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The trouble with learning from experience is that you never graduate.

Doug Larson

Sharing knowledge and BIM philosophy:

addressing most common criticalities of AEC Industry through an integrated platform for the stakeholders

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Preface

Proposal for an integrated BIM environment Platform as a vector to distress AEC sector most common criticalities

Abstract

The technological evolution that permeates from the top of the construction supply chain allows the introduction of technical innovations and the creation of new construction types; software updates, cyclical and punctual, have revolutionized technical design, one of these, BIM, has radically changed the user's approach to the flow of information, scrapping the age-old "paper and pencil" in favor of the new "database integrated".

The substantial advantage of this model lies in the shared management of information, which is accessible at any level, by anyone and at any time; this is because the graphical representation is now only the "user interface" of a set of elements which have – as in a real building – physical and technical properties and which function as part of a system.

This allows quick, precise and punctual consultation of each component in each phase of the life of a building - from conception to demolition - allowing, for example, perfect and immediate integration with facility management systems.

The adoption of this model by technicians is increasing; however, in order to take full advantage of the potential of this new work methodology, a further step is required: the application of the BIM workflow typology in the data flow that flows between the various stakeholders of the construction supply chain.

The availability of information is strictly linked to personal experience, both direct and matured, but it is strictly compartmentalized to the practical case in which it emerged and does not represent a quality, a property that can be modulated, parameterized and is therefore not reapplicable to a new case, remaining acquired information rather than useful information.

Therefore, for each building system taken into consideration, it is necessary to search the various data sources before being able to start

processing any developments, projects, estimates, etc....; past experience certainly helps us to have an idea of what will arise in the future, but an estimate, however reliable, remains so and must be supplemented by a continuous exchange of requests for information, with the possibility that of these are not in any case verified and/or corrected and that the duration of this process is in its turn indefinitely long.

The aim of this thesis is to understand how to solve some of the basic, and yet redundant, issues and criticalities that affect AEC sector and, to do so, it questions why:

- *Why not use the full potential of the technology?*
- *Why using obsolete models?*
- *Why not treasure every day's experience?*

In all cases the answer is always the same and it is the lack of an overview; having a guide available that shows us the shortest and safest route for our goal is, today as in the past, essential for achieving our project effectively and efficiently.

This is the objective behind the ideation of a UGC platform, integrated with PA, which allows the sharing of technical, economic and managerial know-how so that it can be used, consulted, integrated and assimilated.

Realize that everything connects to everything else.

LEONARDO DA VINCI

My experience

Most of the considerations and thoughts expressed in this thesis are personal and come from my journey as a studying worker, as I found to consider myself along the way writing this paper.

The first, and yet still on go, occupation was in a small architecture studio; it began as an internship for the bachelor degree and it has become my longest job so far. In the early days, as many internships I suppose, it wasn't much more than trying to convert the theoretical knowledge of school in concrete abilities and capabilities and sooner or later you'll get to understand that there's not much more than a method that has been taught to you; yes, you've been given many tools to comprehend and to be able to work, you've had a showcase of the job, but that, you realize, is only the method to work, and it is really what matters. At that point is easy to understand that you need to practice your method and it will give you the confidence to go on, ask questions and absorb the job making it yours.

Working in small studio gives the opportunity to see the work all around, so you're faced with all the phases – and faces – of the architectural job:

- *Clients and their needs*
- *public administration and regulations needs to be accomplished*
- *other professionals and consulting needs to project efficiently*
- *suppliers needs for specifications and specific conditions for their supplies*
- *constructors needs to be managed and guided*

At that moment, I personally realized that most part of the architecture job is to satisfy these needs and the ability to anticipate these needs is the what makes this job the most efficient.

So, it is during this time that I started questioning myself about procedures that didn't seem to be polished, tools that couldn't really give the results expected and many the many techniques that everybody was using in different ways to try to make the same result.

Sooner enough, I had the chance to have an experience in a big firm; it was UBI Banca, one of the major bank groups of Italy. Again, this started as a curricular stage and it lasted more than six months.

At that moment the bank was facing an interior style and design renovation for its branches, the job had therefore different tasks depending on the different stages:

1. *creation of the new layouts in compliance to the corporate's guidelines*
2. *approval and sharing of the layout within the different levels of stakeholders*

3. *programing the resources and defining the timetables for the sites*
4. *supervision and support of the construction sites*

From the beginning, there was something not properly working, that were the technical drawings stored in the bank's Real Estate Management Software: different regions, branches different origin banks and different employees had let to a very large differentiation of the plants, which made necessary a full pre-projecting phase of checking the correctness and standardization of the information.

Then, applying the corporate guidelines you eventually would find cases when it was impossible to implement those regulations:

- *heavy structural obstacles*
- *deeply diverse scenarios and (even urban) context*
- *incompatibility with the pre-existing layout and configuration*

Again, this process stopped the projecting phase many times for the local real estate management offices and the headquarters to understand each other's necessities not communicating directly, but only throughout Real Estate Direction.

Yet another stakeholder was not part of the communications, and it was the branch subject to the renovation since this was the last one to get the approval from and, in fact, it was not necessary as it was the involvement of the directors to ensure the best support from them. This is one of the first times I got to use properly and meaningfully some of the assertiveness skills[1] I learned so far: I understood that the best way to get them to like the project was to give them the opportunity to choose among two solutions, so that they would give their opinion on something that just an option and not a full blank answer. This powerful lesson showed me that is not the size of the work that affects its weight, is the way it has done; making double projects was much less time consuming that going back to make it again if the first time there were obstacles.

By the time all the 350 branches projects were deposit and almost fifty of them were completed, the stage was ended, although the teams involved in the tasks still needed some guidance; that is the moment I pursued the goal as the new project manager of the contractor. Knowing all the process and the guidelines for the most delicate stages was a key factor for my presence as once again it would have been really difficult for a new person to take this where I left without all the relative knowledge, especially considering that there were no clearly defined procedures, or instructions, ever written. So, I found myself directing all the tasks as I was before, simply in a new point of view: now the contractors needs were also mine, so

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[1] **Carnegie** D. (2014) *How to enjoy your life and your job.* | *How to win friends and influence people.*

I had to take them in consideration when organizing the schedules and I understood also many of the reasons sometimes task couldn't been accomplished by time they were scheduled. In many cases knowing issues that both parties had and let each other know would have led to a better schedule programming.

Anyway, by the end of the year the 350 branches project were completed with no big delays, and none occurred accidents, so this was probably the reasons why, one year later, I was asked to lead a new project in the same company.

Although this new project was similar to the previous in terms of strict corporate conditions, processes and results, it had some major differences in terms of context: UBI Banca has been incorporated to Intesa Sanpaolo Banca. This meant that we were to operate under two different corporates guidelines, each with a very different procedural scheme and operating hierarchy. Another major condition, perhaps the most vicious to consider, was the fact that at a certain point – a fixed and in anyway not delayable date – all the UBI systems were to be ready to switch to the new Intesa Sanpaolo's one, so all the furniture and equipment's had to switch to the new bank, remaining functional until the very last day of UBI existence to ensure the operation continuity and be able to perfume the remote upgrade.

The project, indeed, was a success, though it again had shown the flaws of a poor communication: most of the regional real estate offices had not properly receive the needed information to be able to perform correctly, causing many building managers to schedule wrong preliminary operations, un-matching site preparation or even disrupting the branch operativity.

The banks incorporation was sudden and the whole process took a little less than a year and this part of migration was the last to occur; the migration project was a two month end term, so it's pretty easy to understand way there wasn't much of a programming nor it was instructing to ensure the most standardized operational flow, though this were, in fact, the best reasons to have done it, especially giving the short time to the mandatory deadline and the very different contexts of the two firms.

As the project leader and manager and UBI Banca's main reference I putted most of my effort to ensure that both parties got to understood the meaning of the various operations and the different policies they were facing with; in a bank environment you have to keep in mind that there are so many different offices linked to each facility and each of them had to be aware of any change to the equipment's in any moment to avoid any fault and keep the business running, this means the sites are crowded with employees and customers and their safety is the most important aspect to consider when planning the activities. The safety regulations included dangers due to the site activities but mostly any threats that can come from outside: any operation that in any moment, in any way, involved

safes or a breach in the perimeter, had to be done under the presence of security surveillance.

Furthermore, part of the tasks was the physical upgrade of some ATM's, these were supplied by Sigma, an Italian firm based in the Marche region, with five sorting points spread throughout Italy. This was one of the main factors to be considered when planning the deliveries of the safes, since only one machine per day could be shipped by each of the five dispatching point and any of this point could deliver only within a certain radius. Every shipment could be accomplished only if any structural and plant predisposition required for the ATM was ready; this was the duty of several contractors, each one was dealing with different parts (wiring, structure, safety, etc....) and each of whom was different depending on the region we were operating.

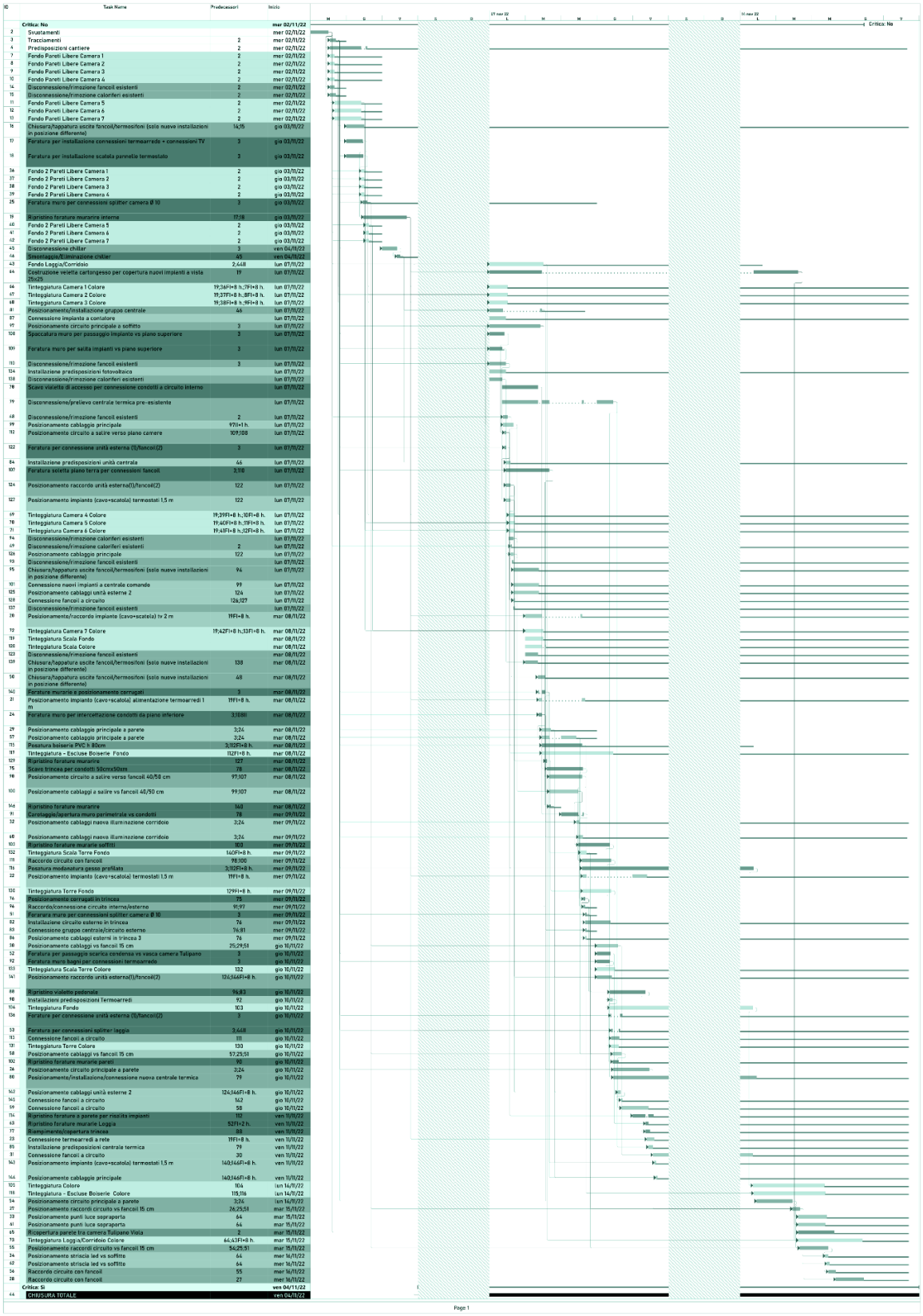
The size of the structure dealing with this project had a massive complexity: considering that for every one, of the almost one hundred branches included in the project, there were – at minimum – five to ten different teams to be engaged to perform the needed tasks, which had to be done in specific order and could not be overlapped or bypassed; when there was any failure, all the remaining tasks had to be rescheduled based on sites requirements but also individual firms availabilities.

In this case it was necessary to adopt a shared timetable, and perform a backwards planification, since the machine delivery was the crucial part of the project and it couldn't not depend much on the bank's needs as much as it depended on the production-shipment rates of the supplier; this meant fixing the deliveries of the ATMs before that site preparation tasks required for them, so that we could be sure to have enough days for every machine to be placed. Any other planification type would not have been feasible to reach the goal and complete the project as required.

Even one of my last projects required this backwards analysis as it was the restoration and renewal of a modest inn who had suffer from an early, and devasting, pipe's degradation: after only twenty years of work the heating and cooling water pipes had corroded, leading to a bad water leak.

When it was time to project the new conditioning system, a main factor had to be considered: as per day of closure, the amount of costs – in terms of active expenses and lost revenues of the inn – could be valuated to the sum of 4.000€. This meant that all the planning choices had to be made taking precise count of the time their realization would require, taking into consideration also the predispositions and later consolidation time requirements. So, after a confrontation with the thermo-technician and the plumber, and once the type of conditioning system was selected, all the different expertise were required to have brainstorm meeting to early discuss the best way to proceed, to reassure any doubts and anticipate every

hitch. So, after taking consideration of each's requirements I set the work breakdown structure for every construction site working team and planned the necessary resources needed, as I learned from my Construction Supply Chain and Project Management courses.



