all the company's members direction to BIM, (9) Information exchange and set up of information from the beginning, (10) The company's BIM capability is not well promoted, (11) Interoperability between different software, (12) High initial time to be invested to create templates, collaborative way of working and first projects with BIM.
The BIM implementation challenges of the case-study were compared with the theoretical framework previously developed. Interesting results emerged from the comparison between theory and practice.
- For the environmental challenges found out from the case-study, the framework does not include directly the common standards and information exchange as a relevant challenge, because of a lack of regulations about this concept. However, it can be seen that the lack of regulations refers to the BIM models' privacy, while the lack of collaboration between companies emerged when data are not protected.
- From the technological challenges which came up from the theoretical framework, only the interoperability between different software slightly affected the BIM implementation in GP as a result of the strong IT system implemented by the company in the last years.
- For the individual challenges it can be noticed as inside GP, almost all the designers seem to show difficulties in overcoming the comfort to change their working practice. For this reason, this issue, which is a consequence of the Italian traditional way of working, includes the cultural aspect as well as the employees' skills and knowledge about new software, which are part of the theoretical framework.
- The organizational challenges are those which changed the most when comparing the theoretical framework with the results. Some of the challenges emerged in the case-study, such as the high initial investment, the lack of company's direction to BIM, lack of BIM capability's promotion, information exchange and time-consuming process. However, two new challenges came up, the lack of a clear BIM workflow and, as a consequence, the lack of well-defined roles and responsibilities aligned with the tasks developed through the workflow itself. Moreover, a lack of all company's members direction to BIM appeared to be relevant, a high top management support emerged, while the business model re-definition did not emerge as a relevant challenge and contract changes will be an important future challenge.

2. *What are the possible strategies and recommendations needed for an Italian design company to overcome the challenges described, and to conduct the digital transition from CAD to BIM and successfully implement BIM into its every-day working routine?*
The third phase of the research aimed to provide an answer to second main research question of the research and it can be divided into two main parts. In the first section an overview of all the recommendations and actions which can be undertaken to overcome the BIM implementation challenges found out in the previous chapter was provided. From the results, it can be seen as the actions can be divided into those which affect the company externally, contextual level actions, and those which regards the company directly, organizational actions. To the first group of contextual level actions, the development of new regulations

about BIM model's privacy and the BIM process in general inside the Italian construction market and the stimulation of the client's BIM request in construction projects emerged to be relevant.
For the organizational level, ten actions proposed to overcome the challenges are: developing a feasibility study for BIM, setting up a BIM strategy, developing a BIM workflow, addressing BIM roles and responsibilities, creating a marketing department, creating the BIM implementation group, developing a business model for BIM, creating a collaboration and procedural protocol and a technical resource plan are considered to be the best actions to be conducted by an Italian design firm trying to overcome the above mentioned challenges. In the second part of phase 3, a sequence of all the actions which can be undertaken to correctly implement BIM inside an organization is provided. As a consequence, a roadmap for BIM implementation which can be used for practical purposes by an Italian design firm is proposed. The roadmap was divided into five phases which are: the Initial or preliminary phase, Decision-making phase, Planning phase, Implementing phase and Post implementation phase. The roadmap resulted from the research can be used either for practical purposes by another Italian design firm trying to adopt BIM, either for future researches.

