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Survey of the Renovation Sector in France: A Necessary Step Towards Implementing BIM in Microenterprises

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Abstract—In recent years, Building Information Modeling (BIM) has spread throughout many Architecture, Engineering and Construction (AEC) companies and contributes to “digitizing” these sectors. Are there any limits to this expansion? Opinions seem to diverge on this matter. What are some of the conditions enabling it to be implemented in what might be called the “average model company” of the French construction sector; that is, a Microenterprise (μ Ent) that primarily does renovations? Implementation templates or studies have little to do with μ Ent and renovation. In order to provide a better definition for the activities, needs and limitations of this average business model and for a better understanding of the mechanisms required for implementing BIM in eligible companies, a survey has been carried out. The main outcomes of this survey are reported in this article.

Keywords— Building Information Modeling (BIM), Survey, Renovation, Microenterprise

I. Introduction

“Industry4.0” was publicly promoted in 2011 in Germany [1] and spread throughout Europe in 2013, after the “Final report of Industry4.0 Working Group” [2] was released. Since then, in many sectors keywords and concepts such as the Internet of Things and Services, smart machines autonomously exchanging information, facilitating optimized decision-making, dynamic business and engineering processes, novel business models, and more, are used to describe future industrial developments. In this expected future World, people, machines, logistic systems and products will communicate and cooperate with each other. This development also concerns the AEC Industry. Management consulting firms use the same vocabulary to describe the transition that awaits this sector and present the transformations imposed by the implementation of BIM [3], [4]. They tend to predict that “*companies that continue to ignore the digital wave will struggle to survive*”. The mere definition of BIM by the “worldwide authority” (<http://buildingsmart.org>) reflects the parallel that can be made with Industry4.0. BIM is defined as “*a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition*”. It is important for AEC companies to become aware of their digital capabilities and to widely modify their behaviors, practices and organization. The French renovation sector will be impacted, even though its specific characteristics will likely make the evolution a long and complex process. This sector is of particular interest for several different reasons: it represents 57% of the French construction market. The major part of this

market (55%) is shared by 650,000 companies that employ fewer than 20 individuals, and represents an annual turnover close to 42 billion Euros [5]. This results in a very diverse and stimulating case study. The typology of companies defined by the European Commission [6] was considered as a reference framework: Microenterprise (μ Ent) stands for enterprises that have fewer than 10 employees and an annual turnover of below €2 million. There are around 635,000 of these enterprises and they represent an annual turnover close to 33.5 billion Euros of renovation work in France. Small enterprises (SmEnt) are those with fewer than 50 employees and an annual turnover below €10 million, while small and medium-sized enterprises (SMEs) employ fewer than 250 individuals. It is difficult to provide appropriate support to μ Ent in their process of adopting the BIM technology without characterizing their current situation, understanding their needs and identifying their potential step-by-step improvements. Almost everything has to be done in this area. As proof, in the sector of energy-driven retrofits of existing buildings, the most frequently studied panel from a scientific point of view (about 60% of scientific publications [7] despite a relative significance of only 1/3 of renovation works [8]), BIM is still considered immature “*because of technical, informational and organizational complications*” [9]. The great diversity of businesses and trades [10], added to the lack of available, significant and ready-to-use scientific data [7] by small companies with tight budgets, are reasons stimulating and justifying this work.

This article includes three main sections. The first aims at detailing the different possible scenarios for implanting BIM in SmEnt, which mostly constitutes the French renovation sector. The decision to carry out a survey with 34 companies to better identify and map the environment as a whole will then be justified. The methodology used for this latter and the main results are detailed in the third section. The conclusion will introduce future works, i.e., how the collected information will be used and will enable the development of a BIM maturity referential, adapted to this particular and important renovation sector.