ID	Task Name	Predecessori	Inizio
	Critica: No		**mer 02/11/22**
2	Svuotamenti		mer 02/11/22
3	Tracciamenti	2	mer 02/11/22
4	Predisposizioni cantiere	2	mer 02/11/22
7	Fondo Pareti Libere Camera 1	2	mer 02/11/22
8	Fondo Pareti Libere Camera 2	2	mer 02/11/22
9	Fondo Pareti Libere Camera 3	2	mer 02/11/22
10	Fondo Pareti Libere Camera 4	2	mer 02/11/22
14	Disconnessione/rimozione fancoil esistenti	2	mer 02/11/22
15	Disconnessione/rimozione caloriferi esistenti	2	mer 02/11/22
11	Fondo Pareti Libere Camera 5	2	mer 02/11/22
12	Fondo Pareti Libere Camera 6	2	mer 02/11/22
13	Fondo Pareti Libere Camera 7	2	mer 02/11/22
16	Chiusura/tappatura uscite fancoil/termosifoni (solo nuove installazioni in posizione differente)	14;15	gio 03/11/22
17	Foratura per installazione connessioni termoarredo + connessioni TV	3	gio 03/11/22
18	Foratura per installazione scatola pannello termostato	3	gio 03/11/22
36	Fondo 2 Pareti Libere Camera 1	2	gio 03/11/22
37	Fondo 2 Pareti Libere Camera 2	2	gio 03/11/22
38	Fondo 2 Pareti Libere Camera 3	2	gio 03/11/22
39	Fondo 2 Pareti Libere Camera 4	2	gio 03/11/22
25	Foratura muro per connessioni splitter camera Ø 10	3	gio 03/11/22
19	Ripristino forature murarire interne	17;18	gio 03/11/22
40	Fondo 2 Pareti Libere Camera 5	2	gio 03/11/22
41	Fondo 2 Pareti Libere Camera 6	2	gio 03/11/22
42	Fondo 2 Pareti Libere Camera 7	2	gio 03/11/22
45	Disconnessione chiller	3	ven 04/11/22
46	Smontaggio/dismissione chiller	45	ven 04/11/22
43	Fondo Loggia/Corridoio	2;44B	lun 07/11/22
44	Costruzione velette cartongesso per copertura nuovi impianti a vista 70x20	19	lun 07/11/22
66	Tinteggiatura Camera 1 Colore	19;36FI+8 h.;7FI+8 h.	lun 07/11/22
67	Tinteggiatura Camera 2 Colore	19;37FI+8 h.;8FI+8 h.	lun 07/11/22
68	Tinteggiatura Camera 3 Colore	19;38FI+8 h.;9FI+8 h.	lun 07/11/22
81	Posizionamento/installazione gruppo centrale	46	lun 07/11/22
87	Connessione impianto a contatore	3	lun 07/11/22
97	Posizionamente circuito principale a soffitto	3	lun 07/11/22
108	Spaccatura muro per passaggio impianto vs piano superiore	3	lun 07/11/22
109	Foratura muro per salita impianti vs piano superiore	3	lun 07/11/22
110	Disconnessione/rimozione fancoil esistenti	3	lun 07/11/22
134	Installazione predisposizioni fotovoltaico		lun 07/11/22
138	Disconnessione/rimozione caloriferi esistenti		lun 07/11/22
78	Scavo viaiello di accesso per connessione condotti a circuito interno		lun 07/11/22
79	Disconnessione/prelievo centrale termica pre-esistente		lun 07/11/22
48	Disconnessione/rimozione fancoil esistenti	2	lun 07/11/22
99	Posizionamente cablaggio principale	97fi+1 h.	lun 07/11/22
112	Posizionamente circuito a salire verso piano camere	109;108	lun 07/11/22
122	Foratura per connessione unità esterna (1)/fancoil(2)	3	lun 07/11/22
84	Installazione predisposizioni unità centrale	46	lun 07/11/22
107	Foratura soletta piano terra per connessioni fancoil	3;110	lun 07/11/22
124	Posizionamente raccordo unità esterna(1)/fancoil(2)	122	lun 07/11/22
127	Posizionamento impianto (cavo+scatola) termostati 1,5 m	122	lun 07/11/22
69	Tinteggiatura Camera 4 Colore	19;39FI+8 h.;10FI+8 h.	lun 07/11/22
70	Tinteggiatura Camera 5 Colore	19;40FI+8 h.;11FI+8 h.	lun 07/11/22
71	Tinteggiatura Camera 6 Colore	19;41FI+8 h.;12FI+8 h.	lun 07/11/22
94	Disconnessione/rimozione caloriferi esistenti		lun 07/11/22
49	Disconnessione/rimozione caloriferi esistenti	2	lun 07/11/22
126	Posizionamente cablaggio principale	122	lun 07/11/22
93	Disconnessione/rimozione fancoil esistenti		lun 07/11/22
95	Chiusura/tappatura uscite fancoil/termosifoni (solo nuove installazioni in posizione differente)	94	lun 07/11/22
101	Connessione nuovi impianti a centrale comando	99	lun 07/11/22
125	Posizionamente cablaggi unità esterne 2	124	lun 07/11/22
128	Connessione fancoil a circuito	126;127	lun 07/11/22
137	Disconnessione/rimozione fancoil esistenti		lun 07/11/22
20	Posizionamento/raccordo impianto (cavo+scatola) tv 2 m	19FI+8 h.	mar 08/11/22
72	Tinteggiatura Camera 7 Colore	19;42FI+8 h.;13FI+8 h.	mar 08/11/22
119	Tinteggiatura Scala Fondo		mar 08/11/22
120	Tinteggiatura Scala Colore		mar 08/11/22
123	Disconnessione/rimozione fancoil esistenti		mar 08/11/22
139	Chiusura/tappatura uscite fancoil/termosifoni (solo nuove installazioni in posizione differente)	138	mar 08/11/22
50	Chiusura/tappatura uscite fancoil/termosifoni (solo nuove installazioni in posizione differente)	48	mar 08/11/22
142	Foratura muraria e posizionamento corrugati	3	mar 08/11/22
21	Posizionamento impianto (cavo+scatola) alimentazione termoarredi 1 m	19FI+8 h.	mar 08/11/22
24	Foratura muro per intercettazione condotti da piano inferiore	3;108B	mar 08/11/22
29	Posizionamente cablaggio principale a parete	3;24	mar 08/11/22
57	Posizionamento cablaggio principale a parete	3;24	mar 08/11/22
115	Posatura boiserie PVC h 80cm	3;102FI+8 h.	mar 08/11/22
117	Tinteggiatura - Escluse Boiserie Fondo	112FI+8 h.	mar 08/11/22
129	Ripristino forature murarire	127	mar 08/11/22
75	Scavo trincea per condotti 50lrcx50cm	78	mar 08/11/22
98	Posizionamente circuito a salire verso fancoil 40/50 cm	97;107	mar 08/11/22
100	Posizionamente cablaggi a salire vs fancoil 40/50 cm	99;107	mar 08/11/22
144	Ripristino forature murarire	143	mar 08/11/22
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52	Posizionamente cablaggi nuova illuminazione corridoio	3;24	mer 09/11/22
60	Posizionamente cablaggi nuova illuminazione corridoio	3;24	mer 09/11/22
103	Ripristino forature murarie soffitti	102	mer 09/11/22
132	Tinteggiatura Scala Terre Fondo	140FI+8 h.	mer 09/11/22
118	Raccordo circuito con fancoil	98;100	mer 09/11/22
116	Posatura modanatura gesso profilato	3;102FI+8 h.	mer 09/11/22
22	Posizionamento impianto (cavo+scatola) termostati 1,5 m	19FI+8 h.	mer 09/11/22
130	Tinteggiatura Terre Fondo	129FI+8 h.	mer 09/11/22
76	Posizionamente corrugati in trincea	75	mer 09/11/22
96	Raccordo/connessione circuito interno/esterno	91;97	mer 09/11/22
31	Foratura muro per connessioni splitter camera Ø 10	3	mer 09/11/22
82	Installazione circuito esterno in trincea	76	mer 09/11/22
83	Connessione gruppo centrale/circuito esterno	76;81	mer 09/11/22
86	Posizionamente cablaggi esterni in trincea 3	76	mer 09/11/22
58	Posizionamente cablaggi vs fancoil 15 cm	25;29;51	gio 10/11/22
32	Foratura per passaggio scarica condensa vs vasca camere Tulipano	3	gio 10/11/22
92	Foratura muro bagni per connessioni termoarredo	3	gio 10/11/22
133	Tinteggiatura Scala Terre Colore	132	gio 10/11/22
141	Posizionamente raccordo unità esterna(1)/fancoil(2)	124;144FI+8 h.	gio 10/11/22
88	Ripristino valvella pedonale	94;83	gio 10/11/22
90	Installazioni predisposizioni Termoarredi	92	gio 10/11/22
104	Tinteggiatura Fondo	103	gio 10/11/22
136	Foratura per connessione unità esterna (1)/fancoil(2)	3	gio 10/11/22
53	Foratura per connessioni splitter loggia	3;44B	gio 10/11/22
113	Connessione fancoil a circuito	111	gio 10/11/22
131	Tinteggiatura Terre Colore	130	gio 10/11/22
59	Posizionamente cablaggi vs fancoil 15 cm	57;25;51	gio 10/11/22
102	Ripristino forature murarie pareti	90	gio 10/11/22
26	Posizionamente circuito principale a parete	3;24	gio 10/11/22
80	Posizionamento/installazione/connessione nuova centrale termica	79	gio 10/11/22
140	Posizionamente cablaggi unità esterne 2	124;144FI+8 h.	gio 10/11/22
145	Connessione fancoil a circuito	142	gio 10/11/22
61	Connessione fancoil a circuito	58	gio 10/11/22
114	Ripristino forature a parete per risalita impianti	113	ven 11/11/22
63	Ripristino forature murarie Loggia	52FI+2 h.	ven 11/11/22
77	Riempimento/copertura trincea	88	ven 11/11/22
23	Connessione termoarredi a rete	19FI+8 h.	ven 11/11/22
85	Installazione predisposizioni centrale termica	79	ven 11/11/22
31	Connessione fancoil a circuito	30	ven 11/11/22
143	Posizionamente impianto (cavo+scatola) termostati 1,5 m	140;146FI+8 h.	ven 11/11/22
144	Posizionamente cablaggio principale	140;146FI+8 h.	ven 11/11/22
105	Tinteggiatura Colore	104	lun 14/11/22
116	Tinteggiatura - Escluse Boiserie Colore	115;116	lun 14/11/22
34	Posizionamente circuito principale a parete	3;26	lun 14/11/22
27	Posizionamente raccordi circuito vs fancoil 15 cm	26;25;51	mar 15/11/22
33	Posizionamente punti luce sopraporta	64	mar 15/11/22
61	Posizionamento punti luce sopraporta	64	mar 15/11/22
65	Ricopertura parete tra carrera Tulipano Viola	2	mar 15/11/22
73	Tinteggiatura Loggia/Corridoio Colore	64;43FI+8 h.	mar 15/11/22
55	Posizionamente raccordi circuito vs fancoil 15 cm	54;25;51	mar 15/11/22
54	Posizionamente striscia led vs soffitte	64	mer 16/11/22
62	Posizionamente striscia led vs soffitte	64	mer 16/11/22
56	Raccordo circuito con fancoil	55	mer 16/11/22
28	Raccordo circuito con fancoil	27	mer 16/11/22
	Critica: Si		**ven 04/11/22**
44	CHIUSURA TOTALE		ven 04/11/22

Figure 1 Gant chart representing some the activities to be performed in the inn during November 2022 – Author's

The graph showed some expected information including the feasibility of the project within the two weeks deadline and, also some un-expected one, like the fact that would have been necessary to start with the painting job instead of leaving it, as usual, at last. Shortly before the beginning of the construction site I shared this graph to team leaders involved thinking this would have been a useful information; none of them really tried to read or understand it. Once again I saw the difficulty of the people in this field to embrace the change that comes with the technological upgrade.

This is one of my main concerns about our sector. During my whole short career, I often stepped in to mined fields of deep-rooted habits people who work repeatedly the same not continuously improving it, being hostile to the unknow, to the unpredictable, to tomorrow. I truly believe our experience, as individuals or as comunity, is all to us, but how much we would have advanced if we ever had stopped asking ourselves how to better?

Today, as my boss Mara finally calls me architect, after ten years of practice and all the wisdom she expressed me, I can see clearer than ever the value my professors gave me during the classrooms: I understood that that method is not only the way to work, but is the ability to see the world critically, questioning myself about it so that I can try to understand how things work, what are the meanings and the thought behind the forces that move people around me and, perhaps most importantly, how can I return something as my added value.

It is from this point that my analysis and thesis on our sector came; using the tools my academic experience had provided me, I wanted to give a solution to those everyday problems I found along the journey so far.

Experience is not what happens to you;

it's what you do with what happens to you.

ALDOUS HUXLEY

The idea – the method

In a world of continuous innovation and transformation seems strange to try to implement a standardized model pretending to solve the everyday issues that all the actors of AEC sector are facing; and yet all of us struggle on ordinary tasks such as preventing delays, anticipating obstacles, and most importantly keeping records of everyday updates, although we keep updating our technology.

In this world, where we are pushed to running, fast towards our goals, never-minding overtaking our competitors, maybe all we need is to take a break, team up and push on each other; maybe we need to understand better that the collective wellbeing is affecting us more than we think and that there's no success for the induvial unless there's a loss for the community.

In this spirit my idea is to imagine a collaborative platform where we all could give our value and be part of the sector success. Doesn't care if you are a technical or a professional, public administration or supplier, every information that could be gathered will come to its importance today, tomorrow, or every day.

And yet, without yesterday's experience we wouldn't be able to make our way to the target. That's our everyday luggage we bring with us; that's perhaps the most important piece of information we hold. This is the fundamental information we all need to succeed, that's what we learn in schools, that's what we share, that's what makes the mankind technological progress.

Learning from yesterday's mistakes prevents future disasters, makes us experienced and ready for our future tasks.

It is not tomorrow achievements that says who we are, is the mistakes we faced on our way.

Experience is simply the name we give our mistakes.

OSCAR WILDE

As for BIM, my personal approach was during the 2nd year architectural design lab course, looking for a tool that would help me give more details of what I was capable of. It's been ten years, so fast. I have found that BIM, or Building Information Model(ing), can help improve the planning, design and execution of building projects by providing a digital representation of a building that includes both graphical and non-graphical information, which can facilitate communication and collaboration between team members and enable more efficient and accurate project planning. As a tool, BIM refers to the use of software to create a digital representation of a building that includes both graphical and non-graphical information, such as the technical and physical properties of building components. As a methodology, BIM refers to the use of this tool and associated processes and workflows to facilitate communication and collaboration among team members, improve project planning and execution, and optimize the overall performance of a building.

In this context, BIM can be seen as a holistic approach to planning, design, construction and management of a building which involves the use of digital tools and processes to manage and integrate information throughout the entire lifecycle of a project . It is a collaborative approach that involves all stakeholders in the construction supply chain, including architects, engineers, contractors, project managers, building owners and building regulators.

Figure 2 BIM and LEAN principles intertwining. Author's collage.

When you read a book, is its formal shape which you are interested in, or is it the story that it tells among its pages?

BIM is often concepted as 3D model who has been given some – real world's – information; this is very reductive, considering that:

1. all the added information aren't quite part or useful to the virtual model
2. all the added datasets are the major difference with CAD

Therefor this should mean that, before being a virtual model, BIM is a matrix of real life/world qualities and properties, defining individual components that are combined to generate a building system which is virtualized by a 3D model.

This conceptualization is necessary to understand the meaning of BIM as an approach, more than a tool: tearing the building apart in small components, which have individual identity and ability to conglomerate and cooperate as a whole, single system, is the key factor to consider about this thesis.

Parametric Objects

As it's precisely defined in the following lines, taken from the book *BIM Handbook - A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors (chapter 2.1.4, page 35),* BIM most critical foundations are its parametric capabilities:

The concept of parametric objects is central to understanding BIM and its differentiation from traditional 2D objects. Parametric BIM objects are defined as follows:

- *consist of geometric definitions and associated data and rules.*
- *geometry is integrated non-redundantly and allows for no inconsistencies. When an object is shown in 3D, the shape cannot be represented internally redundantly, for example as multiple 2D views. A plan and elevation of a given object must always be consistent. Dimensions can-not be 'fudged'.*
- *Parametric rules for objects automatically modify associated geometries when inserted into a building model or when changes are made to associated objects. For example, a door will fit automatically into a wall, a light switch will automatically locate next to the proper side of the door, a wall will automatically resize itself to automatically butt to a ceiling or roof, etc.*

- *Objects can be defined at different levels of aggregation, so we can define a wall as well as its related components. Objects can be defined and managed at any number of hierarchy levels. For example, if the weight of a wall subcomponent changes, the weight of the wall should also change.*
- *Objects rules can identify when a particular change violates object feasibility regarding size, manufacturability, etc.*
- *objects have the ability to link to or receive, broadcast or export sets of attributes, e.g., structural materials, acoustic data, energy data, etc. to other applications and models.*[2]

And later on, in *chapter 2.1.4 User-Defined Parametric Objects*

While each BIM design tool has a growing set of pre-defined parametric object families (see Table 2-1), these are complete only for the most standard types of construction. They are incomplete in two ways:

- *Their built-in assumptions about design behavior for the pre-defined object families are normative and do not address some special cases encountered in real world contexts.*
- *The base object families include the most commonly encountered ones but omit those needed in many special types of construction and building types.*

Another perspective is that the base object families in a BIM design tool represent standard practice, as does Ramsey and Sleeper's Architectural Graphic Standards (Ramsey et al. 2000).

While standard practice reflects industry conventions, best practice reflects the adjustments to details, the experience a designer or firm has acquired with respect to how elements are to be detailed. Best practices distinguish the quality of design offered by most successful design practices.

That is, the predefined objects that come with a BIM design tool capture design conventions rather than expertise. Any firm that considers itself BIM-capable should have the ability to define its own libraries of custom parametric object families. All BIM model generation tools support the definition of custom object families. If a needed parametric object family does not exist in the BIM tool, the design and engineering team has the option of either laying out the object instance using fixed B-rep or CSG geometry and remembering to update these details manually or alternatively defining a new parametric object family that incorporates the appropriate design rules and automatic updating behaviors. This

[2] (Rafael Sacks, 2008)

embedded knowledge captures, for example, how to frame a particular style of stairway, how to detail the joining of different materials like steel and concrete or synthetic stucco and aluminum extrusions. These objects, once created, can be used in any project in which they are embedded. Clearly, the definition of details is an industry-wide undertaking that defines standard construction practices and a firm-level activity that captures best practice. Detailing is what academics such as Kenneth Frampton have referred to as the tectonics of construction (Frampton et al. 1996). It is an essential aspect of the art and craft of architecture.[3]

Standard models of detailed objects

The next step of BIM methodology should be the definition of real-life aspects, that have not been settled yet, and those must be user defined in order to have a "standard model of a detailed object". To achieve this object, every type of element needs to be further described by singular combinations of new properties, which would be logically and dependently intertwined between them and the existing ones; these connections would not be limited to the singular element but every family – as these are commonly referred – could have attachable properties to other ones via shared properties, rules and functionalities.