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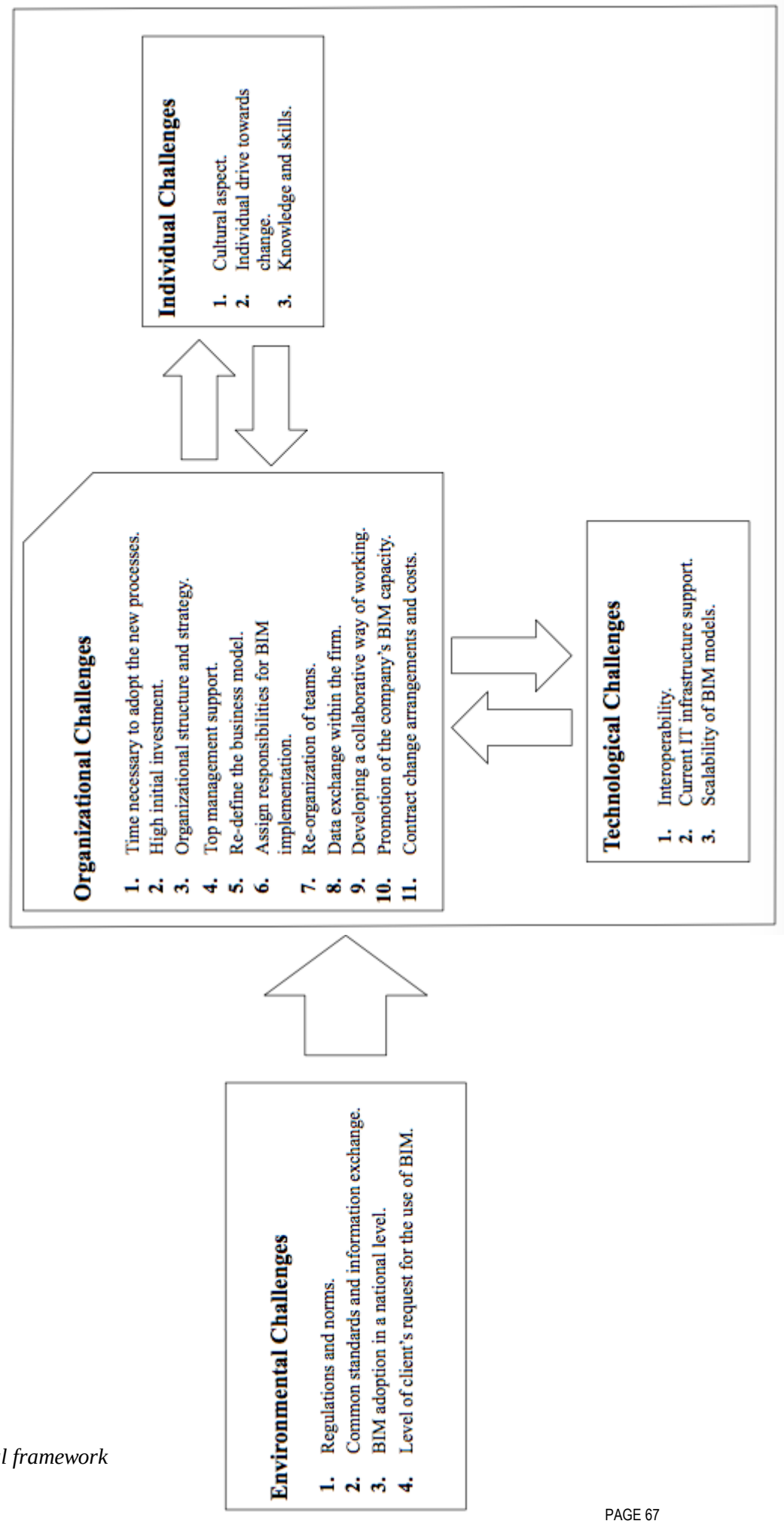
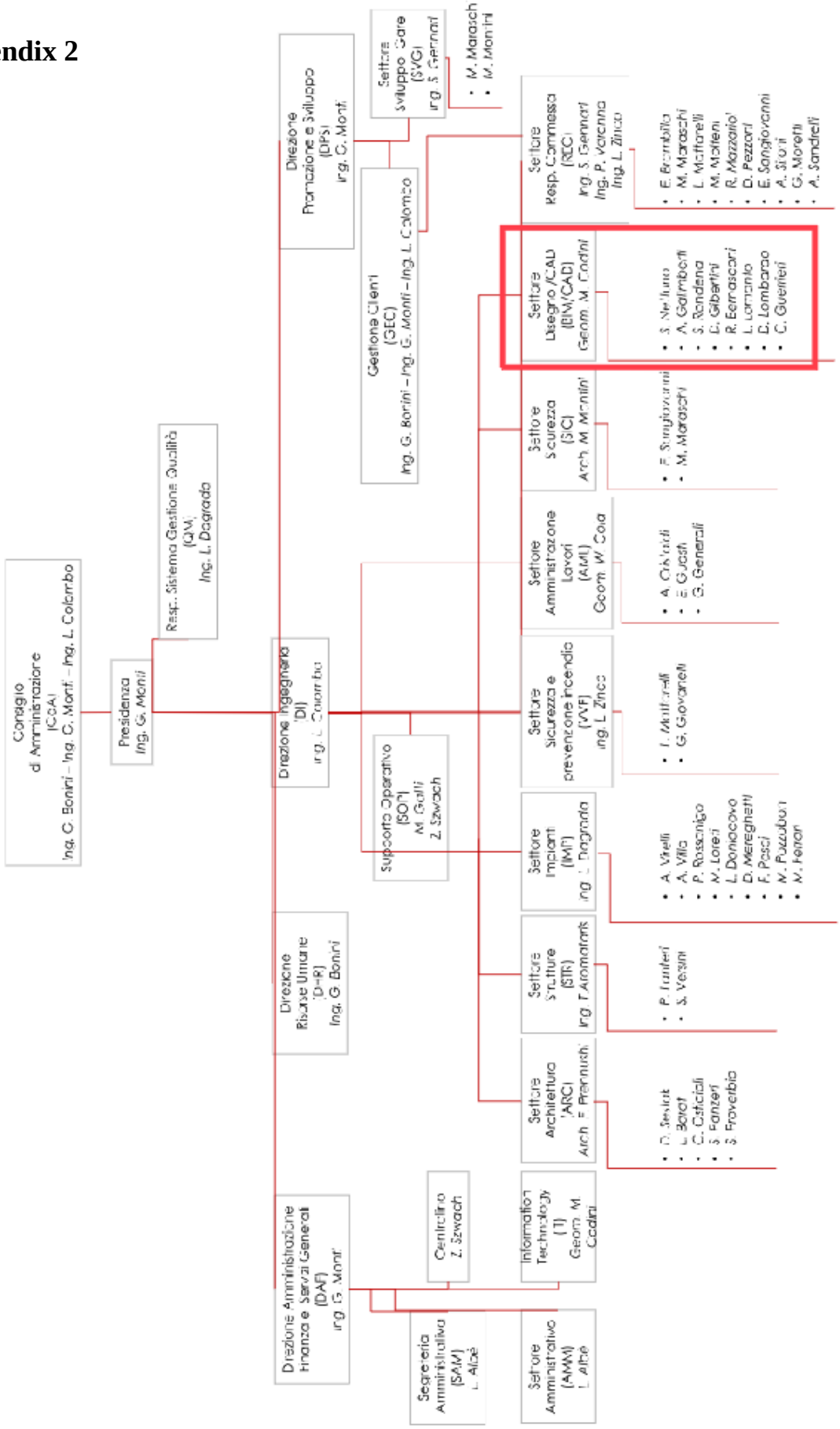
10. Appendixes