II. Implementation scenarios

A first approach to accelerate BIM implementation in France could be to transpose what leading countries in Europe, such as the UK, have achieved in the past 5 years. Similarities exist with the UK, where μ Ent represent 93% of the construction sector [11]. There is also a resemblance between the 2012 BIM posture of the UK’s AEC industry [12] and the French industry in early 2017 [13]. According to these studies, only 25% of SMEs were using 3D digital models. 81% of SMEs’ contractors were only vaguely familiar with the levels of BIM while 32% of 400 French SmEnts’ executives had

heard about it. At least 3% of SmEnt surveyed planned to integrate BIM in the upcoming months. Despite this, however, a cautious approach is advisable. The French and UK construction market are different. Repair and Maintenance of buildings only account for 38% in the UK's construction outcomes (vs. 57% in France) [14]. Another study in 2013 is also of interest to, but not representative of, the UK's present situation [15]. In this "survey of current status of and perceived changes required for BIM adoption in the UK", only 13% of answers were from enterprises with fewer than 20 employees, 90% of organizations that responded were using BIM tools, but 3 years later, in a representative sample of UK construction SMEs [16], it was stipulated that out of the surveyed SMEs, "mostly SME Companies (75%) in UK are at BIM infant level, as their business processes involve 2D workflows, generally using AutoCAD, have some knowledge of BIM and have yet to start their BIM journey....Around 75% of construction SMEs which form the backbone of construction market are non BIM". Works that present strategies to implement BIM in a practical context were also considered [17] [18]. The input model (project cost of several million Euro, size and sector of the industry, systematic use of accepted construction project management practices, use of a formal technical path scheduling techniques to estimate the duration or structure project, Work Breakdown Structures of the physical project work) revealed to be out of the scope and the transposition of it to the French renovation sector was found to be too risky. Previous studies have shown that the needs of stakeholders and the diversity of renovation fields are extremely varied [7][10]. Implementing BIM requires developments with and for users with a logical step-by-step evolution, on-site, by gradually capitalizing [19]. BIM has to adapt to these realities, and the environment should also adapt to BIM. Important gaps have to be addressed and a more in-depth analysis of this French area is necessary to map business processes and uses in renovation. For example, 3D scanning is often mentioned as a key lever and many solutions are imagined by the scientific community [20]. However, the ROI of the process, change effort and the added-value of involving a capable surveyor remain unclear. Should it become systematic? It is also difficult for a μ Ent to identify affordable partners that master the scanning technology. Architects are more likely to use it, but they have very few relationships with the renovation shareholders. So as to characterize BIM implementation scenarios, it is necessary to map the situations that coexist today and those that could coexist tomorrow. Practically, this means accounting for the French renovation sector according to the point of view of diversity in renovation, which is mostly performed by μ Ent and SmEnt. Renovation processes in public projects are formally prescribed in French law. Depending on European thresholds, public customers in France can choose between 4 regulatory process [21]; **Adapted procedure, Competition, Competitive Procedure with negotiation or Competitive dialogue tender.** All this is part of the "MOP law" published by the French Government [22], which governs public project contracts and their relationship with private project management. The aim of the current study is to better understand the way of working outside these later cases. Indeed, 75% of the French market is constituted by individuals and private clients [23]. The remainder is state and local authorities. The regulatory process

that was previously defined impacts not more than 15% of the enterprises with fewer than 20 employees [5].

In this context, best practices from abroad cannot be directly transferred to the French renovation sector without further examining what the current situation of this sector is. This is why a survey and interviews with companies mainly engaged in renovation was undertaken and is presented in the next section.

III. Objective of the survey

A. Representative nature of the survey

According to the Trades Construction Observatory[10], construction covers 2 major sectors: "building companies" and "Civil Engineering Industry". This latter, representing only 7% of the total, is considered out of the scope of this work. 34 companies were interviewed. 85% of the panel consisted of individuals in place for 16 years (with a standard deviation (SD) of 9 years). The panel was split into 2 complementary classes:

- Group A (GrA) comprised of 23 "technical companies". 70% only have one laying activity; the others are both a manufacturer and layer.
- Group B (GrB) includes Architects, Project Managers, Construction Consultants and Designers, Quantity surveyors, Geometrician expert, Commercial and Social Landlords. Their primary missions are to advise and organize projects.