In this way everyday items – and even tasks – can be synthetized and described by a series of properties such as qualities, context, operations, functionalities, etc. ., part of whom would be used in the BIM tool itself, some would help data analysis or serve as best practices, some would be useful in the future maintenance process and some will provide operational guidance.

In case of a pavement, for instance, those can be:

- Qualities | *how it is done?*
    - Size, type, state, age, conditions, etc....
    - weight, load capacity, transmittance, etc....
    - Materials, composition, construction technique, etc....
    - Etc....
- Context | *which are the conditions?*
    - Building, floor, room, etc....
    - Country, Region, County, etc....
    - Type of building, function, etc....
    - Etc....

[3] (Rafael Sacks, 2008)

- Operations | *what can be done?*
    - Build, fix, restore, etc....
    - Reinforce, check status, sample, etc....
    - Etc....
- Functionalities | *what has to do?*
    - Hold up particular loads
    - Provide required characteristics (hygiene, friction, washabilty, etc....)
    - Durability
    - Etc....

Standard operations

From this point is necessary to make a little step back to see our model from a different perspective; till now, the correlations were between objects but the abstract the idea of connections among datasets doesn't necessarily require the families to be object; any task, in fact, can be defined in the same way as objects are: a dataset of instructions. Thus, procedures, as sets of activities, simply become a list of instructions, legislations are list of laws, teams' group of people and so on, and these are all linked together in various different ways, for instance:

- Regulations dictate aspects of operations and tasks people have to perform
- The function of the construction requires precise techniques achievable by specific materials
- The condition of a building is given by its maintenance, type, age, constructive solution, etc....
- Etc.

So, considering the case of the pavement, as before, its construction task can be synthetized as following:

- Qualities | *how it is done?*
    - Type of construction
    - Number of workers
    - Experience of workers
    - Quantity built per hour
    - Cost per hour
    - Etc....
- Context | *which are the conditions?*
    - Country, Region, County, etc....

    - Type of building, function, etc....
    - Required skills, SLA, KPI, UNI, Regulatory, etc....
    - Etc....
- Operations | *what can be done?*
    - Assimilate the work
    - Adopt the right technique
    - Manage resources to match time/cost requirements
    - Produce with the requested characteristics
    - Provide required documentation
- Functionalities | *what has to do?*
    - Comply the relative UNI standards
    - Fulfil safety regulations
    - Meet Sustainability standards
    - Etc....

Best Practices, models, techniques and operators

At this point, the vision of this thesis – and platform – should be clear: simplify the CSC's elements, operations and people into parametric families, cataloging them and create the most real, precise and manageable source of wisdom, a continuously updated library of AEC world.

The platform created this way could have endless possibilities in terms of helpful and practical applications for design, management, communication and data storage and this all will lead up to huge opportunities for researches and data analysis as the platforms evolves everyday as the sector technology does, in fact, as we do.

This platform has the ability to change how the people of this sector are making choices, not by influencing them, but providing them a large amount of real-life cases scenario: a wide range of sector workers experience and expertise and, mostly, identifying the best practices that has proven their worth with empirical precision.

As day passes, the platform would gather new information on future projects, on on-going tasks and updates of existing systems and as the data analytics elaborates those information the platform would show which has been the best solutions adopted so far, which are the current trends and what are most promising technologies in development.

So, as a team develop a project through the platform, they would be able to find the most suitable solution for the context and conditions they are dealing with, but also its best technological realization and the best way to perform it, technically and in

terms of time-cost; and this is true for professionals, constructors, suppliers, consulting firms and even for civils.

This, covered so far, are some of the advantages of the platform, the ones more connected to the scientific progress of AEC sector, meanwhile, on the basis of the data collected, various applications will significantly improve the quality of work as a process and as a product. Many everyday operations of each segment of this industry could be fastened and facilitated, in such manner, the tool used to perform the job provides and shares knowledge and vice versa as two beautiful collateral effects.

The more the platform is used to ease the work, the more it becomes significant; the more it's consulted, the more it will better the standard practice.

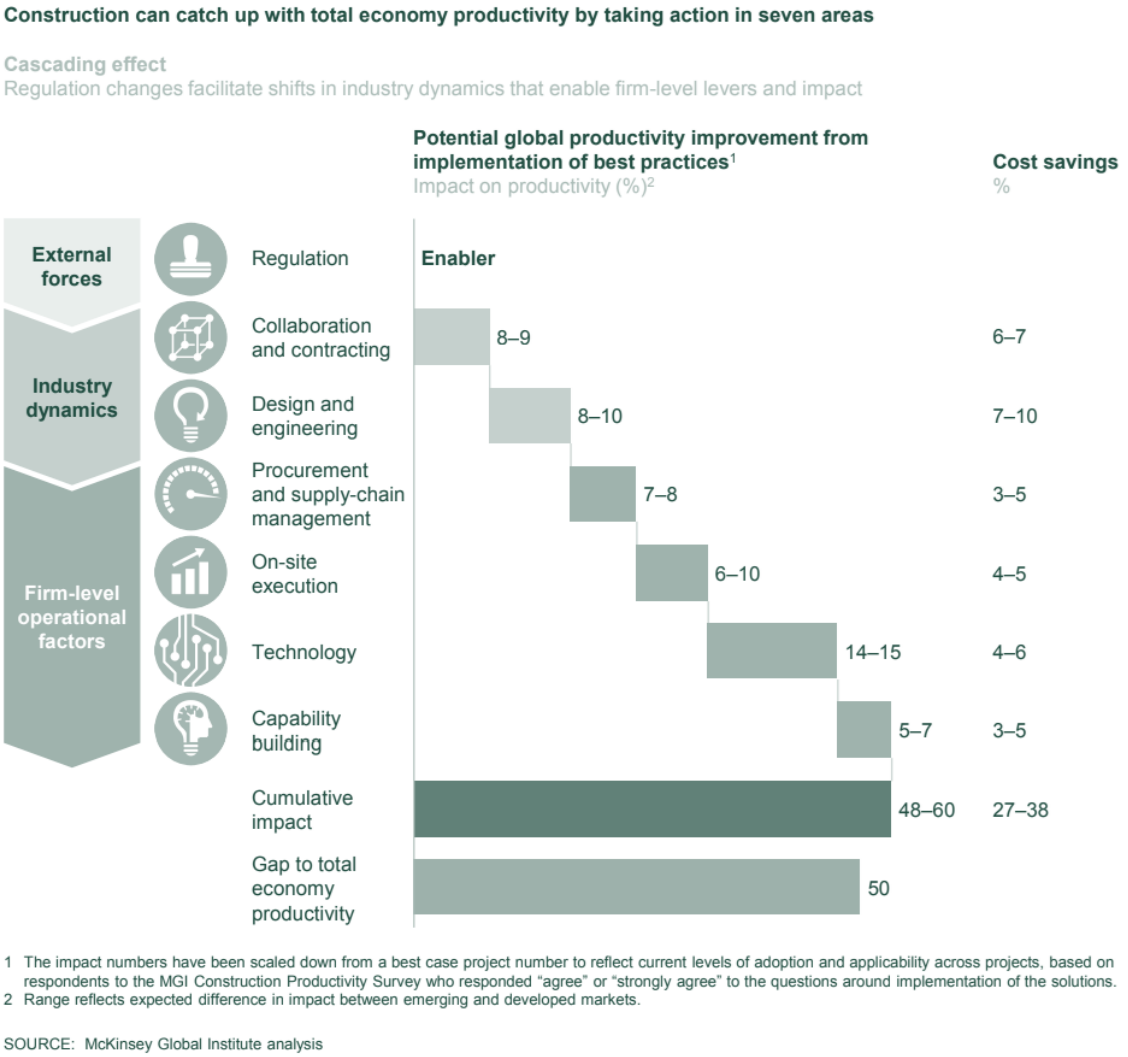

Figure 3 Figure 8 McKinsey's research potential improvement for the construction industry outcomes – (MGI 2017)

So, to summarize, applying BIM as a tool can pass through different steps:

- Using BIM software to create a digital representation of the building that includes both graphical and non-graphical information, such as technical and physical properties of building components. This step can help to facilitate communication and collaboration among team members and allow for more efficient and accurate project planning.
- Use BIM workflows and processes to manage and integrate information throughout the lifecycle of the project to track progress, schedule work, assign tasks, and manage budgets.
- Use BIM to optimize the overall performance of the building analyzing and comparing different design options, identifying potential issues or risks, and making data-driven decisions about materials and systems.
- Use BIM to facilitate collaboration with regulators and other stakeholders, sharing project data and documents via BIM format to ensure compliance with regulations and standards.

While, adopting BIM as a methodology consists in the creation of an environment where elements are shrinked to their simplest form so that they could be parametrized allowing for them to be used as an existing model that is adaptable to the specific requirements of each project as well as quarriable to perform calculations and surveys. Till now, the industry has managed to create these models only on the material side of the supply chain, whereas the idea of the thesis is to enlarge the current library of models to the procedures and people who perform on the Construction Industry. This new data center, will provide knowledge as records of the experiences, and the best practices inserted so far, providing tools and guidance to recreate remarkable results, to automate the processes providing functioning models that are usable, lowering the errors managing data since the information will be less and less hand inputted and more standardized and at the end allowing stakeholders to collaborate freely from many constraints to pursue the innovation and quality progress.

Success means using your knowledge and experience to satisfy yourself.

Significance means using your knowledge and experience to change the lives of others.

- BOB BUFORD

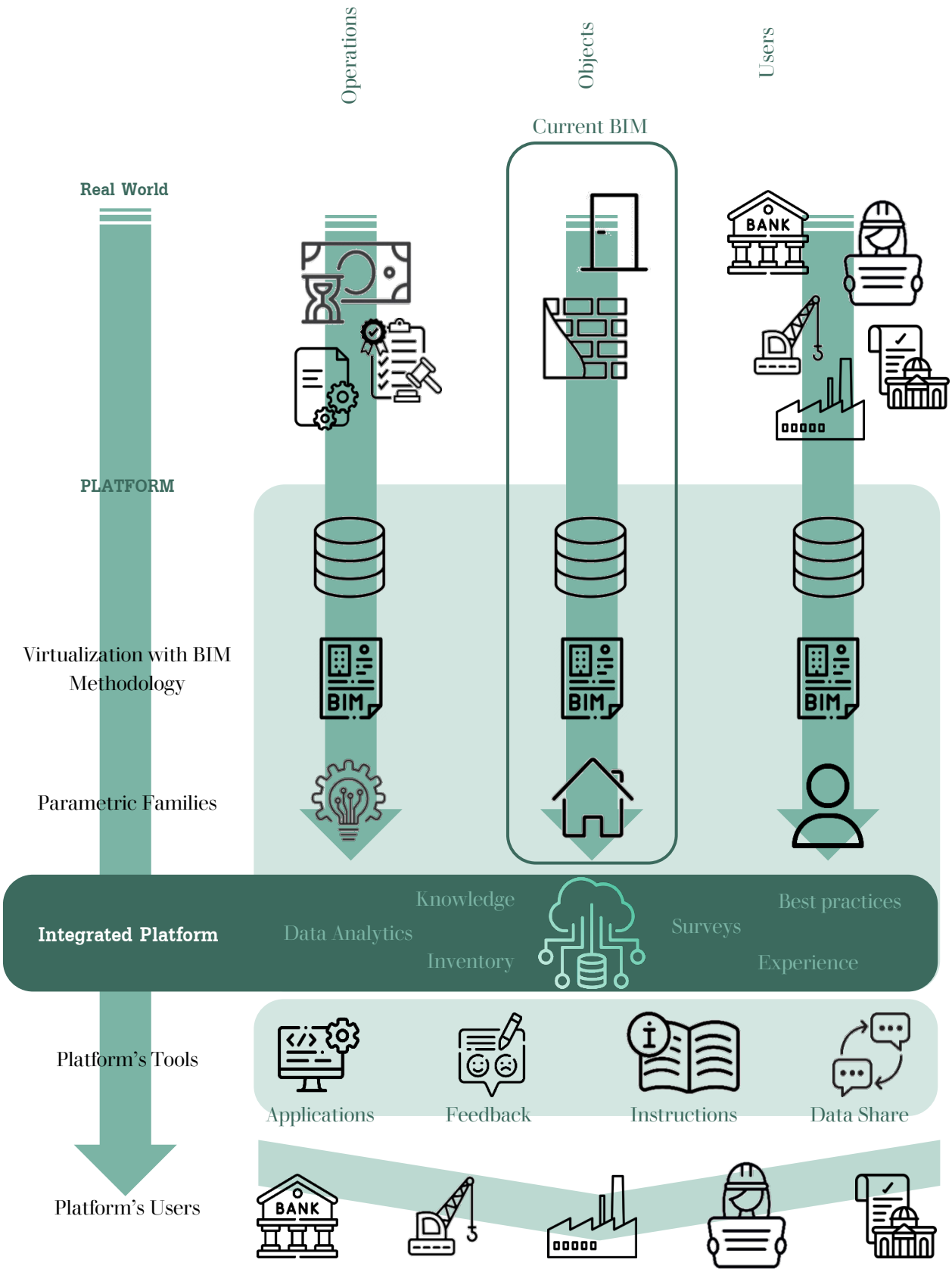

Figure 4 Enlargement of BIM concept on the side of procedures and people creating the BIM platform – Author's

The present model of project development

This thesis will cover some of the specific criticalities of the main parties involved in the Construction industry and to be able to do so, we have to firstly describe the system by its component members as well as the relationships that occur between them within the constraints of the sector environment. Therefore, among the forces that low construction productivity, we'll be able to differentiate the criticalities among the complexity of interactions, as the sectors most common problematics, from the issues that are embedded in the network, as the organism of the Construction Industry.

Heterogeneous stakeholders

Defining the Construction Industry firstly needs to define the main actors involved and a brief analysis of the process of conception, development and realization of construction project can immediately give us the first ideas on which to base the development of the platforms simply considering the vast number of subjects involved even in the smallest construction site:

- The public administration and regulatory bodies: starting with the international regulations that dictate the key principles of building regulations and then developing into increasingly restricted and specific territorialities and, farther, all bodies - provincial, regional, state and international – which regulate issues other than construction but whose scope of application extends to this; we have, for example, institutions for the safeguard of protected areas, bodies for hydro-geological safety, for fire prevention or health protection, etc.
- Lenders: banks and credit institutions, investment funds, foundations, and individuals; all the figures who undertake a building project, some as directly interested parties, others as third-party lenders. These are the party to whom the project is intended and the most interested in the accounting/time aspects and yet their contribution is limited to monetary resources and do not act on the project phases.
- Professionals: architects, engineers, surveyors and technicians; the cornerstone of the project is the bridge between the lenders and the public administration.
- Suppliers: this is the largest category, here we find suppliers of building materials, manufacturers of components and elements (windows, doors and windows, etc.).
- Consultants: specific sector of large constructions but increasingly present also at a capillary level; project managers, site managers, construction managers, etc. are included in this section.

- Contractors: firms, businesses and craftsmen who deal with the physical implementation of the project. Well, all these figures have a specific pattern of relationships, often intertwined, which involves a series of multi-stage exchanges of information, in each of which part of the information is lost to acquire new ones.

All these figures have a specific relationship schema, often intertwined, that involves a series of multi-step information exchanges, in each of which some information is lost in order to acquire new information, making it necessary to adopt strategies to ensure the effectiveness of the communications.

(Data) Workflow

The construction Let us analyze specifically the chain of exchanges in the design-construction of an office building, on behalf of an important company.

1. The client offers the architectural design contract to a renowned architectural firm.
2. The firm analyzes the relevant regulations and finds the characteristics that must be respected for obtaining the necessary authorizations to proceed.
3. A series of proposals is formulated so that the client can choose the one they prefer.
4. The design firm entrusts a third-party company with the realization of an estimate of costs and a timeframe.
5. The client proposes changes to the budget, which entail a remodeling of the project and of the necessary time for its realization.
6. The project is delivered to the client who initiates bids for the selection of the executing company.
7. The selected executing company, in turn, publishes the tender notices for the selection of the general contractor(s) and executive design firms.
8. The executing company initiates the planning of the project.
9. Upon obtaining the executive projects, the cost accounting begins.
10. The suppliers make and communicate their estimates.
11. The executing company shows the client the results of the various temporal planning and budget studies.
12. The client requests financing for the project.
13. The financiers analyze the project to give their approval.
14. Once the approval is obtained, the executive projects are shared with the various general contractors who prepare to start the construction site.