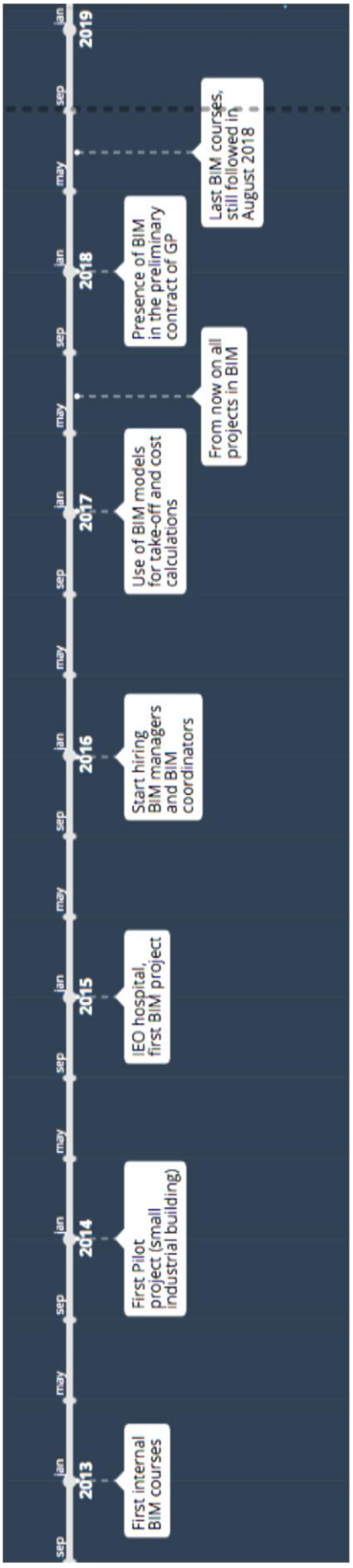
Appendix 1. Theoretical framework

Appendix 2



Appendix 2. General Planning's organization chart.

Appendix 3



Appendix 3. Timeline about BIM implementation steps of General Planning.

Appendix 4: Case study – Interview questions

Fixed questions

General questions
1 What is your role within the firm?
2. What are the general characteristics of the firm? (History, markets, general development)

Current BIM situation
3. Why and when did you implement BIM into the practices?
4. What is the current situation regarding designing practices (or the use of BIM) within your team/department/division?

Desired BIM situation:
5. What is the desired situation regarding the use of BIM in your team/department/division?
b. Is there a consensual opinion formed around these intentions?
c. What benefits are expected from implementing and using BIM?