In accordance with the major trends described above, 70% of GrA realize more than 80% of their projects' turnover in renovation. 65% work is done exclusively for individuals. For 90% of the group, tenders and processes related to the MOP law represent less than 10% of the activity. The average turnover of these companies is between 250 and 500 k€. The objective was to be as representative as possible, so the survey was carried out as long as necessary to obtain the mapping of a sufficient number of projects, specifically here 3200/year for the whole GrA, mainly carried out by Microenterprises (average of 7,65 employees SD of 7,5). This panel was formed from networking, advice from the French Building Federation and snowball sampling [24]. The survey was mainly conducted in the Bourgogne-Franche-Comté (BFC) Region. BFC has an enterprise size distribution very close to national figures as shown in "TABLE 1", synthesized from [25]. From a "technological or cultural" point of view, it is equally possible to justify this restrictive choice by two studies that tend to cancel each other out: [13] highlights that, in France, the BIM integration and knowledge level are quite steady over different regions, estimated between 23% and 37%.

TABLE 1 French Construction size distribution of enterprises

	size total	0	1 to 9 employees	10 to 19 employees	20 to 49 employees	More than 50
Enterprises in France	666 739	469 267	166 446	17 887	9 764	3 375
distribution	100%	70,4%	25%	2,7%	1,5%	0,5%
Enterprises in BFC	24 271	16 014	6 948	775	431	103
distribution	100%	66%	28,6%	3,2%	1,8%	0,4%

This corresponds to the percentage of SMEs that have only heard about BIM. Unexpectedly, the Paris region is just under the average, with 30%. At the same time, the engineering (GrB) is well documented in a recent study [26], showing that BIM projects are concentrated around Paris. Therefore, a survey focused on a French region is capable of representing the overall situation in France.

B. Methodology

Data were collected through 1 to 3 hours of face-to-face interviews, between Dec. 2016 and Feb. 2017. They were semi-structured, with open and closed ended questions. This approach allows the researcher to discover the way people work, visiting offices, identifying software, computer means, and sometimes machines or inventories to better understand the type of company it is. As described in [27], the intention here is “descriptive,” “explanatory,” and certainly in works that will follow, “prescriptive”. As also noted in this book, the objectives of these interviews are mid-way between consulting (*obtaining results that enrich knowledge and the corpus of existing hypotheses*) and research-intervention (*no preconceived outcome*) for the continued work. In this sense, the approach adopted is quite similar to the one used in [28] for the UK construction industry. The aim is to identify a “true picture of the situation”, the needs and uses of the companies to which the BIM might respond and lastly the optimal way to achieve it. So a representative population of the renovation sector (GrA) was chosen so as not to distort the photography and then to understand and build models on a strong basis, making them as realistic as possible. Individuals in the main trades and professions involved in renovation, as defined by the Observatory of the Construction Industry [10], were interviewed (electricity, plumbing, roofer, mason, etc.). Companies apply to several work areas, so the particularities of each of the 18 main trades and professions were addressed between 2 and 7 times during the survey. The feedback did not stop with just their main trades and profession, since each stakeholder is in contact with many others; therefore, the working habits of a much broader panel of companies and professions were also addressed.

The objective transcription of the data collected following the combination of qualitative and quantitative questions to identify the uses of μ Ent was not easy [26]; however, the results of this survey are presented in the following section.

IV. Major results

A. Technical actors (GrA)

Of the around one hundred points covered during the interviews, only the useful parts for decrypting the functions of the SmEnt are presented here. Some elements or details of the survey will, however, be useful in the continuation of the work, which is detailed in part V.

1) General information

Among the key observations, raising some doubts about the introduction and use of the digital mock-up or BIM, we can point out, for example, that 60% of GrA work without

quote software or simply use MS EXCEL. More than 95% have no procedures and 2/3 work without indicators. They practically have no relationship (90%) with surveyors who can perform 2D or 3D studies. For 50%, 2D drawings are provided less than 20% of the time, and only 15% of them are confident in using 100% exploitable and up-to-date drawings. 33% estimate that 2D drawings are useless in renovation activities. When they realize a drawing or diagram, they do it by hand or without dedicated software (50%). Less than 40% are equipped with computer solutions for this, yet it is necessary in 44% of cases (SD of 41). In this context, it is understood that only 13% have ever used electronic data interchange systems for their 2D drawings (very rarely) and favor the exchange of information by phone, email or on-site meetings.