15. The procedure for requesting building/urban/landscape permits is initiated.
16. Upon obtaining the favorable opinion, the construction site is inaugurated.
17. A critical situation arises!
18. The site manager involves the works manager to find the most appropriate solution and agrees on the need to make changes to the project;
19. The executing company makes the necessary changes to the project and requests that the executive design firm update the executive projects;
20. The PM, Site Manager, and Construction Manager make changes to the planning;
21. The executive project requires a new approval, so the appropriate requests for variations are presented to the competent authorities;
22. Once all the consents are obtained, they are circulated;
23. The general contractor informs the suppliers of the changes that were not received, creating a delay in the supply;
24. The accumulated delay affects the project costs:
25. The executing company shares the information with the client.
26. The procedure for requesting additional funds to cover the extra costs is initiated.
27. To reduce the impact of the increases, slight modifications are made to the finishing and furnishing projects.
28. The modifications are shared with the suppliers who adjust their production.
29. All the work is completed.
30. The predetermined technicians carry out the attestations to obtain the realization certificates according to the standards.

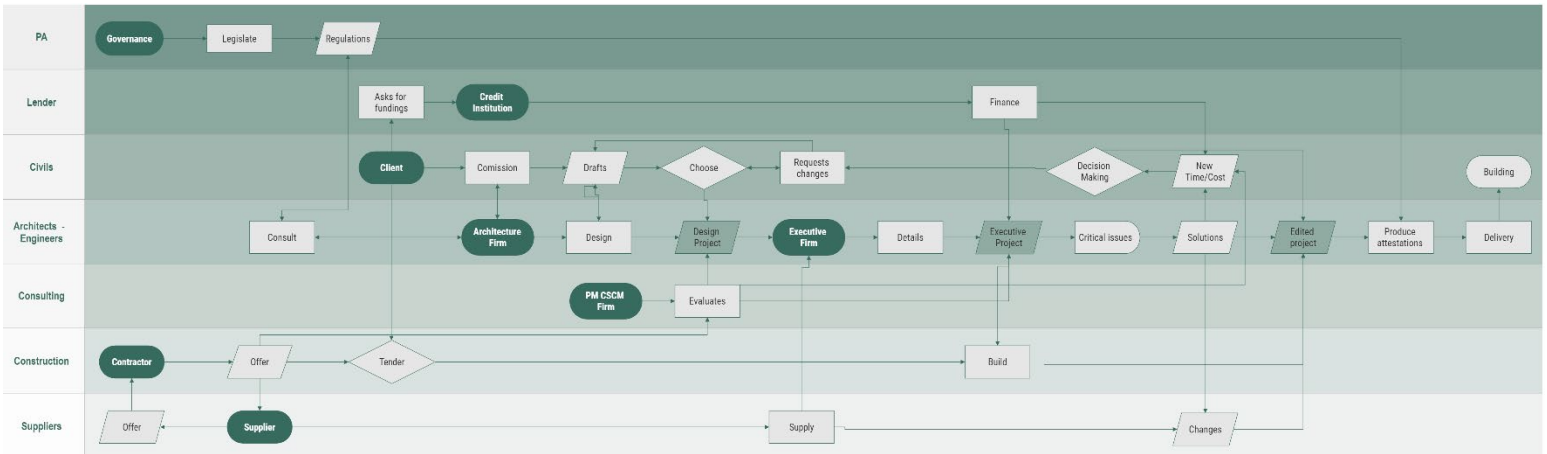

Figure 5 Workflow graph of the previous example showing the stakeholders involved and the different levels of data flows – Author's

As it can be seen shortly (in Figure 4), data is continuously bouncing among the different segments of the sector, in different directions, with multiple parallel flows directed to various stakeholders which often edit it, causing possible losses of information because they adapt it to their needs or because they don't share the changes with all the other stakeholders, which are proceeding parallelly on other levels. As mentioned in the paper *Analysis of effective project-based communication components within primary stakeholders in construction industry*[4], various factors are responsible for effective communication and the among these, experience is one of the most impactful.

Since the project management team is commonly responsible for applying effective techniques, tools, knowledge and skill to meet the project's requirements, lack of sufficient experience causes improper management of the project. In addition, project managers with insufficient experience would not be able to transfer data and information among the project's team members at the right time, consequently, the quality of internal communication within each of the three primary stakeholders decreases.[5]

Section	Description
Respondent Information	(1) Company's role for this project
	(2) Region of this project
	(3) Work experience
	(4) Position in this project
Project	(1) Project goal
Target	(2) Project scope
Stakeholder	(1) Project management team experience
Management	(2) Project management team size
	(3) Number of owners
	(4) Number of design/engineering entities
	(5) Number of contractors
Authority	(1) Impact of approvals
Level	
Legal	(1) Difficulty of approvals
Requirement	(2) Required total permits
	(3) Impact of external entities/agencies
Fiscal	(1) Clarity of funding process
Planning	(2) Project funding delay
Project	(1) Craft labor turnover
Resources	(2) Reuse of machinery resources
	(3) Specifications
	(4) Delay in delivery of resources
	(5) Labor quality issues
	(6) Material and machinery quality issues
	(7) Sources of resources
Design and Technology	(1) Familiarity with technologies
	(2) New systems tied into existing system
Location	(1) Off-site construction
	(2) Number of involved countries
	(3) Number of execution locations
	(4) Modularization
Communication	(1) Quality of communication within the organization

Table 2.
Descriptions of survey

Figure 6 List of factors impacting effective communication collected throughout scientific literature in the publication "Analysis of effective project-based communication components within primary stakeholders in construction industry" – (Safapour, Kermanshachi, Kermanshachi, Rad, & Tran, 2020)

The table (Figure 3) shows the subject of the survey described in the paper, in it, there are listed the aspects of a project development and execution that are most frequent

[4] (Safapour, Kermanshachi, Kermanshachi, Rad, & Tran, 2020)
[5] (Safapour, Kermanshachi, Kermanshachi, Rad, & Tran, 2020)

throughout the scientific literature; it is noticeable that many factors are not strictly related to the object of the communication nor are methods and methodologies.

In fact, in many cases is the number of actors and their experience that makes the difference between effective and un-effective communication.

Constraints environment

While some factors may be specific to a particular project or site and can arise during the construction process, there are constrains that are transversally spread through the industry and face all the different stakeholders indistinctly. These factors are due to the complexity of the system in within they operate, in fact they are results of the intricacy of the system itself, therefor they can be expressed as Construction Industry main constraints:

- Managing the large amounts of data and documentation that construction projects involve as a large amount of data and documentation, including design plans, specifications, cost estimates, and schedules are needed to develop and execute it. Managing and organizing this information is a main challenge, particularly when working with multiple stakeholders.
- Coordinating with the multiple stakeholders of the sector can be a complex and time-consuming task.
- Meeting deadlines and budgets is crucial to success. Delays and cost overruns can have serious consequences, including lost revenue, legal disputes, and reputational damage.
- Managing risks effectively, including accidents, natural disasters, and changes in market conditions, is critical to the success of a project.
- Ensuring quality and compliance is essential to its success. This may involve adhering to building codes and regulations, as well as working to maintain high standards of craftsmanship and quality.

Productivity lost opportunities

The factors mentioned so far, showed a complex system made of nonlinear procedures and flows of motley information among a vastly heterogeneously crowd of people without a standard model for the active and efficient cooperation as results of a poorly effective information share and a very fragmented data clustering.

The current model of project development is not just not efficient per se, but doesn't really encourage the creation of added value during the process since in not a model that stimulates the coordination and cooperation of the parties, besides the project execution needs for co-operation. Nor it helps the establishments of best practices or incentives the persecution of rising quality standards as a common objective for the industry instead of individual goal for the singular stakeholder.

Construction supply chains on larger projects typically involve hundreds of different companies supplying materials, components and a wide range of construction services (Dainty et al., 2001). A continued reliance on a fragmented and largely subcontracted workforce has arguably increased the complexity of this supply network and delimited opportunities for process integration. [...]

Despite the difficulties that the industry faces, it is essential that it develops its supply chain practices to deliver value to the client, rather than simply seek to generate short term cost savings (see Lockamy and Smith, 1997).[...]

Headings drawn from the coding system have been used to collate the key attributes deemed to be the most important for the successful integration of the construction supply chain [...]:

Managing communication

Establishing direct communication paths with both main contractors and second-tier subcontractors is critical to project success [...]

Mechanisms for problem resolution

Rapid action is required to minimize supply chain problems at an early stage [...]

Managing information flow

Where confidence is lacking in the working relationship between client and contractor, the exchange of information is often very poor [...]

Engineering added value in projects

We have a lot of specialized knowledge and, if we are involved early in a project, we can give the client much better value [...]

Alignment of supply chain systems

It is very important for an efficient supply chain that our main contractors and suppliers bring their management systems into line with ours [...]

Ensuring high quality standards

We are always looking to make quality improvements, but this can be expensive for a small organization, so we depend on our clients to initiate and fund most of these quality investments [...]

Establishing long-term supply chain relations

We are wary of entering into long-term contractual relationships with our contractors. Our previous experience of partnering with main contractors ended badly and we lost out financially [...]

Securing commitment to the client and the project objectives

Where we have been able to build a long-standing association with a particular client over a number of contracts, we develop a strong loyalty to that client and try to do a very good job on all their projects [6]

Failing these pointed objectives means, for the current model, failing to the assist every day's interactions between the different parties and, most importantly, causing issues, delays, misalignments, misunderstandings and ultimately income losses. And this is true to the individual stakeholder as it is cumulatively to the sector itself.

On the face of it, the construction industry is a growing and dynamic sector. Around $10 trillion a year is spent on the buildings, infrastructure, and industrial installations that are the backbone of the global economy, and that amount is projected to increase to $14 trillion in 2025. But the fact is that the industry loses a huge amount of value because of its low labor productivity, a shortcoming that has dogged the industry—whatever the location or stage of economic development—for decades. [...] The poor productivity performance of the construction sector is a missed opportunity to create value that we estimate at between $1.6 trillion and $2.3 trillion. We arrived at the $1.6 trillion figure by benchmarking construction against overall productivity in the economies that we have examined. [...] A new framework is needed—in essence, a project-operating system that takes into account the fact that project systems are both technical and social, and oriented around managing variability and flow efficiency. Critical elements of the next-generation capital-operating system are technical, managerial, and behavioral elements that are interconnected and linked (Exhibit 38): [7]

[6] (Briscoe & Dainty, 2005)
[7] (McKinsey, 2017)

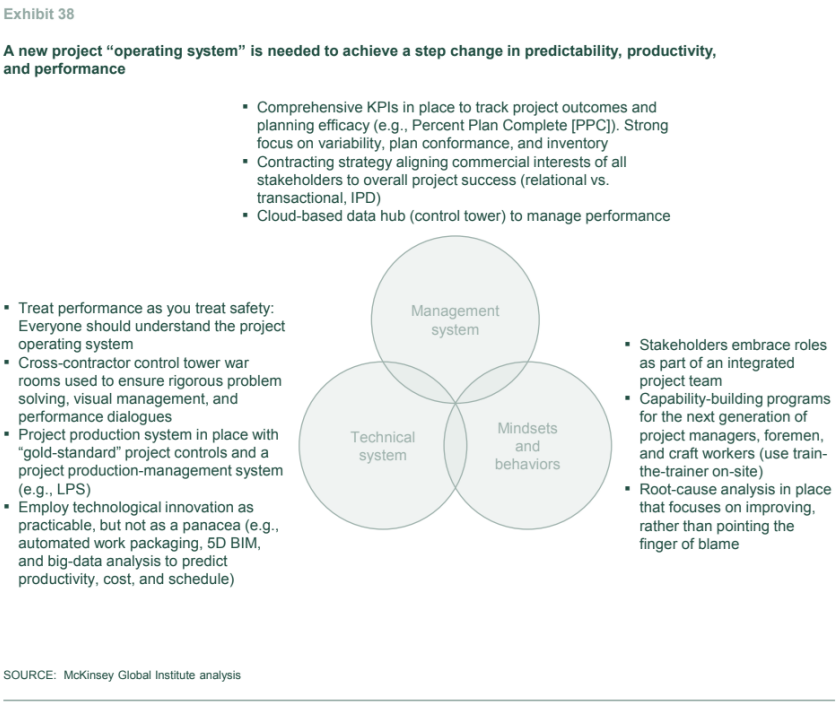

Figure 7 Main fields of interest and action of for a project operating system. (McKinsey, 2017)

Therefor we can assume that some changes bust be operated upon the management of the Construction Industry's organization and flows of information; for this purpose it's necessary to provide a system, that is both a tool and a method, for the vehiculation of processes and knowledge, increasing the collaboration and integration among the users as well as stimulating the pursuit of technological innovation and excellence.

A platform for the intricacies of CSC's data workflow

As covered so far, effective clear communication and shared knowledge are key factors to try to address many lags of the current model of project development.

Communication simply refers to the exchange of information and other resources such as ideas, knowledge, skills, and technology among team members and organizations (Cheng et al. 2001). As several entities, such as primary and secondary stakeholders, are generally involved in the execution of a construction project, extensive information exchanges among the members of a project are required. Dainty and Lingard (2006) explained that through the transmission and exchange of information and knowledge, communication may become distorted, resulting in misunderstandings, from which extra workloads, or even conflicts may arise. These issues cause schedule delays, cost overruns, and project failure.[8]

[8] (Safapour, Kermanshachi, Kermanshachi, Rad, & Tran, 2020)

As shown from the different papers, some common criticalities of the data workflow in the current global construction supply chain can be condensed as following:

- Subjectivity of information: as already established, the subjectivity of information allows the tampering or incorrect transposition of data at any stage of the process. This can result in a final product with different traits than the original ones.
- Differentiate data based on intended use: Information typically needs to be tailored for any stakeholder due to differing approaches from distinct stakeholders. As a result, combining the many data streams into one coherent project can be difficult.
- Parallel data flow: Many forms of information, such as project and planning data, may work simultaneously and are not sufficiently integrated. This could make middle-of-the-road people and the like lose sight of the overall picture.
- Process inefficiency: The continuous requests for resources and time can make the process inefficient. It can also be difficult to use pre-designed and tested models, which could standardize processes and reduce the margins of error.
- Untapped feedback sharing: Best practices learned by individual operators are only valuable to those who have implemented them. There is no sharing outside of the organization, which limits the potential for increasing transversal quality.
- Lack of transparency: Data circulation between the parties involved in the project often lacks transparency. This may lead to misunderstandings and misunderstandings, and it makes it difficult for all parties to understand the progress of the project.
- Ineffective communication: The present data flow frequently relies on slow and ineffective manual communication techniques, like emails and phone conversations. This could cause delays in the project and make it challenging for everyone to stay informed about its status.
- Limit access to data: The main contractor or project manager can usually access limited data. This can enable other parties, such suppliers or subcontractors to access this problem in order to access the information they need to complete the work.
- Lack of the integration process: The data flow frequently isn't coupled to other systems and procedures, such financial software or project management tools. This can make it challenging to monitor the project's development and spot any possible problems.

The current communication model in the construction supply chain can be described as un-structured, asynchronous, and out-of-date. This can lead to a number of issues, including the loss or distortion of data during the transmission process, difficulty in accessing and using information from different sources, and a lack of transparency and visibility into the project. By adopting a platform that enables more efficient and effective communication, it may be possible to address these issues and improve the overall efficiency and effectiveness of the construction process.

Un-structured, asynchronous and out-of-date communication between the various levels

An extensive range of individuals, including engineers, contractors, architects, subcontractors, and others, are typically involved with a building project. separate individuals, frequently belonging to separate individuals, with some individuals in charge of general project leadership and others in charge of particular duties such as constructing a building or establishing electrical equipment.

Many times, there is no structure or manageable organization to the communication between different project levels. For instance, crucial information might be discussed in a meeting or in a chain email. This could lead to miscommunication, poor implementation, and other problems that could affect the project.

Asynchronous communication is the term for verbal exchanges that don't happen instantly. For instance, if a contractor responds to an email from an architect with a question many hours later, this is an example of asynchronous communication.

Communication that is out of date is said to be inaccurate or irrelevant. An example of outdated communication is when an engineer delivers a contractor a set of designs but then modifies those plans without informing the contractor first.

Unstructured communication among the various levels of a construction project is communication without a specific framework, plan, or goal. Unstructured communication may be casual, impromptu, and lacking in a defined aim or purpose. This could result in misconceptions, confusion, and miscommunication, which in turn could cause mistakes, interruptions, and price overruns.