6.. Do you think the company is representative for the Italian construction sector or a frontrunner? Why?

Variable questions

BIM implementation challenges
7. Which BIM major challenges did the company face with, when implementing BIM?
a. What is the level of importance for all the expected BIM challenges in the implementation process?
Specifically (Depending on the department and the role in the company):
Environmental challenges

- *How is the company affected by regulations and norms regarding BIM implementation?*
- *What is the situation regarding Commons standards and information exchange?*
- *To which extend does BIM adoption in a national level affect the company?*

Organizational challenges

- *What was (is) the time necessary to implement BIM within the organization?*
- *How does the high initial investment affect the company's decision to implement BIM?*
- *How did the organizational structure and strategy of the company change when BIM was implemented?*
- *Did the top management support BIM implementation?*
- *How was re-defined the business model when BIM was implemented?*
- *Who took the responsibilities for BIM implementation? Internal or external?*
- *How did the re-organization of teams take place?*
- *How did the data exchange methods change within the firm?*
- *Was there a problem in developing a collaborative way of working? To which extend?*
- *What was necessary in order to promote the company's BIM capacity?*
- *What was changed in terms of contract arrangements and costs?*

Individual challenges

- *How did the cultural aspect affect BIM implementation?*
- *How did the individual drive towards change affected BIM implementation?*
- *What were the knowledge and skills and how did they had to change when implementing BIM?*

Technological challenges

- *Was it there a problem of interoperability within the firm?*
- *How did the current IT infrastructure support BIM?*
- *How did the scalability of BIM model issue affect the company?*

8. What are specific issues playing at the firm?

Appendix 5. Level of challenges' impact on the BIM implementation process

BIM implementation challenges of the case-study	Level of Impact on the BIM implementation process	Number of interviews underlying the challenge
Lack of client awareness about BIM advantages and request of BIM	high	8
Lack of regulations about BIM models' privacy, collaboration and in general how to deal with a construction process with BIM	difficult to define	4
Lack of collaboration between companies, especially when data are not protected	difficult to define	4
Traditional way of working is still followed without a clear BIM workflow	high	9
Lack of well-defined roles and responsibilities	high	7
Overcoming the comfort of employees to change their working practice	low	3
High initial investment without assessing BIM economic advantages in the short-term	low	1
Lack of all the company's members direction to BIM	low	2
Information exchange and set up of information from the beginning	high	7
Promotion of the company's BIM capacity	low	3
Interoperability between different software version	low	3
High initial time to be invested to create templates, collaborative way of working and first projects with BIM	difficult to define	5

Table 16. BIM implementation challenges' impact on the BIM implementation process of General Planning.

The previous chapter aims to underline and describe the BIM implementation challenges of the case-study. However, the effect of these challenges on the BIM implementation process is not the same. For this reason, this chapter will assess the level of impact those challenges had on the BIM implementation process. This assessment is a consequence of either the results of the interview (perception and opinion of the respondents) either the number of interviews the challenge emerged, and as a consequence, how many times it was noticed during the case-study. For challenges which occurred from 7 to 10 interviews, a high level of impact was assigned. On the other hand, challenges which emerged from 0 to 3 times in the interview process did not largely affect BIM implementation inside GP. For all the other challenges which came up only in 4, 5 or 6 interviews, the level of impact is difficult to measure, and for this reason a high or low impact cannot be assigned based only on the results of the interviews. Afterwards, the challenges' level of impact was validated by the Project manager of the firm itself, in order to get an internal confirmation of the results. Table 16 provides an immediate description of how the previously described impact affected the digitalization process in GP. As it can be seen from Table 16, the lack of client awareness about BIM advantages and request of BIM, the lack of a clear workflow and well-assigned roles and responsibilities, the information exchange and set up of information from the beginning are the challenges which mostly affected the implementation of BIM within the firm. On the other hand, it can be noticed as challenges such as Overcoming the comfort of employees to change their working practice", the high initial investment, the lack of company's members direction to BIM, the promotion of the company's BIM capacity and interoperability did not highly affected BIM implementation in GP, as they did not occur in many interviews. For other challenges such as the lack of collaboration between companies, lack of regulations, and the high initial time invested the level of impact is difficult to measure and for this reason it cannot be assigned based only on the result of the interviews.