Other elements that can be helpful for future works are presented “Fig 1 & 2”. In these representations, the bubble size represents the proportion of turnover obtained from an invitation to tender for each company. “Fig 1” clearly indicates that a correlation between the size of the enterprise and the relationship it weaves with Architects exists. In the same way, the need for companies to respond to calls for tender and to seek to work on public projects tends to grow with its size. “Fig 2” shows the involvement of companies in new constructions according to the firm size. These two elements seem to be linked and this was explained during the interviews by the fact that companies with a relatively high payroll need to identify and smooth their load, and also to fill their order backlog.

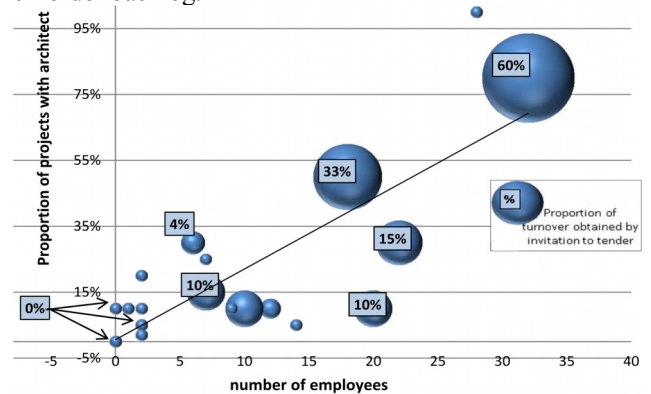


Fig. 1 Responding to calls for tender and proportion of projects with architects according to the number of employees.

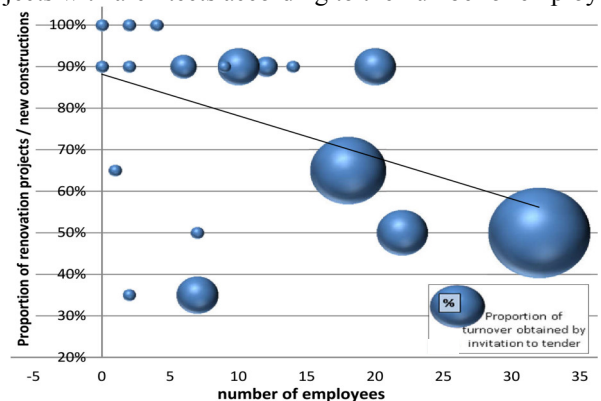


Fig. 2 Proportion of renovation and new construction according to the number of employees.

This is then made possible by new constructions, which require more advance planning, and also by invitation to tender (proportional to bubble size).

2) Technology, 3D and BIM knowledge

The aim of this survey is to understand, among other items, what BIM could provide and help to resolve. It is important to note that major difficulties include unexpected events and their consequences in terms of planning, workload and costs (56% of the answers), but also relationships, increasing workload and red tape year after year at once for 1/3 of those surveyed. During projects, partners use tablets in fewer than 6% of the cases and they are absent in 7 cases out of 10.

After the general principles of BIM were presented to participants (only 26% had previously heard of it at all), a third were not concerned by BIM. Time and money investments and complexity are fears raised and revealed by more than 50% of those surveyed. Almost 20% of the projects or interventions are carried out on sites where the company has already intervened. This point emphasizes the information and management capacities proposed by BIM. According to our interviews, changes have already taken place in the construction sector since 80% of orders are already made online (existence of some business software for visualization, order components via WEB portals and QR and barcodes scanning on Smartphone). Despite the fact that construction actors are attached to their benchmark and their working methodology, some expectations are still persistent and could be bridged by BIM and 3D. It is possible to mention, for example, the improvement of exchanges and interoperability, or reducing conflicts for 26% of the participants, and better apprehension, visualization and anticipation of difficulties by 44%. Finally, this could facilitate an understanding and decision-making on the part of customers, 57%.