Subjectivity of information

The first issue to pay attention to is the strong possibility of tampering/wrong transposition of data in each single step: the information is constantly "owned" by a single subject who makes changes - rather than additions - to then share them with the next interested party. These changes are made - in cases where there is no adequate standardization of the documentation - with a strong component of discretion. Each of these integrations can generate a distortion - more or less evident - of the data and lead to the final product having characteristics quite different from

the initial ones, as happens in the wireless telephone game. Although the initial definition of standards to be used during the process can limit this danger, the strong differentiation of the platforms used for the development of the project makes this risk extremely likely.

In this sense, adopting standardization practices, like using a common platform, could be helpful to reduce the risk of data tampering and ensure that all parties have access to accurate and up-to-date information. Additionally, it would be handful to ensure the accuracy and reliability of data implementing processes and protocols for verifying and validating information input.

Another potential solution is the use of Building Information Modeling (BIM) as a methodology, as BIM can help facilitate the sharing and management of information among all stakeholders and improve communication and collaboration throughout the project. By creating a digital representation of the building that includes all graphical and non-graphical information, BIM can help ensure that all parties have access to accurate and up-to-date information and reduce the risk of errors or misunderstandings.

Data differentiation by intended use

The difference in the approaches by the various subjects involved entails a further need to adapt the information reported, for which the architectural project, the layout of the systems, the abacus of materials, the calculation of the elements must be extrapolated from an executive project and so on, to each stakeholder a report. The BIM software finds its strength in this, precisely because it manages to combine different "user interfaces" to each element of the project so that it is accessible to various users in relation to their needs; but the difficulty of having a BIM file available to everyone lies in the fact that the software that allows it to be read is extremely technical and not very immediate for those who do not know it.

Another challenge with the current model of development in the building supply chain is the differentiation of data by intended use. Because different stakeholders have different needs and approaches, it is often necessary to adapt the information provided to each of them. This can lead to a proliferation of different reports and documents, which can be time-consuming and error-prone.

The strength, in this sense, of the platform would be its native integrational being: the platform intended target is every stakeholder, which will be entering data based upon their mansions. The platform, as itself, is to be considered simply as an inventory of information which, once linked together, form a building – or a project – so that it combines all the data in itself; then, accessing the differentiated data it's just a matter of filtering information.

Parallel data flows

Another challenge with the current model of development in the building supply chain is the issue of parallel data flows. Even when the majority of project engineers and executors are proficient in the use of BIM software, there is often a need for updates from and for planning consultants that is poorly integrated into the BIM process. This type of information, which relates to the temporal and monetary valuation of a construction site, can run parallel to the project data and may not be easily integrated into the BIM model.

However, the monitoring and supervision of a construction site are also an integral part of the process, and the management of this information should also be integrated into the data flow. In smaller projects, this integration may occur naturally, as the designer, planner, and construction manager may all be involved in the implementation of the project. Anyways, in larger projects, the fragmentation of information can lead to a loss of the overall picture for intermediate stakeholders and the need for top management to bring together disaggregated data from various levels, resulting in a subtraction of resources and time, so, parallel data flows can also lead to a fragmentation of information and a lack of an overall picture for intermediate stakeholders.

It may be helpful, it this sense, to adopt tools and techniques such as 4D and 5D BIM, which can help facilitate and complete the design phase by integrating temporal and monetary data into the BIM model. This can allow for better tracking of progress, identification of potential issues or risks, and optimization of the overall performance of the project.

The 4D and 5D BIM (respectively "times" and "costs") manages to facilitate and complete the design phase that impacts on the programming having as input processes the IFC file and as output the estimated metric calculation deriving from the parametric design, the times of execution grouped by Work Package (work packages) and costs, which spread over time generate an S-curve and the cost baseline or site budget. Unfortunately, the schedules, with the non-graphical information that are exported from the various design software, are not enough on their own. [9]

It may be helpful to adopt processes and protocols for integrating this type of information into the BIM model in a more seamless way. This could involve using tools on the platforms that allow for the integration of financial and scheduling data into the BIM model. Integrating this type of information into the BIM process, will make it easier to track progress, identify potential issues or risks, and optimize the overall performance of the project. And this is the type of operational families which needs to be set to speed up the system even more. By configuring, once, models for progress track, potential issues and risk forecast and general optimization they can be used for

[9] (Ortenzi, 2018)

each project, because they will be parametric and they'll take the already InSite data, as input for the calculations.

Process inefficiency

One of the main challenges with the current model of development in the building supply chain is the inefficiency of the process. The need for continuous requests for resources and time, as well as the inability to use pre-designed and tested models, can lead to delays and increased resource requirements.

The continuous requests for resources and time are another of the factors that distinguish this work model: on the one hand the waiting times necessary for the completion of the continuous processing and on the other due to the impossibility of using pre-designed and tested models. If all the phases analyzed up to now require resources to be carried out, each of the phase passages is itself an important receptor of time, for the project and for the figures who are employed in each phase; in order to streamline times, it is therefore necessary to try to limit this waiting time. A further factor that does not allow the efficiency of the project is the difficulty of being able to use models that have already been tested, in terms of performance and results; the use of these "best practices" would allow a standardization of processes, data, processing and work methodologies with a consequent reduction in the margins of error, an increase in the ability to predict errors, as well as a simpler and clearer procedural steps.

To address these issues and improve the efficiency of the process, there are a few approaches that can be taken. One option is to streamline the waiting times associated with each phase of the project by implementing processes and protocols that allow for more efficient communication and coordination among all stakeholders.

Another option is to adopt the use of "best practices" and models that have already been tested and proven to be effective. By standardizing processes, data, and work methodologies, it can be possible to reduce the margins of error, increase the ability to predict potential issues or risks, and simplify the procedural steps involved in the project. This can help reduce the overall time and resource requirements of the project and improve its efficiency.

In this sense, the platform, as a storage of historic data, could lead to time optimizations providing information needed on existing files, providing already established models and suggesting the best records.

Untapped feedback

Sharing best practices learned from individual operators are added value only for those who have had the way to implement them, there is no sharing outside to allow an increase of transversal quality.

Yet another struggle faces the current model of development in the building supply chain is the lack of sharing of feedback and best practices among all stakeholders. When individual operators learn from their experiences, this knowledge is often only shared within their own organization or team, rather than being made available to others who could benefit from it. This can lead to a lack of transversal quality and a missed opportunity to improve the overall performance of the project.

Today, we need just cultures across all our working environments, not just to prevent crashes but to draw from every single employee the best ideas, observations, concerns, and concepts inside every mind. We can't afford to let some thrive while others sit passively, demotivated or disenchanted. Our challenges are too big, the times too urgent, and the human capacity locked inside organizations too rich to let any of it go to waste. Just cultures tap the ingenuity, initiative, and sheer cleverness of every single individual; they reward imagination and celebrate truth-telling.

They recognize that, while the road to success is littered with mistakes, it matters more to build trust and encourage ambition than to reward obedience. [10]

Sharing feedback and best practices among all stakeholders is crucial for the entire system because if even the smallest of the suggestions, let it be a tip to improve quality or to avoid an error, can lead to the efficiency of the sector, the sum of those together can produce outstanding results.

Creating a more collaborative environment in which all stakeholders can share their experiences and knowledge, can make possible to tap into the full potential of the project and improve the overall quality and performance, as well as encouraging a culture of continuous learning and improvement.

Process faults and results faults

Concerns with the construction process, such as delays, misunderstandings, and ineffectiveness, in addition to concerns with the construction's outcomes, such as flaws or faults with the final product, are possible. By offering a central area for interaction and sharing of data, as well as a mechanism to track progress and detect difficulties as they appear, a collaborative platform may be able to assist with both kinds of challenges. This can result in a construction process that is more effective and efficient and produce completed goods of greater quality.

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[10] (Heffernan, 2015, p. 3)

There are several ways in which an interactive tool for building projects could aid in resolving concerns with processes and outcomes. A centralized repository for project records, such as plans, sketches, and requirements, which would help ensure that all All parties have access to the same information and can easily introduce you if needed. It can also provide a platform to communicate and cooperate, and all project stakeholders exchanged and updated, asking questions and solving problems in real time. This can help streamline the building process and reduce the chance of delays or misunderstandings.

A collaborative platform could also offer tools for monitoration, development and issues individuation as they materialize. For instance, it might have tools for organizing projects, scheduling them, and tracking resources and materials.

This could make it easier to spot any inefficiencies or bottlenecks in the construction process and enable them to be fixed before they cause delays or other issues. Overall, offering a central site for communication, information sharing, and progress tracking, as a collaborative platform for construction projects, could assist increase the effectiveness, efficiency, and quality of the construction process.

Learning from previous mistakes

Users need to be able to consult and learn from the experiences of others, including any problems that were found and the solutions that were applied to solve them, by archiving and making available previous examples on the platform. This might increase productivity and lessen the chance of mistakes or delays in subsequent initiatives. Additionally, standardizing processes and identifying best practices could aid in producing more reliable and fruitful results. Additionally, by making this information generally accessible, it might promote an industry-wide culture of ongoing learning and development.

A culture of continuous learning and improvement is essential for any industry, and the construction industry is no exception. Information needs to be widely available and it's necessary to encourage the sharing of knowledge and experiences, as a possible driver to innovation and improvement of the overall quality of projects.

Tools to improve

There are several ways in which a platform like this could facilitate the sharing of knowledge and experiences in the construction industry:

- User profiles and ratings: By allowing users to create profiles and rate the content shared by other users, the platform could create a sense of community and encourage the sharing of high-quality information.
- Discussion forums: A discussion forum or chat feature could allow users to ask questions, share insights, and collaborate on projects.

- Knowledge base or library: A section of the platform dedicated to storing and organizing articles, guides, case studies, and other resources could provide users with a central location for accessing valuable information.
- Collaboration tools: Tools like project management software or online collaboration tools could allow users to work together on projects in real-time, regardless of location.

Overall, the key to success will be in creating an active and engaged community of users who are committed to sharing knowledge and experiences, and in providing the tools and resources necessary to facilitate that sharing.

The outcomes of an integrated collaborative platform for sharing, consulting, and analyzing the technical, economic, and managerial know-how AEC sector may be widely spread across the industry sector, affecting the individuals welfare and work quality, as well as their performance and product improvement; this all can contribute to advancing towards technology innovations and economic advantages for the network of people involved.

However, many executives consider their data's potential hasn't been reached yet, mainly because it is still separated in different siloes and systems. In a research by PWC (2019) it is highlighted that executives believe they can get an enormous value just with the possibility to better access and use data they already have inside the organization, with a potential effect on cost savings by 33% and increased revenue of 31%.[11]

Farther, considering the importance of the sector, in size and output matters, any chances to develop a clean a lean CSC can provide outstandingly significant results globally.

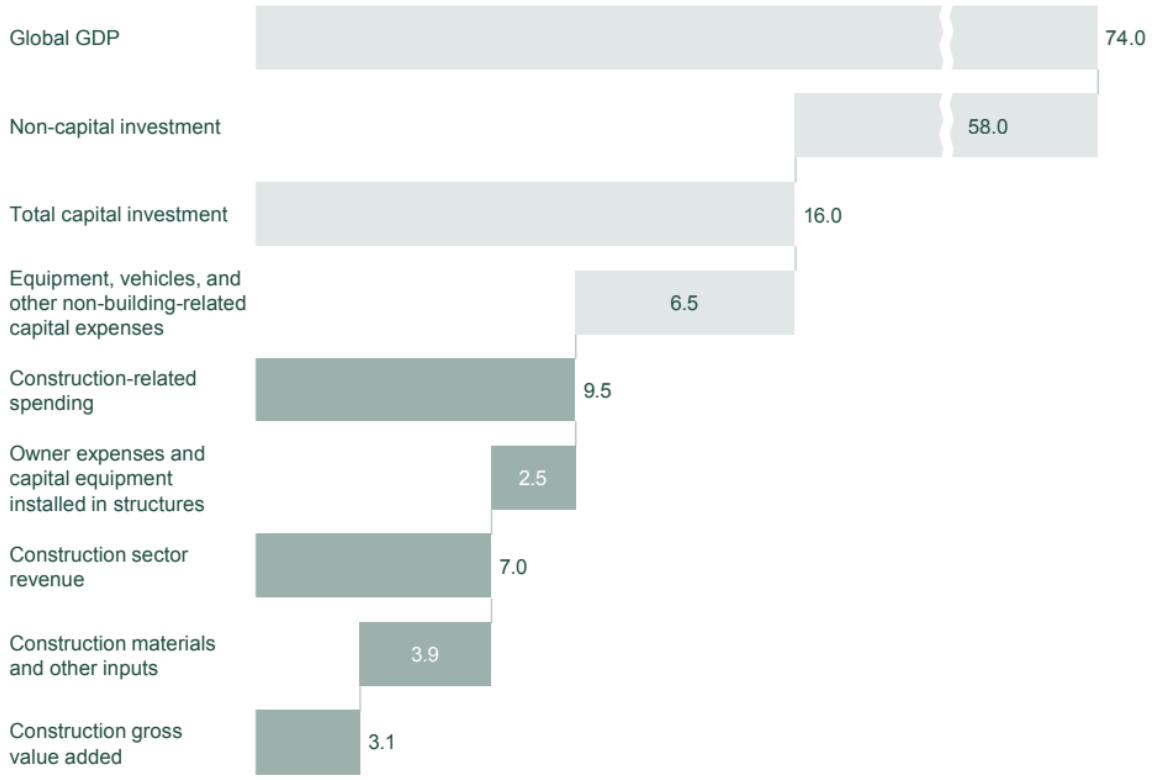
The need for construction is ever present. Construction related spending today is equivalent to 13 percent of global GDP, and it fuels economic activity in a wide range of sectors. The US Bureau of Economic Analysis estimated that an additional $0.86 of economic activity was generated by every $1 of construction sector GDP in 2012, making it one of the industries with the largest economic spillover effects.12 The Australian Bureau of Statistics estimates that there is $2.86 of additional economic benefit for every $1 of construction GDP.[12]

[11] (Pezzi A., 2021)
[12] (McKinsey, 2017)

Exhibit 4

The global construction sector generates $3.1 trillion of gross value added to meet $9.5 trillion of construction-related demand

$ trillion, 2014



1 Estimated based on 2009 WIOD values, scaled to 2015 using a 3.7 percent compound annual growth rate and adjusted for coverage of investment and global GDP database.
NOTE: Numbers may not sum due to rounding.

SOURCE: World Bank; IHS; ITF; GWI; McKinsey Global Institute analysis

Figure 8 Classification of the global investments expenditure, enlightening particularly CI's weigh on total. (McKinsey, 2017)

Workflows

Edward A. Stohr and J. Leon Zhao show in their paper, Workflow Automation: Overview and Research Issues[13], that workflow management system can be categorized in three basic alternatives:

- Production-oriented WfMS architecture
- Messaging-based WfMS architecture
- Document-oriented WfMS architecture

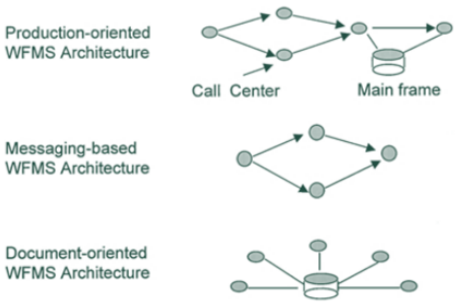


Figure 9 Edward A. Stohr and J. Leon Zhao's basic architectures

[13] (Stohr & Zhao, 2001)

As previously seen (Figure 3 *Workflow graph of the previous example showing the stakeholders involved and the different levels of data flows*), the current AEC Industry adopts, at different stages and levels and with different purposes, the three basic WfMS architectures.

While procedures regarding resources management tend to be more production oriented, the communication among different levels is more messaging based; in a sense, it possible to say that data flowing along the executives' paths is proceeding on a horizontal axis among the different stages and has a more production profile, meanwhile consulting and commitments related data crosses the main flow from a vertical angle and has a more message based profile and, lastly, the document-oriented architecture of data is usually found within organizational borders of – important – companies since it requires quite some efforts.

Further, the paper focuses on the necessity to develop standards to address the interoperability issues of the various WfMS and, within them, to get a structured a synchronous communication.

Technical research issues

Workflow technologies are not as mature as (say) database technology in terms of scalability, flexibility, fault tolerance, and the other technical qualities listed as research issues in the table. This is because they are a newer technology and because they face more demanding requirements such as long transactions (lasting hours or days), geographic distribution of processing nodes, and the involvement of humans in the processing steps. The technical issues in Table 1 are being actively researched and many research and commercial WfMS are being developed that will provide proof of concept for new ideas on workflow modeling, hardware and software architectures, and new approaches to handling problems of data integrity, and so on. However, progress is likely to be steady rather than revolutionary because of the technical complexity of these systems.