Appendix 6: BIM experts – Interview questions

Fixed questions

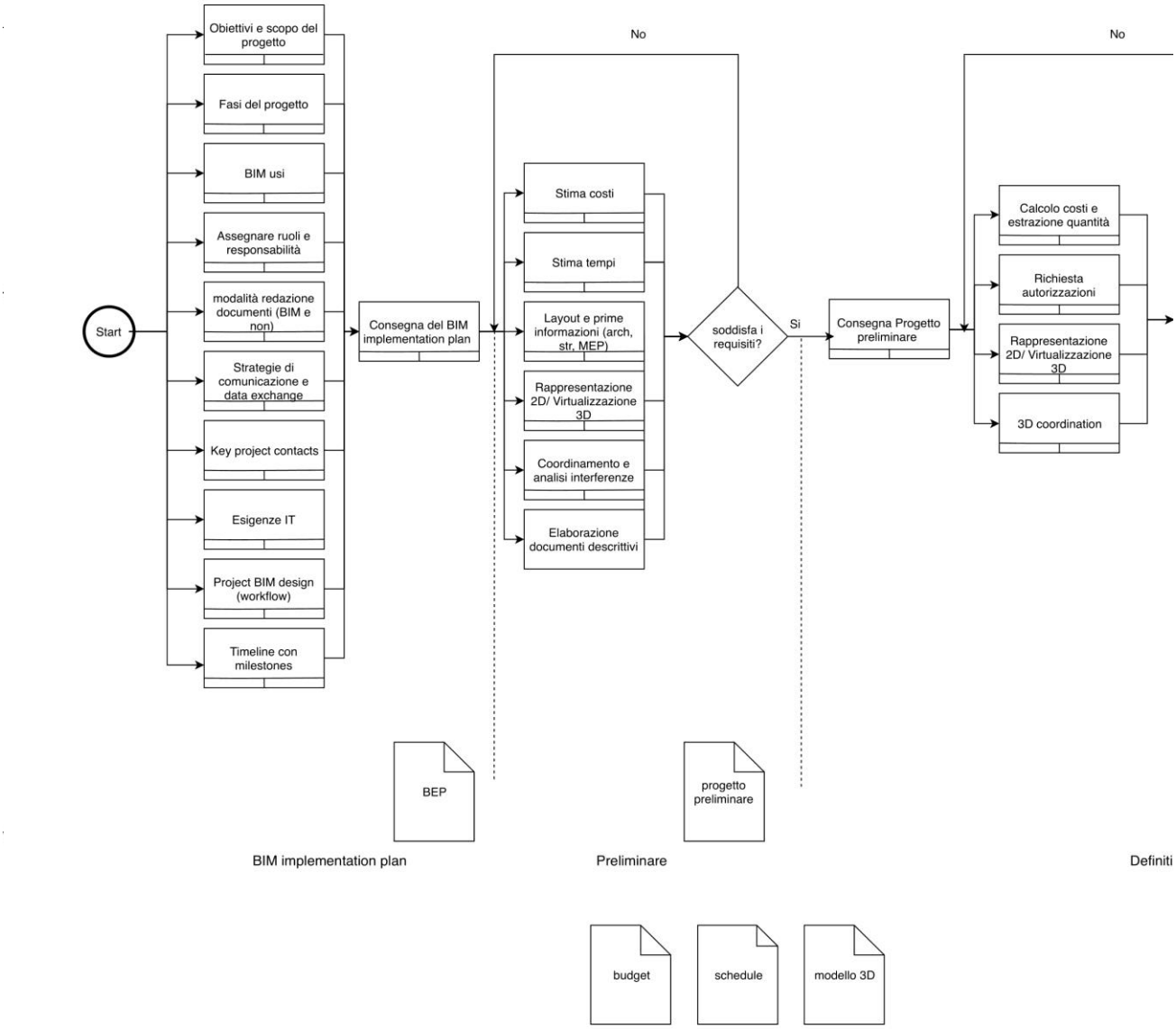
General questions

1. What is your role and expertise?
2. How are you involved in BIM implementation?

Main questions

3. Given the developed framework, how can an Italian design firm overcome the most important issues encountered when implementing BIM into the firm?
4. What kind of changes are necessary in a design organization in terms of people and managers (change management), when implementing BIM?
5. What kind of changes are necessary from an ICT perspective (not only from a software prospective) and licenses in order to make it worth the implementation of BIM?
6. What kind of business model can be defined when implementing BIM and how can be considered a correct business strategy for a design firm which is conducting the digital transition CAD/BIM?
7. Which steps are necessary in order to implement BIM into a design firm, which has never worked with it before?

Appendix 7: BIM workflow



Appendix 7: BIM workflow (continuation)