Unfortunately, the path is still long, since 65% of renovation projects are done without 3D and in more than 8 times out of 10, 3D is used for fewer than 10% of the projects. 3D models are read via acrobat viewer, only one person uses Autodesk AUTOCAD. In other rare cases, 3D uses correspond to visualization via computer-aided manufacturing software (for manufacturers) or reseller applications (kitchen specialists).

B. Group B

GrB is composed of a construction economist, two members of design office (one digitization specialist for deconstruction, and one thermal), 5 architectural firms ranging in size from 1 to 6 people, a sales rep in custom joinery, the chairman of a company of 25 geometrician experts and a project manager in a BFC Social Landlords, which rehabilitate 800 housing units per year (<http://www.opacsaooneetloire.fr>). There are therefore 8 μ Ent, 1SmEnt and 2SMEs, which allows for an extension of the field of analysis. The panel respects the scope, since for 90% of businesses, more than 50% of their activity is in renovation. Fairly logically, half of the activity of this group is realized through tenders and are subject to the MOP law. Difficulties encountered are contingencies in 63% of cases, but the latter was said to be reduced by scanning after minor demolitions. Relationships with clients and employees

are other noted challenges (36%), particularly in occupied sites, and finally, technology and administrative (27%), especially for requesting and obtaining planning permission in classified areas. There are stronger relationships between these actors and the geometrician experts that intervene in 3 projects out of 10 for topographical surveys and two times less often for internal surveys. 91% of this panel is equipped with 2D and 3D software. 3D is used in 53% of renovation projects. The strengths of this approach (with the same response rate of 36%) are the reduction of conflicts, the possibility of storing and visualizing more information, assistance for client appropriation and a better understanding of the difficulties. Realistic renderings are also appreciated for insertions built in the landscape, an obligatory stage for obtaining permission.

Due to the specific nature of the professions combined with a "higher level" of studies (high school diploma plus 2 years for 90% of GrB versus a maximum of high school diploma level for 60% of GrA), GrB members logically have fewer difficulties in projecting themselves in BIM, as far as is known for 72% of them. Only one representative of this group works in BIM. Autodesk REVIT and Abvent ARCHICAD are present in 45% of companies, but only to be able to open files. Except for the digitization and demolition specialist, no collaborative work is set up even for the social landlords that realize more than 1000 interventions each year, of which 75% are in renovation. There is a growing awareness and it is possible to point out that the people interviewed feel that their working methods are about to change (more than 5 cases out of 10). They expect BIM to be able to improve interoperability (72%) and reduce conflicts by facilitating anticipation (45%). This point will also be important for future works because these kinds of actors are essential links in the transformation of working methodologies of the renovation profession as a whole. They are likely to be pioneering or privileged users of the digital model. They will certainly take the lead on BIM procedures or conventions in effect on projects. This awareness and this will to evolve is therefore a plus on which we can rely in the future. Lastly, profitability and sharing of investments are the main concern for 72% of GrB. All architects highlight that the additional time and fees for them must be taken in consideration if they have to play the role of BIM Manager.

C. Fundamental contrasts

To conclude this analysis, exposing some remarkable results, "Fig 3" shows few differences found (Proportion of positive responses) within the two groups that impact the companies' capacities and investment needs. A third of GrA do not feel concerned with BIM and changing in the near future. It is, however, interesting to contrast this feeling with a recent survey [29] showing that only about a third of owners judged that craftsmen were well coordinated, according to 1500 people interviewed after renovation works. It is important to add that current and future constructions built with BIM will one day need to be renovated, or that whatever happens, new business start-ups are emerging with BIM. They are logically less conservative and will not have to implement BIM since they are innate users.