[...]

Table 1 Workflow research issues

Technical issues

- *Interoperability: standards and implementation strategies*
- *Scalability and WF architecture*
- *Availability, reliability, concurrency, fault tolerance*
- *Security, especially in B2B workflows*

- *Increasing the scope of systems (desktop, department, enterprise, B2B)*
- *Integration of WfMS with: external application systems, ERP, component-based application systems, business objects*
- *Integrity of cross-enterprise workflows (deadlocks, rollback, etc.)*
- *Monitoring & controlling cross-organizational workflows*
- *Integration of multi-paradigm process modeling methods*
- *Business process management suites (modeling, simulation, verification, workflow, analysis)*
- *Dynamic process change*
- *Exception handling with and without manual intervention*
- *Authorization flexibility and integrity*
- *Resource management and brokering*

Management and organizational issues

- *New analysis and design methodologies for automated processes*
- *Flexible modeling of workflows, verification of process models*
- *Matching workflow to organizational strategy, structure, and culture*
- *Analysis and design of collaborative systems*
- *Workflow implementation and change management*
- *Cost/benefit analysis and impact studies*
- *Factors leading to adoption of workflow systems*
- *Controling work and monitoring of employees*
- *Performance measurements and incentive systems*
- *Integration of audit trail data and data warehouses; data mining opportunities*
- *Run-time scheduling and utilization of workflow human and software agents*
- *Impact of WfMS on clerical work and middle management Market, economic and social issues*
- *WF market directions and investment opportunities*

- *Prospects for competing stand-alone, embedded, & component-based workflow engines*
- *Impact of workflow on supply chain automation, electronic markets, & industry structure*[14]

This, above, were listed in 2001, as implications – or they can be considered opportunities – when developing a WfMS, and yet today they describe pretty well some of the current issues of the AEC sector due to the data fragmentation.

In particular, as further written in the article, is worth mentioning the opportunities that a working system with a coherent and integrated data management grants:

- *WfMS as a vehicle for control and performance measurement. Workflow automation provides unique opportunities for directing work and measuring performance. In effect, a WfMS supports a cybernetic feedback mechanism executing a continuous loop of six sub-processes: goal setting, directing work, monitoring work, measuring performance, recording outputs, analyzing outputs, and evaluating personnel*
- *WfMS as a platform for knowledge sharing and learning. Because WfMS automate the mechanical aspects of work, an argument can be made that workers are free to perform more satisfying and creative intellectual activities. WfMS are, of course, a repository of valuable process knowledge. If the WfMS is capable of dynamic change as described by van der Aalst in this special issue, it can greatly facilitate continuous process improvement. Beyond this, a WfMS can directly support the learning objectives of an organization by acting as a vehicle for the collection and distribution of knowledge.*[15]

And still, there are growth prospectives for performance improvements and general improvements.

Successful WfMS deployment results in significant process cycle time reductions, cost reductions, improved accuracy, greater control, and greater worker satisfaction. For example, (Ader, 2000) reports productivity gains from process automation of 5% to 30% and cycle time reductions of 30% to 80%. According to the Gartner survey cited above, successful workflow projects met or exceeded ROI expectations approximately 89% of the time. A comprehensive set of case studies of successful workflow projects is contained in (Fischer, 1997, 1998, 1999, 2000).[16]

One of the great advantages of a WfMS is its ability to separate the logic of the workflow from the logic of the applications that are used to automate or assist users

[14] (Stohr & Zhao, 2001)
[15] (Stohr & Zhao, 2001)
[16] (Stohr & Zhao, 2001)

in performing specialized tasks. This allows application programs to act as independent computational units and greatly simplifies the task of enterprise integration[17]

Solving the inefficiencies

This is the sense for the platform's elements to be divided in single parametrized families, so that they could be individually modelled, inspected, queried, updated and shared-used; in this way is possible for the users to access a library of models that will help improving standardization, speed up tasks and perform fine and accurate measurements of processes which often struggle to get countable.

Thus, if the implementation of a WfMS itself it's a production efficiency boost, there are several ways in which a collaborative web portal could be designed to address the issues described and improve the efficiency and effectiveness of the construction process. Here are a few ideas:

- Create a central repository for all project-related information providing a single location for all project documents, plans, and data, the platform to help reduce the need for multiple rounds of information exchange and reduce the risk of errors or misunderstandings.
- Implement real-time collaboration features allowing team members to work together in real-time, so that the platform can help improve communication and coordination among all stakeholders. This could include features such as shared document editing, chat, and video conferencing.
- Provide interactive visualizations and dashboards presenting project data in interactive visualizations and personalized dashboards, in this way the platform can help stakeholders quickly understand the status and progress of the project and identify any potential issues or risks.
- Integrate with other systems and tools integrating the platform with other systems and tools that stakeholders use, such as project management software, BIM software, and facility management systems, thus, the platform can help facilitate the exchange of information and improve the overall efficiency of the construction process.
- Provide resources and support for compliance with regulations and standards as the platform helps stakeholders understanding their obligations and ensuring that the project is in compliance with all relevant requirements.

These are some of the tools that platforms users will benefit from its usage, though some of the most relevant opportunities are those regarding the community; the platform, in fact, would be an agglomerated center for knowledge to be stored and

[17] (Stohr & Zhao, 2001)

easily accessible through forums, surveys or queries. Furthermore, clustered data allows analytics and searches, providing a wide understanding of the built – building – environment.

On top, the parametric families system, created by the direct supplier of each family, would be precise and detailed, providing a meaningful library for the community which, in exchange, will update feedbacks on the family recorded, allowing the supplier to perform ready adjustments in case any of its products faces any issue, for the platform to have a dynamic inventory and the best possible production quality for the construction supply chain actors.

Overall, a well-designed collaborative web platform can help improve communication and collaboration among all stakeholders involved in a building project, optimize the performance of the building, and facilitate compliance with regulations and standards but, mostly, it can serve as a point of collection for knowledge to the community.

Implementations for the stakeholders

As an integrated platform, this web portal, needs to provide value over the entire spectrum of parties involved in the sector, cause the best results are achieved only once every stakeholder is generating data and to ensure this result is important to engage them providing meaningful information and useful applications. Therefore, to be able to outstand these requirements is necessary to understand the issues these stakeholders are currently facing and what are the possible solutions. Farther, increasing the cooperation among the stakeholders is crucial to ensure a better work environment and a stronger network.

To achieve well-working relationships the parties need to develop from a low-trust base to a high-trust base in their relating. Misztal (1996) argues that trust is seen as being particularly important in both organizations and projects, since it is viewed as "essential for stable relationships, vital for the maintenance of cooperation, fundamental for any exchange and necessary for even the most routine of everyday interactions.[18]

Public Administrations

These legislative, supervisory and control bodies regulate the process through instructions transcribed in articulated regulations, often difficult in interpretation and clarity to those little usual in handling them; this, builds up a structured and tangled bureaucracy system which is a very well know problem for the Italian construction industry, especially when it comes to public projects:

Italy is an interesting case study for testing the differences in the completion times across different levels of government because all levels are generally involved in the execution of

[18] (Karlsen, Græe, & Massaoud, 2007)

public works. Moreover, they may manage the same category of works. Delays in the completion of public works are a relevant phenomenon in Italy. In its 2007 annual report to the Parliament, the Italian authority in charge of controlling the public procurement contracts (Autorità di Vigilanza sui Contratti Pubblici di lavori, servizi e forniture – AVCP) computed the per cent delay with respect to contracted time of completion for the works awarded since year 2000 and completed by 2007 (AVCP, 2008).

More than 77% of these works were completed with delays, and approximately 66% evidenced a delay greater than 20% of the contracted time of completion. Italy is also an interesting case study because it offers evidence of the performance of sub-central levels of government within a national procurement system. The Italian procurement system is based on a detailed and complex set of rules established by the national Parliament, and sub-central governments have quite limited power to implement marginal changes of the national legislation.12 Italian procurement rules are quite strict in specifying the award criteria and all the procedures that must be followed at any stage of procurement. The main implication is that all public institutions in Italy "play" according to the same rules. Therefore, the differences in performance are not related to the nature of the procurement procedures, but to the behavior of the procurers in the execution of public works.[19]

Furthermore, is notable that PA has lost, over the years, part of its supervising and leading position on public projects:

As technologies advance, the processes that regulate the construction of civil and infrastructural works assume dimensions of growing complexity and need, from a technical-administrative point of view, an increasingly multidisciplinary approach and integrated, in the face of an impressive body of legislation that regulates them in sometimes dispersive and contradictory way. In most cases, the Public Administrations, although are by far the most important player in the arena civil and infrastructural contracts, they have not always known fully and promptly seize the opportunity to act a active leadership role in leading the sector towards newcomers technical-administrative scenarios, which now appear as looming.

On the contrary, the Public Administrations themselves – which constitute an extremely large, heterogeneous and fragmented, with technical personnel often lacking in skills specialist and professional updating and without an adequate generational renewal program - rather than stand out for a pragmatic, substantial and objective approach towards the management of the various life stages of civil works ed infrastructural, have ended up retreating more and more over the years often towards a function of mere procedural control, in the sense sterilely formal.[20]

[19] (Guccio, Pignataro, & Rizzo, 2014)
[20] (Rustica, 2022)

Thus, defining some of the major issues of the PA as a stakeholder in the AEC sector is the key to address the possible solutions:

- extremely fragmented, disaggregated, unclear and updated regulations with strong territorial differences
- laborious and rather varied input required
- completely manual and little automated input
- unforeseeable output generation times
- poor reception of feedback and poor disposition to adapt solutions
- outdated system for the collection and consultation of buildings technical data which is often available only at certain levels of PA and accessible throughout all of its parts.

To address the challenges and improve the efficiency of the development process in the construction supply chain, a possible solution is to adopt the use of a collaborative platform that can facilitate communication and coordination between all stakeholders since it is it is essential for the platform to be integrated into public administration systems, allowing the sharing of asset information and the alignment of data entry with governance directives.

To be able to sort these changes, the platform needs to be able to:

- Group and translate of the regulations in the form of instructions in order to create much simpler and immediate guided procedures, based on the type and geographic area of the project site area
- Link different systems (public and private) for immediate connection and sharing of property information with public registers - with consequent update of these
- Allow the sharing of thea project entire documentation and the standardization of the data entry to make the verification of the correct compliance with the regulation faster
- Keep track of the normal duration of the permit issuing procedures, allowing to have an increasingly accurate estimate of the time required
- Provide user feedbacks, received by the system, to be recommended to the pa and implemented in regulatory updates so that the process can be made ambi-directional and functional.
- Keep record of the built environment details, so that it can be analyzed, updated and consulted in order to favor the awareness of the state and needs of the constructed environment and have a much conscious regulation’s draw up.

Owners

As a house owner using a collaborative web platform working with BIM, your role would be to provide input and feedback on the design and construction of your property. You would work closely with the architecture and construction teams to ensure that your needs and preferences are incorporated into the final design. You would also be responsible for providing necessary information, such as site surveys, zoning regulations, and building codes, to ensure that the project is in compliance with local laws.

One of the key issues that house owners may face when using a collaborative web platform working with BIM is the level of technical expertise required to navigate the platform. The software used in these platforms can be complex, and not all house owners may have the necessary knowledge to use them effectively. Another issue is communication, as it may be challenging to ensure that all parties involved in the project are on the same page and are working towards the same goals .

Additionally, using a collaborative web platform working with BIM can provide several benefits to house owners. This platform allows for more efficient and accurate communication, enabling house owners to see the progress of their project in real-time. It also allows for better collaboration between all parties involved in the project, which can lead to a more successful outcome. Further, the platform can provide detailed information on how long each stage of the construction process will take, and how much it will cost, which can help the owner better understand the progress of the project and any potential delays or cost overruns.

As a non-technical person approaching the sector, the benefits of using a collaborative web platform would be the ability to access the community knowledge about time and costs involved in the construction process, as the platform can also provide access to the database of past projects, which can be used as a reference to estimate the effort and time required for similar projects in the future. Additionally, the platform can provide information on the latest trends and techniques in the industry, as well as pricing information for different materials and services. This can help the owner make more informed decisions when it comes to selecting the building qualities; top performing technologies, innovative design and contemporary solutions, in fact, will slow down building's aging and postpone future needed restoration, this results in a higher overall economic value of the building and represents, along with the savings from the best performances and the postponed renewal operations, an important opportunity for savings and cost reducing.

Finally, the use of BIM technology can improve the accuracy and quality of the final product, which can ultimately lead to a more satisfied and aware owner; since the technology used is BIM, its embedded capabilities of information carrying and monitoring, will provide to the owner the necessary tools and documentation to perform the appropriate maintenance throughout the life-cycle of the building. This

documentation has a major importance to future implementations since it can overpass the standard preliminary relief stages and it can also be meaningful to the feasibility checks, both resulting in a drastic cost cutting.

The LCC analysis is a method used to assess design alternatives considering all the significant costs of ownership. The ultimate objective of LCC is the determination of optimum design decisions following the evaluation of all viable design alternatives. The LCC process can be applied to a total building or to any building components. It generally includes the following steps:

- *Choose design alternatives for cost studies.*
- *Determine elements for each option to be studied.*
- *Establish capital cost and cost-in-use for each alternative.*
- *Convert cash flow for each option to a common time basis for rational comparison using discounting techniques.*
- *Select final design solution with consideration of function, quality etc.*[21]

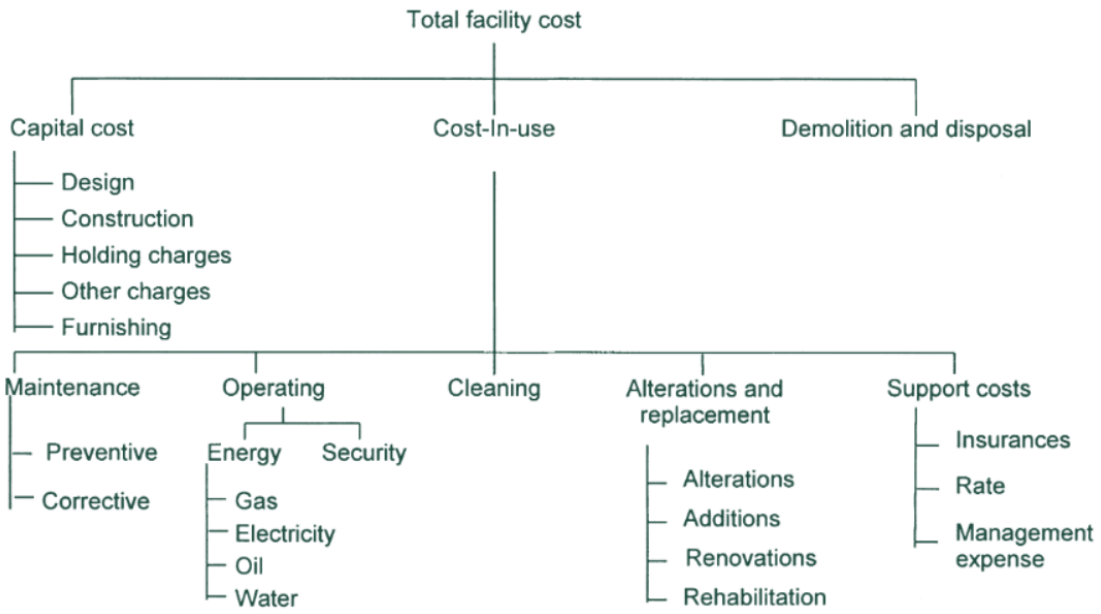


Figure 10 LCC cost components. (Yang & Peng, 2001)

Most importantly, the parametric family articulation of the various building parts, can serve as status check, meaning that once a failure occurs, at any level of the building, all the other buildings carrying that same part can be alerted of the interruption preparing the owners to the inconvenience much earlier than its occurring.

[21] (Yang & Peng, 2001)

Lenders

Lenders, such as banks, credit institutions, and investment funds, play a significant role in the development of building projects as they provide the necessary financial resources.

As users of the collaborative platform, lenders may encounter a few key issues that can impact their involvement in the project.

One issue that lenders may face is the lack of transparency and visibility into the project. Without access to the necessary information, lenders may struggle to assess the progress of the project and make informed decisions about their financial support.

To solve this inconvenience, the collaborative platform could provide lenders with access to real-time data and updates about the project, including its progress, budget, and any potential risks or issues. By having this information readily available, lenders can better understand the status of the project and make more informed decisions about their financial support.

Lenders may encounter lack of standardization and integration of data. Without a consistent and coherent approach to data management, lenders may struggle to accurately assess the project and its financial need; The collaborative platform could standardize the data management process and facilitate the integration of information from all stakeholders. By having a single, unified platform for managing data, lenders can more easily access the information they need and make more informed decisions about the project.

Noteworthy are also the opportunities coming with the platform regarding project financing since, as previously mentioned, market surveys and estimations with real world/real time data can be performed having a much clearer vision of the state of built environment.

Project Finance Project finance refers to the development of a stand-alone project on a nonrecourse or limited recourse financing structure, where debt and equity used to finance the project are paid back from the cashflows generated by the project. Unlike corporate finance where lenders examine a company's general credit and use the cashflows generated by its entire asset portfolio for debt service, in project finance, lenders look primarily to the revenue stream generated by the project for repayment and to the assets of the project as collateral for their loans. Lenders have no recourse or only limited recourse to the general funds or assets of the project sponsors. The project company is a distinct legal entity; project assets, project-related contracts, and project cashflows are segregated to a substantial degree from the sponsoring entities (Merna and Dubey 1998; Project finance in developing countries 1999).

[...] In addition to REPR (Ratio of Equity at Project Risks), other key financial viability indicators can be used in the evaluation of a privatized infrastructure project. They are

project bankruptcy probability during construction (PBPDC), self-financing ability (SFA), net present value (NPV), IRRE, DSCR, and loan life coverage ratio (LLCR). [22]

Once these tools are modeled and parametrized into the platform, the data stored could be used to calculate these indicators on existing projects, for academic purposes, to measure their reliability and find any room for improvement, and also this would be useful tools to examinate projects feasibility.

In general, the use of a collaborative platform can help lenders better understand the progress and needs of the project, allowing them to make more informed decisions about their financial support. By providing access to real-time data, standardizing data management, and facilitating the integration of information from all stakeholders, the platform can help lenders play a more active and effective role in the development of building projects.

Professionals

Professionals, such as architects, engineers, and surveyors, play a crucial role in the development of building projects as they are responsible for designing and planning the project. As users of the collaborative platform, professionals may encounter a few key issues that can impact their involvement in the project.

One issue that professionals may face is the lack of coordination and communication among all stakeholders. Without effective communication and coordination, professionals may struggle to effectively collaborate with other parties and complete the project efficiently, the collaborative platform could provide a central location for communication and coordination among all stakeholders.

By having a single platform for communication, professionals can more easily collaborate with others and stay informed about the progress and needs of the project.

Without access to the necessary data and information, professionals may struggle to accurately design and plan the project. To overcome this issue, the collaborative platform could provide professionals with access to relevant data and information about the project. By having this information readily available, professionals can more easily design and plan the project and ensure that it meets the needs and requirements of all stakeholders.

Overall, the use of a collaborative platform can help professionals effectively collaborate with other parties and access the data and information they need to design and plan the project. By providing a central location for communication and coordination and facilitating access to relevant data and information, the platform can

[22] (Zhang, 2005)

help professionals play a more active and effective role in the development of building projects.

Professionals constrains

There are a few key constraints that professionals, such as architects, engineers, and surveyors, may face in their tasks related to building projects. Some examples include:

- Time constraints: Professionals may have limited time to complete tasks and meet deadlines, which can impact their ability to effectively contribute to the project.
- Data and information constraints: Limited access to relevant data and information can hinder professionals' ability to accurately design and plan the project.
- Coordination and communication constraints: Poor coordination and communication among stakeholders can hinder professionals' ability to collaborate effectively and complete the project efficiently.
- Budget constraints: Limited financial resources can impact professionals' ability to access the tools and resources they need to complete their tasks effectively.
- Regulatory constraints: Complex and ever-changing regulations can make it difficult for professionals to navigate the project development process and ensure compliance with relevant laws and regulations.

Useful tools for mitigation

There are several tools and resources that professionals, such as architects and engineers, may need to effectively contribute to building projects. Some examples include:

- Project management software: This software enables experts to keep tabs on the project's development and to organize tasks, due dates, and resources. Project management software, task tracking software, and project scheduling software are among examples.
- Communication and collaboration tools: Professionals may cooperate and communicate with other stakeholders more successfully by using tools like chat, video conferencing, and file sharing.
- Data and information management tools: Accessing and analyzing pertinent data and information about the project can be facilitated by tools like document management systems and data visualization tools.

- Tools for 3D modeling and visualization can assist professionals in designing and planning projects in 3D and in seeing the finished outcome. Software for 3D modeling and visualization are two examples.
- BIM integration: Using BIM (Building Information Modeling) software integration can aid in more accurate and efficient project design and planning.
- Resources for continuing education and professional development can assist professionals in keeping abreast of the most recent innovations in their field's best practices and technologies..

The precise objectives and requirements of the undertaking and the associated stakeholders will ultimately determine the tools and resources that experts will require. A collaborative platform can assist professionals in effectively contributing to the development of building projects by offering a variety of tools and resources that promote interaction, cooperation, data management, and visualization. Most significantly, the platform will get meaningful data from the experts that use it. As previously said, a crucial element in generating value from the platform is the importance of the participation from the stakeholders..

BIM is poised to revolutionize the construction industry because of its promise to radically improve collaboration among the wide ranging and expertise needed to design and construct a building and to increase efficiency (Bedrick and Rinella 2006). However, the perceived legal risks of moving from a two- to a three-dimensional (3D) industry are a major stumbling block for many companies to move aggressively into BIM (Perlberg2009b). The absence of standard BIM contract documents and issues arising from how BIM is used as a collaborative frame-work are two major obstacles to fully adoption. Business models and contract relationships to reward "best for project" decision making should be established for widespread BIM adoption (Ash-craft 2008). There are also some constrains and difficulties of applying IPD (Integrated Project Delivery). While new contracts supporting IPD exist, they have not been tested over time and are not fully proven or even understood. Also, the insurance industry does not yet have cover-ages for IPD. More important, construction industry firms are accustomed to traditional way of leadership, responsibility, and opportunity, and change is slow. Public institutions and agencies lack the authority to restructure their procurement processes to enable the IPD model. However, if implemented successfully, can facilitate sharing of rewards and risks among stakeholders, create incentives for exceptional results, reduce operational and maintenance costs of the finished project, improve project delivery timelines, and reduce waste through better planning and shared costs (DeBernard 2008).[23]

As for the other stakeholders covered so far, the possibilities, coming from the adoption of the integrated platform, spread through a wide range of handful

[25] (David C. Kent & Burcin Becerik-Gerber, 2010)

implementation, automation tools and the very important chance to share knowledge and experience among colleagues and improve the general quality of the sector, working together as a team, to rise the standards and quality of work and life.

Suppliers'

Suppliers are essential to building projects because they provide the supplies and parts required to finish the work. Suppliers may encounter a number of significant problems in this situation, including:

- Restricted access to project information: Supplier might not have full access to project information, which may affect their capacity to predict demand correctly, organize their production, and adhere to project deadlines.
- Difficulties with collaborating and communicating Suppliers' capacity to work successfully together and coordinate the supply of goods and parts might be hampered by ineffective interaction and coordination between stakeholders.
- Ineffective procedures: Disconnected systems or manual, printed processes may result in supply chain delays and inefficiencies.

A collaborative platform could make the following tools and information accessible to suppliers:

- Access to project information by offering a single location for the storage of project data, a platform can assist suppliers in gaining access to the information they require to organize and manage their business operations.
- platforms for communication and collaboration: Suppliers may work efficiently with other stakeholders by using platforms like chat, video conferencing, and file sharing.
- Supply chain management systems integration Integration with supply chain management systems enables providers to estimate demand, schedule production, and monitor the status of orders and delivery.
- Standardized procedures and data: Suppliers may streamline their operations and cut down on errors a nd delays by using standard processes and data.

By providing these tools and resources, a collaborative platform can help suppliers effectively contribute to the development of building projects and improve the efficiency of the supply chain.

Suppliers would also have some big advantages, in fact, a collaborative platform could potentially provide suppliers with access to aggregated market demand data that could help them optimize their production and plan for future demand. This data could be collected from various sources, such as project estimates and orders placed by contractors and professionals.

In addition to helping suppliers improve their production efficiency, access to this data could also help suppliers identify trends and new needs in the market, which could inform the development of new technologies and products. By providing a centralized repository of information and data, a collaborative platform could help suppliers better understand the needs and preferences of their customers and develop new products and services that meet these needs.

In addition, suppliers role on the platform could provide huge amount of families to be used by architects and engineers to automate their work and built a much more detailed and realistic model of the building; in exchange for that, suppliers would have a new showcase for their products which, ultimately, is free and capillary spread throughout all the actors of the sector.

As a result of the BIM environment on which the platform is based, the life-cycle management of the buildings, would also provide information on the performances of its parts; therefore, suppliers and producers could have a very precise overview over their products integrity, usage and decay factors, directing the production and supply to solve any inconvenience.

Market and Supply Chain

The industry for building construction has seen an increasing tendency toward the use of digital tools and platforms to enhance collaboration and streamline procedures. This tendency is caused by a variety of things, such as:

- Growing demand for tools to support data-driven decision making: As the volume of data generated during the building construction process keeps growing, there is a growing need for solutions to support stakeholders in doing so. A consolidated information repository that can be utilized to guide decision-making can be offered through collaborative platforms.
- Greater emphasis on sustainability: The building construction sector is placing a greater emphasis on sustainability, and digital tools and platforms can assist stakeholders in monitoring and optimizing resource consumption and minimizing the environmental effect of construction projects.
- Increased use of Building Information Modeling (BIM) and IPD: collaborative platforms that support BIM can help stakeholders manage and share information and data related to building projects.

Thus, several opportunity to develop the construction market as a whole from the use of a collaborative platform, including:

- Improved efficiency and productivity providing a centralized repository of information and tools for communication and collaboration, the integrated

platform can help streamline processes and reduce the time and effort required to complete building projects.

- Enhanced communication and coordination facilitating communication and coordination among stakeholders, reducing the risk of misunderstandings and errors that can lead to delays and rework.
- Reduced costs improving efficiency and reducing the need for manual, paper-based processes, an automated platform can help reduce the overall cost of building projects development.
- Increased competitiveness since it makes possible to perform data analytics on a market scale data bank, allowing for demand aggregation and best practices surveys helping companies to identify opportunities, to differentiate themselves and improve their competitiveness.
- Improved quality as a general outcome from the previous advantages and furthermore cause the meaning of the platform itself, is to arise knowledge and awareness among the actors.

Overall, a collaborative platform for the building construction industry could be a valuable resource for helping users stay informed about and understand trends in the market.

Creativity leak due to standardization

Although standardization in some sectors would be facilitated by a collaborative platform, it is unlikely that the industry as a whole would become less creative as a result.

In some circumstances, standardization can be advantageous since it can help to ensure that specific processes and procedures are reliable and effective. It's crucial to understand that standardization does not automatically imply a lack of originality or creativity. Instead, it can offer a structure or a base upon which innovation and creativity might develop and flourish.

Standardization could be used to speed some procedures and guarantee that all stakeholders have access to the same information and data in the context of a collaborative platform for the building construction sector. However, the system might potentially offer resources and tools that encourage innovation and creativity, such as collaboration and communication tools, design and visualization tools, and other resources that encourage the sharing of ideas.

As a whole, it is important to strike a balance between standardization and creativity in the building construction industry. A collaborative platform that facilitates standardization in certain areas while also providing tools and resources that support creativity and innovation could be a valuable resource for helping the industry achieve this balance.

Consultants

In the building construction sector, a consultant is often a person or business that offers clients specialized knowledge or advise on a certain area of a construction project. For advice and assistance on a variety of topics, including project planning, design, budgeting, scheduling, construction techniques, and project management, clients may hire consultants.

Consultants may be hired by clients at various stages of a construction project, including during the planning and design phases, during the construction process, or after the project is complete to provide support with facility management or other ongoing needs.

Architects, engineers, project managers, and professionals in other relevant professions are just a few of the backgrounds and areas of knowledge that consultants in the building construction sector may have. Depending on the needs of the customer, they may be employed on a temporary or long-term basis and may work alone or as a team inside a consulting firm.

Consultants in the building construction industry may have a variety of job titles, depending on their specific area of expertise and the nature of the services they provide. Some common job titles for consultants in this field may include:

- Architectural consultant: Provides expertise on the design and layout of buildings, including layout, materials, and aesthetics.
- Engineering consultant: Offers expertise on the structural, mechanical, electrical, and other technical aspects of a construction project.
- Project management consultant: Provides guidance and support on the management of a construction project, including budgeting, scheduling, and coordination of resources.
- Construction consultant: Offers expertise on the construction process, including construction methods, materials, and equipment.
- Facility management consultant: Provides support with the ongoing management and maintenance of a building or facility after it has been completed.
- Sustainability consultant: Specializes in issues related to energy efficiency, environmental impact, and sustainable design in the building construction industry.
- Safety consultant: Provides guidance and support on safety issues and regulations related to construction projects.

Strategic and operative consulting

It is possible to divide consultants in the building construction industry into strategic and operative – or operations – consultants categories.

Strategic consultants might focus on providing high-level guidance and support on issues such as overall project planning, design, and management. These consultants might work with clients to develop long-term strategies and plans for the development and maintenance of buildings and facilities. This would be the category much interested in the study of the built environment as is and as it evolves; in this sense, the accurate inventory that the platform represents is a major opportunity for consulting the state of art of the sector, providing an expertise that is:

- wider, for the amount of accessible shared information that can be assimilated
- wiser, for the chances of collaboration among the top level planification consultant, towards transversal common objectives

Operative consultants, on the other hand, might focus on more specific, hands-on tasks related to the execution of a construction project. These consultants might provide support with issues such as material selection, procurement, construction techniques, and quality control. To these are more important tools to perform metrics and measurements; the platform, then, could provide a cluster of procedures and applications to automate their calculations.

It is also worth noting that many consultants may have expertise in both strategic and operative areas and may be able to provide a range of services depending on the needs of their clients.

Consequently, the platform might offer a collection of processes and programs to automate their calculations.

It is also important to keep in mind that, depending on their clients' needs, many consultants may be able to offer a variety of services and may have competence in both operational and strategic areas.

Depending on the focus of their work and the particular requirements of their clients, consultants in the construction sector could be characterized in a variety of ways, including:

- Project management consultants: These professionals can aid with responsibilities like budgeting, scheduling, resource allocation, and risk management while working with customers to build and implement project management strategies and processes.
- Design consultants: Working with customers to create architectural, structural, mechanical, electrical, and other design plans, these consultants may concentrate on the design and planning components of a building project.

- Technical consultants: These professionals may be experts in a particular technical field, such as materials choice, structural engineering, or electrical systems, and they can advise and assist clients on these particular subjects.
- Environmental consultants: These professionals may concentrate on matters relating to the environmental impact of a building project and can offer advice on matters like waste management, energy efficiency, and sustainability.
- Health and safety consultants: These consultants might focus on issues related to the health and safety of workers and the public during a construction project, and may provide guidance on topics such as risk assessment, safety training, and emergency preparedness.
- Financial consultants: These consultants might focus on financial aspects of a construction project, and may provide support with tasks such as budgeting, cost estimation, and financial risk analysis.
- Legal consultants: These consultants might focus on legal issues related to a construction project, and may provide guidance on topics such as contracts, liability, and regulatory compliance.

They can benefit from using a collaborative web platform working with BIM, some potential benefits are:

- Increased efficiency: BIM parametrized models, of procedures, resources and buildings will allow for fast and automated inspections, calculations, forecasts and reviews.
- Improved accuracy: BIM can help eliminate errors and inconsistencies in design by allowing multiple disciplines to work together on the same model It is simple to update in real-time, which reduces the likelihood of contradicting information and can save consultants a lot of time when compared to conventional techniques.
- Improved collaboration: A BIM-compatible collaborative online platform enables consultants to communicate more effectively with other team members like architects and engineers and share information in one place. improved decision-making and ultimately improved project results may result from this.
- Improved visualization: BIM makes it possible to create 3D models that are simple to view and manipulate, which helps consultants better envision and explain their designs to clients and other stakeholders.
- Competitive advantage: Consultants can set themselves apart from rivals by providing a more sophisticated and effective service by utilizing BIM and a collaborative web platform. This can help them win more business and build a stronger reputation in the industry.

General contractor and construction companies

The many tasks and procedures involved in the construction of a building or other structure must be supervised and coordinated by general contractors and construction firms. They can be in charge of overseeing a group of employees, liaising with suppliers and subcontractors, and making sure that every phase of the project is finished on time and within budget.

These experts could encounter difficulties with managing massive volumes of data and documentation, working with numerous stakeholders, and keeping track of deadlines and budgets, among other things. By offering a common site for storing and accessing project data, encouraging team member contact and cooperation, and enabling more effective tracking of project progress and budget, using a collaborative platform could potentially help to address these difficulties.