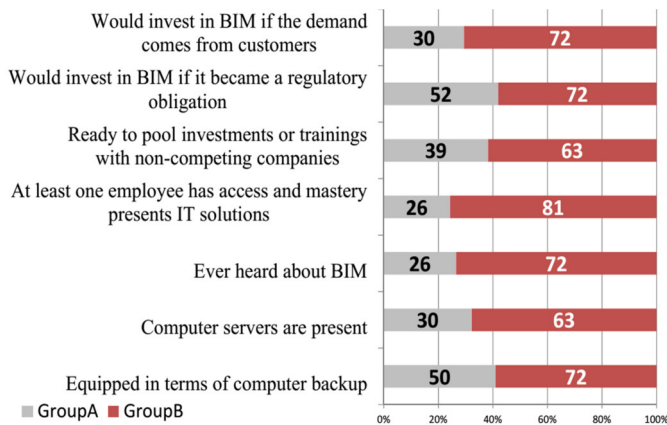


Fig. 3 Fundamental contrasts

These competitors, this latter point, and several difficulties and issues revealed in the survey, are sufficient to justify that changes are coming.

Data collected during the interviews corroborate well with recent studies, highlighting the persistence of a traditional 2D paper-based in AEC [30]. This is often explained by the history and organization of the profession itself. It was therefore necessary to organize exchanges, interviews and observation of the current practices. This has allowed for a better understanding of “*new insights into how to make the transition easier and more functional*”. In conclusion, the following section presents how this is planned to work in the future, what will be our core target group, and subsequently explains why the creation of a BIM maturity framework adapted to the sector seems to be relevant.

V. Lessons learned and implications for future works

In preliminary works, the authors had planned to carry out this survey [7] “*to gain a better overview of relevant renovation processes and actors...to establish a maturity measurement tool for the renovation sector as flexible as possible to fit to the majority of scenarios observed in the field.*”. The present study confirms that the task will be significant, alongside AEC professionals, to deploy BIM and a fortiori in companies performing renovation. Both computing and organizational means have to be provided to achieve this goal. This survey clearly reinforces recent studies carried out with 400 SmEnt that point out that only 1% of them actually have a BIM approach [13]. The current study has attempted to bring a description, as accurate as possible, of the French companies that realize the bulk of the repair and renovation projects of buildings. Presently, it seems complicated, as a first step, to respond and contribute to the transformation of all of the business models encountered in the field. As indicated in Part IV, some professions (GrB) are more ready to invest and more aware of this urgency and the opportunities that BIM can provide. The imminent decision of the French government to impose a certain level of BIM during tenders, the emergence of digital models in new constructions coupled with interviews and analysis of figures 1 and 2, lead to a conclusion that companies with fewer than 5 employees may be considered only in exceptional cases, and without high priority, in future works. Priority targets for future development are also the ones that will be most quickly impacted by BIM and are firms with the following features:

- Between 5 and 50 employees
- Making (but not exclusively) renovation work
- Taking part in few public procurement procedures
- In contact with the professions targeted by GrB.

Thanks to this survey, their workflows, the means at their disposal, exchange and communication vectors that are usually set up, the “concrete” needs and challenges they face, and more, are now characterized. The specificities of this sector, as well as some habits or state of mind differences have emerged and appear to depend on the membership of GrA or GrB, but also depend on the activity; whether they are a layer and/or manufacturer. Although only partially presented before, some professions are evolving and the emergence of new skills or requirements, such as property or facility management, house automation, etc., were addressed during the interviews and will be taken into consideration in models to be constructed. SmEnt have to be supported during their evolution. For this, it still seems appropriate to establish a maturity measurement tool and associated metrics for the renovation sector [7]. In full agreement with other works, these developments should help adopt a *collaborative mindset contributes towards some of the aims of BIM* [31]. To enhance this, some collaborative models discussed and implemented by audited companies (but not presented here) would be in-depth and at the heart of the reflection. Many BIM maturity matrices already presented [32] [33], will be analyzed in greater detail, but other authors [16] share this sense of a lack of an adapted tool, and highlight that for a BIM novice (or BIM infant) SMEs, *using an inappropriate BIM assessment & adoption strategy might result into waste of valuable time & resources*. So as not to overthrow the codes and uses of the companies encountered and lead to an evolution within this matrix, the mapping and the processes identified here will be a skeleton of the future maturity measurement tools designed. To increase the strength of these tools, we will also synthesize and take into account key factors of the success of Implementations of BIM and ERP in SMEs, as well as process and methodology advised in BIM conventions.

Our ambition is to contribute to progress from an equivalent of the level 0 defined in the UK, highlighted in [15], and widely encountered among the 34 companies surveyed, to a specific French renovation sector at Level 3, corresponding more precisely to the industry 4.0 that was initially presented. The number of steps and the levers to achieve this remain to be defined and will be subsequently submitted.

References

- [1] H. Kagermann, W.-D. Lukas, & W. Wahlster, “Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution” *VDI Nachrichten*, vol.13, 2011.
- [2] H. Kagermann, J. Helbig, A. Hellinger, and W. Wahlster, Recommendations for Implementing the strategic initiative INDUSTRIE 4.0. Forschungsunion, 2013.
- [3] P. Gerbert, S. Castagnino, C. Rothballer, A. Renz, and R. Filitz, “The Transformative Power of Building Information Modeling,” *bcgperspectives.com*, accessed Mar. 1. 2017.

- [4] McKinsey, “Accélérer la mutation numérique des entreprises : un gisement de croissance et de compétitivité pour la France,” mckinsey.com/, accessed Jun. 29. 2016. .
- [5] CAPEB, “artisanat du bâtiment Les chiffres clés 2015,” capeb.fr/chiffres-cles-segmentation-region-metiers-poids-et-evolution-secteur/, accessed Feb. 8. 2016. .
- [6] European commission, “Micro-, small- and medium-sized enterprises: definition and scope,” <http://eur-lex.europa.eu/eli/reco/2003/361/oj>, accessed Sep. 7. 2016.
- [7] L. Joblot, T. Paviot, D. Deneux, and S. Lamouri, “Analyse du BIM appliqué à la rénovation,” 11th International Conference on Modeling, Optimization and SIMulation (MOSIM 2016), Montréal, Canada, Aug. 2016.
- [8] ademe, “Bâtiment : chiffres clés 2013,” ademe.fr/sites/default/files/assets/documents/chiffres-cles-batiment-edition-2013-8123.pdf. .
- [9] M. Khaddaj and I. Srour, “Using BIM to Retrofit Existing Buildings,” *Procedia Eng.*, vol.145, pp.1526–1533, 2016.
- [10] Observatoire des métiers du BTP, “Chiffres clés des entreprises,” metiers-btp.fr/les-chiffres/les-entreprises.html, accessed Nov. 9. 2016. .
- [11] Office for National Statistics, “UKBC Enterprise/local units by Industry, Employment size band and Legal status,” <http://web.ons.gov.uk/>, accessed Mar. 8. 2017. .
- [12] National Federation of Builders, “building information modelling BIM: ready or not?,” http://builders.org.uk/eblock/services/resources.ashx/000/318/333/NFB_BIM_Survey_BIM-ready_or_not.pdf, accessed Jan. 3. 2017.
- [13] M. Giroud, “Baromètre des entreprises du bâtiment / KPMG,” home.kpmg.com/fr/fr/home/media/press-releases/2017/01/barometre-des-entreprises-du-batiment.html, accessed Mar. 1. 2017.
- [14] Experian, “UK Construction Forecast A report by the Forecasting Committee for the Construction Industries,” experian.co.uk/assets/economics/samples/uk-construction-forecast-sample.pdf, accessed Mar. 8. 2017.
- [15] R. Eadie, M. Browne, H. Odeyinka, C. McKeown, and S. McNiff, “A survey of current status of and perceived changes required for BIM adoption in the UK,” *Built Environ. Proj. Asset Manag.*, vol.5, no. 1, pp.4–21, 2015.
- [16] A. Ghaffarianhoseini, D. T. Doan, T. Zhang, A. Ghaffarianhoseini, N. Naismith, and J. Tookey, “A BIM Readiness & Implementation Strategy for SME Construction Companies in the UK,” Proc. of the 33rd CIB W78 Conference 2016, Oct. 31st – Nov. 2nd 2016, Brisbane, Australia.
- [17] T. Hartmann, H. van Meerveld, N. Vosseveld, and A. Adriaanse, “Aligning building information model tools and construction management methods,” *Autom. Constr.*, vol.22, pp.605–613, 2012.
- [18] B. Gledson, D. Henry, and P. Bleanch, “Does size matter? Experiences and perspectives of BIM implementation from large and SME construction contractors,” 1st UK Academic Conference on Building Information Management (BIM) 2012, Northumbria University, Newcastle upon Tyne, UK, Sep. 2012.
- [19] R. Miettinen and S. Paavola, “Beyond the BIM utopia: Approaches to the development and implementation of building information modeling,” *Autom. Constr.*, vol.43, pp.84–91, Jul. 2014.
- [20] R. Volk, J. Stengel, and F. Schultmann, “Building Information Modeling (BIM) for existing buildings — Literature review and future needs,” *Autom. Constr.*, vol.38, pp.109–127, Mar. 2014.
- [21] MIQCP, “La réforme de la commande publique de 2016 applicable à la commande de projets de construction : quelles évolutions pour choisir les concepteurs?,” miqcp.gouv.fr/, accessed Jan. 5. 2017. .
- [22] Ministère français de l’industrie, des postes et télécommunications et du commerce extérieur, “modalités techniques d’exécution des éléments de mission de maîtrise d’oeuvre confiés par des maîtres d’ouvrage publics à des prestataires de droit privé,” legifrance.gouv.fr/, accessed Feb. 5. 2016. .
- [23] CONSTRUCTIF, “Grands chiffres et figures - Le Bâtiment : regards, enjeux, défis,” constructif.fr/bibliotheque/, accessed Feb. 6. 2017
- [24] L. A. Goodman, “Snowball Sampling,” *Ann. Math. Stat.*, vol.32, no. 1, pp.148–170, 1961.
- [25] Insee, “Caractéristiques des établissements au 31/12/2014,” insee.fr/fr/statistiques/2021289, accessed Nov. 8. 2016. .
- [26] KYU Lab pour OPIIEC –, “Etude sur l’évolution de l’ingénierie française de la construction liée au BIM,” eduscol.education.fr/sti/sites/eduscol.education.fr/sti/files/ressources/techniques/8118/8118-la-synthese.pdf. .
- [27] H. Savall and V. Zardet, Recherche en Sciences de Gestion : Approche Qualimétrique, observer l’objet complexe. Economica, 2004.
- [28] F. Khosrowshahi & Y. Arayici, “Roadmap for implementation of BIM in the UK construction industry” *Eng. Constr. Archit. Mng.*, vol.19, no. 6, pp.610–635, 2012.
- [29] ademe, “OPEN : Observatoire permanent de l’amélioration énergétique du logement,” ademe.fr/open-observatoire-permanent-lamelioration-energetique-logement-campagne-2015, accessed Feb. 6. 2017. .
- [30] Cuš Babić and Danijel Rebolj, “Culture change in construction industry: from 2D toward BIM based construction,” itcon.org/cgi-bin/works/Show?2016_6, accessed Aug. 9. 2016. .
- [31] S. Mellon and T. Kouider, “SMEs and BIM in preparation for 2016: a case study,” Architectural Technology, Towards Innovative Professional Practice: Conference Proceedings of the 5th International Congress of Architectural Technology, Aberdeen 2014, 2014.
- [32] A. Copping, P. Shepherd, and A. Azzouz, “Emergence of Building Information Modelling Assessment Methods,” *Integr. Des. 50 Build. Our Future*, 2016.
- [33] B. Succar, W. Sher, and A. Williams, “Measuring BIM performance: Five metrics,” *Archit. Eng. Des. Manag.*, vol.8, no. 2, pp.120–142, May 2012.