These professions may benefit from using the platform to speed up communication and collaboration, track project progress and budgets more efficiently, and have access to a plethora of information and resources offered by other industry professionals. Additionally, the platform might give users access to instruments and materials that might aid in streamlining the building process, such as project management software, simulation tools, and design software.

The Platform

Although the object of this thesis is non the development of the platform, to further discuss its implementation, a brief explanation of data and databases is necessary to better understand the concepting phase of the platform development.

Data Science introduction

Data Science is a combination of multiple disciplines that uses statistics, data analysis, and machine learning to analyze data and to extract knowledge and insights from it.

What is Data Science?

Data Science is about data gathering, analysis and decision-making.

Data Science is about finding patterns in data, through analysis, and make future predictions.

By using Data Science, companies are able to make:

- *Better decisions (should we choose A or B)*
- *Predictive analysis (what will happen next?)*
- *Pattern discoveries (find pattern, or maybe hidden information in the data)*

Where is Data Science Needed?

Data Science is used in many industries in the world today, e.g. banking, consultancy, healthcare, and manufacturing.

How Does a Data Scientist Work?

A Data Scientist requires expertise in several backgrounds:

- *Machine Learning*
- *Statistics*
- *Programming (Python or R)*
- *Mathematics*
- *Databases*

A Data Scientist must find patterns within the data. Before he/she can find the patterns, he/she must organize the data in a standard format.

Here is how a Data Scientist works:

- *Ask the right questions - To understand the business problem.*

- *Explore and collect data - From database, web logs, customer feedback, etc.*
- *Extract the data - Transform the data to a standardized format.*
- *Clean the data - Remove erroneous values from the data.*
- *Find and replace missing values - Check for missing values and replace them with a suitable value (e.g. an average value).*
- *Normalize data - Scale the values in a practical range (e.g. 140 cm is smaller than 1,8 m. However, the number 140 is larger than 1,8. - so scaling is important).*
- *Analyze data, find patterns and make future predictions.*
- *Represent the result - Present the result with useful insights in a way the "company" can understand.*

What is Data?

Data is a collection of information.

One purpose of Data Science is to structure data, making it interpretable and easy to work with.

Data can be categorized into two groups:

- *Structured data*
- *Unstructured data*

Unstructured Data

Unstructured data is not organized. We must organize the data for analysis purposes.

How to Structure Data?

We can use an array or a database table to structure or present data.

Structured Data

Structured data is organized and easier to work with.

Database Table

A database table is a table with structured data.[24]

As described the process of creation of a database follows a simply but rigid steps to ensure that data is structured and workable with.

[24] (W3Schools, 2023)

Big data definition

The etymology of 'Big Data' has been traced to the mid-1990s, first used by John Mashey, retired former Chief Scientist at Silicon Graphics, to refer to handling and analysis of massive datasets (Diebold, 2012). In 2001, Doug Laney detailed that Big Data were characterized by three traits:

- *volume (consisting of enormous quantities of data);*
- *velocity (created in real-time) and;*
- *variety (being structured, semi-structured and unstructured).*

Since then, others have attributed other qualities to Big Data, including:

- *exhaustivity (an entire system is captured, n ¼ all, rather than being sampled) (Mayer-Schonberger and Cukier, 2013);*
- *fine-grained (in resolution) and uniquely indexical (in identification) (Dodge and Kitchin, 2005);*
- *relationality (containing common fields that enable the conjoining of different datasets) (Boyd and Crawford, 2012);*
- *extensionality (can add/change new fields easily) and scalability (can expand in size rapidly) (Marz and Warren, 2012);*
- *veracity (the data can be messy, noisy and contain uncertainty and error) (Marr, 2014);*
- *value (many insights can be extracted and the data repurposed) (Marr, 2014);*
- *variability (data whose meaning can be constantly shifting in relation to the context in which they are generated) (McNulty, 2014).*[25]

Table 1. Big Data Analytics in Continuous Auditing [25]

Big Data Features: 4Vs	• Volume • Variety • Velocity • Veracity
Big Data Gaps	• Data identification • Data integrity • Data consistency • Data confidentiality • Data aggregation
Challenges in Continuous Auditing	• Conflicting data • Incomplete data • Data with various identifies • Data with different formats • Asynchronous data • Illegally tampered data • Searching encrypted data • Auditing encrypted data • Auditing aggregated data

Figure 11 Big Data Analytics in continuous auditing. (Kitchin & McArdle, 2016)

[25] (Kitchin & McArdle, 2016)

Platform database

Following the order of this thesis the ideation of the platform will start from the BIM elements that already exist and continue with their implementations.

Currently, BIM objects are categorized depending on their functions and subsequently further differentiated on the base of the values of the parameters.

Anyway, the model categorization, used up till now, could no longer be the main index key nor it is enough to express correlations with people and the operations, and to further implement feedback and progress track, a new stack of attributes must be added to existing one.

Is important to mention that, in anyway, the existing properties and parameters needs to be erased or putted aside.

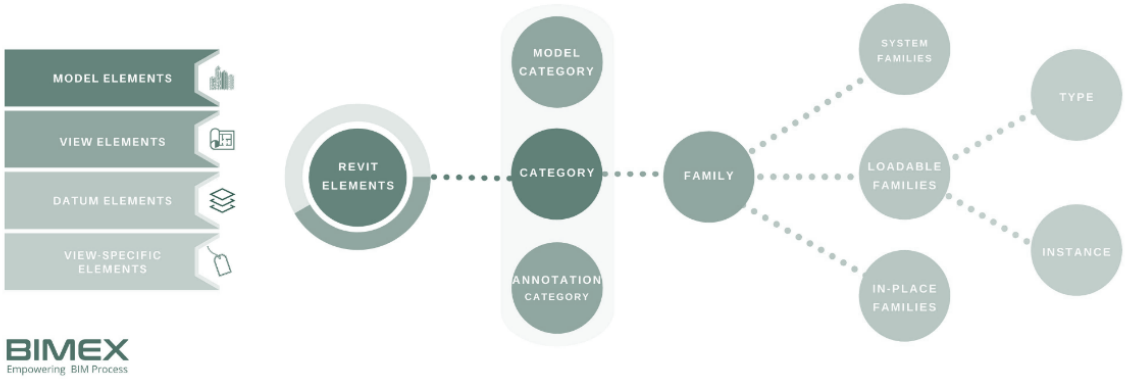


Figure 12 Revit's BIM Families classifications. (BIMEX)

In order to be able to create an auditable database, it has to present some characteristics, principally related to the prevention of unintended faults or error in data integrity, consistency, aggregability and so on.

While many anomalies can occur during the auditing process, three are caused during the manipulation, but they are directly derived from the design of the database itself, which, as said, should be preventing this anomalies:

- Insertion anomalies, causing data inconsistency when adding a new record
- Update anomalies, causing data discrepancies when editing a record
- Deletion anomalies, causing data loss when deleting a record

To avoid this faults and have a consistent database five rules, called normal forms, must be applied to the ideation of the database [26]:

[26] (Kent, 1983)

First Normal Form (1NF)

- Using row order to convey information is not permitted
- Mixing data types within the same column is not permitted
- Having a table without a primary key is not permitted
- Repeating groups are not permitted

Second Normal Form (2NF)

Each non-key attribute in the table must be dependent on the entire primary key.

Third Normal Form (3NF)

Each non-key attribute in the table must depend on the key, the whole key, and nothing but the key.

Fourth Normal Form (4NF)

The only kinds of multivalued dependency allowed in a table are multivalued dependencies on the key.

Fifth Normal Form (5NF)

It must not be possible to describe the table as being the logical result of joining some other tables together.

Heterogeneous data are any data with high variability of data types and formats. They are possibly ambiguous and low quality due to missing values, high data redundancy, and untruthfulness. It is difficult to integrate heterogeneous data to meet the business information demands.[27]

Table 1. Big Data Analytics in Continuous Auditing [25]

Big Data Features: 4Vs	• Volume • Variety • Velocity • Veracity
Big Data Gaps	• Data identification • Data integrity • Data consistency • Data confidentiality • Data aggregation
Challenges in Continuous Auditing	• Conflicting data • Incomplete data • Data with various identifies • Data with different formats • Asynchronous data • Illegally tampered data • Searching encrypted data • Auditing encrypted data • Auditing aggregated data

Figure 13 Big Data Analytics in Continuous Auditing (Wang, 2017)

[27] (Wang, 2017)

Anyway, the BIM families have to be described as aggregated and consistent data, even thought it has many variabilities and is massively heterogenous.

For instance, for a BIM object to be useful into the platform, a set of (new) attributes must be added:

Table 1 BIM Object's properties, Author's

Object		
BIM Software related Information	IFC	Category
		Family
		Reference Level
Description	Qualities	Type
		Size
		State
		Production year (Age)
		Condition
	Properties	Weight - Density
		Mass
		Load Capacity
		Transmittance
	Technology	Construction Technique
		Composition
		Material
	Economic	Price
		Construction Costs
		Running Costs
	Ownership	Producer *
		Manufacturer *
		Designer *
		Installer
		Builder
		Owner
Context	Within the Building	Building
		Floor
		Room
	Within the Territory	Country
		Region
		County
		City
		Address
	Functional	Type of Building
		Function of the object

Operativity	Constructive	Build
		Fix
		Restore
		Reinforce
	Verificative	Check Aging
		Check Conditions
		Check performance
		Sample
Functionalities	Capabilities	Perform in specific way *
		Provide required characteristics *
		Durability
	Ratings	Compliance
		UNI ISO *
		Feedback
		Notes

For the system to properly work, only some of this fields could be inserted "manually", while the vast majority of values should be directly linked to the corresponding database.

Manually added value is the one that the producer/manufacturer can add as the only source of that information, because of the paternity of the product. In any case, information may be intrinsic to the object, but still be a connection to some other database to ensure a continuous connection between the elements so that the system can be integrated on the various levels.

The difference of the platform with current BIM software is precisely this lack of strong integration beyond the building itself that the current SW have; in fact till now, to be able to perform further estimations, calculations, forecast and so on, the user was forced to export the needed data from the BIM SW and subsequentially to its editing re-input it, or parts of it, inside the appropriate time, cost, procedures, maintenance, etc., program.

As covered during the thesis, this kind of aggregation of different provenience data – more appropriately BIG DATA – is the key to the creation of an integrated collaborative platform that has standardized data flows, high efficiency due to its great automation and data integrity and interconnection and ultimately, describing and including all the segments of the sector, a great source of knowledge and experience.

On the following page, a sample, of the connections among the different databases

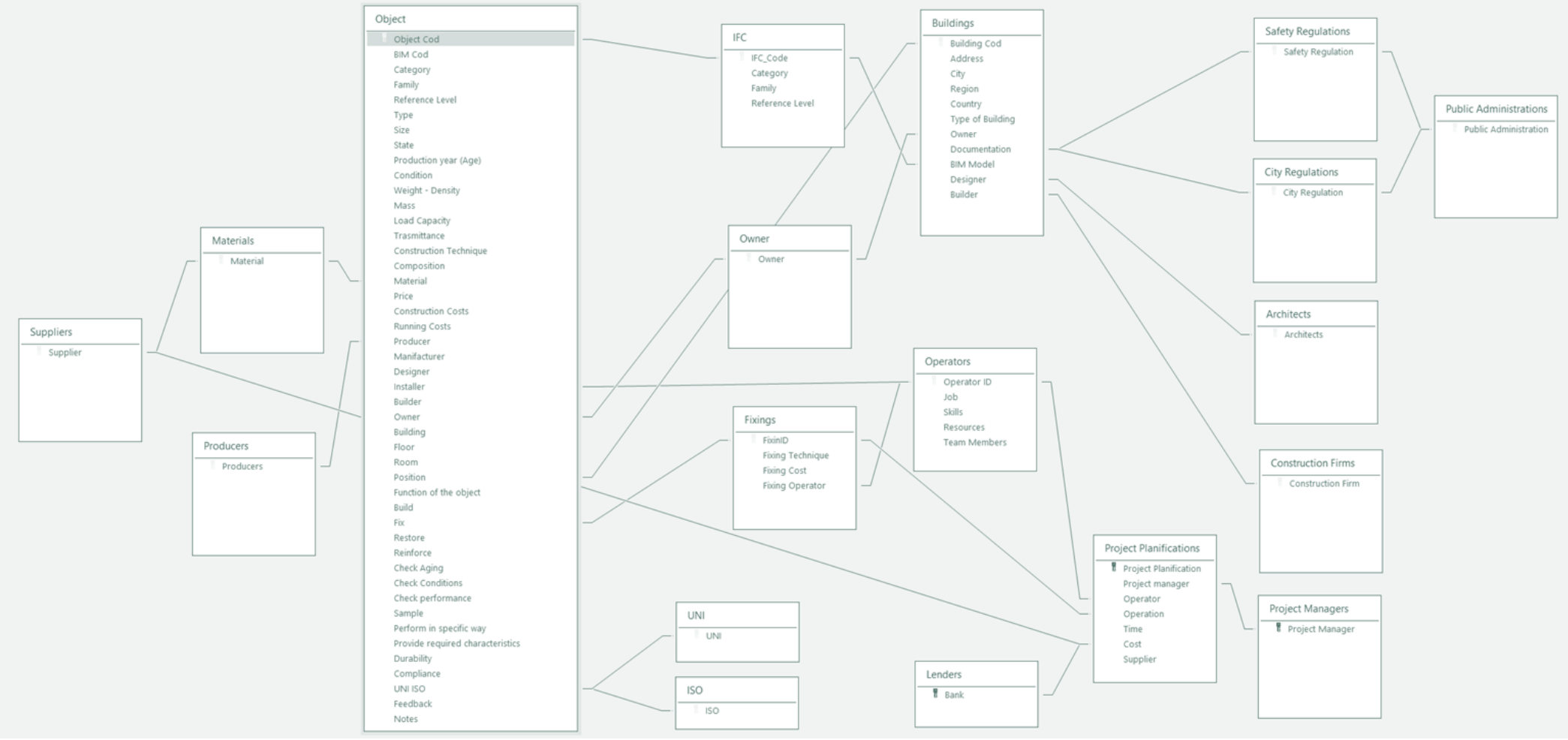


Figure 14 A Simplified Development of the platform's database interconnections. Author's

Data workflow features

A platform created to enhance data workflow and communication in the for construction supply chain, as covered so far, should have the following features:

- A collaborative workspace is a central location where all participants in a project may view and share documents, plans, and other pertinent information in real-time.
- Document management: a system that allows for version control and simple access for all parties, organizing and storing project documents in a single spot.
- Task assignment, tracking, and team member motivation are all aided by project management tools and capabilities.
- Communication technologies, including as chat, video conferencing, and others, can let team members and stakeholders communicate more easily.
- Data analysis and reporting: tools to assist in keeping track of key performance indicators (KPIs) and analyzing project data to spot patterns and areas for development.
- System integration: The capability of the platform to integrate with other systems and tools utilized in the building process, such as project management software, accounting software, and other pertinent tools.

User Experience and Applications

Following, are listed some the practical applications that could be possible to perform on the platform depending on the user.

Owner

- user wants to understand if he can apport some differences to the building
- User wants to know what is regulation about and what needs to do if he has to do (and who to contact) to enlarge its building.
- The user wants to know the (typical) construction constraints, times and costs of a building
- The user must choose how to resolve a procurement error that causes a delay of several weeks on site, in a 4-way dialogue with the PM, Builder and Supplier.
- You have a detailed model of your property useful for any future needs

The professionals

- It can use the data already surveyed of a property during the preliminary investigation phases of the practices - having access to documentation and appraisals already carried out in the past
- Can discuss with other professionals about the resolution of problems and perplexities about the design choices
- He can make more conscious choices when, finding himself working in a respected range, he has the possibility of dealing with the solutions that other professionals have already found when they have found themselves working in the same conditions.
- He has a totally guided experience of use for each type of practice, so he has less chance of incurring unexpected events or shortcomings; also having access to a series of services that speed up the work

The supplier

- It has a showcase for its products
- It has the possibility of providing the blocks of its products to allow professionals to verify their design suitability and simplify their design
- He has the opportunity to follow the construction sites he has commissioned as they develop, having an overview of the entire process and being able to organize his deliveries more efficiently
- They have the ability to see market trends and predict future scenarios so they can improve their production
- It has the ability to cooperate with professionals in product creation to resolve situations that require specific products.
- It can carry out feasibility/compatibility studies of its product with the precise information of the property

The Consultants

- They have an immediate, precise and punctual vision of the project and can convey resources in a safer way
- They have the opportunity to study the best practices of other professionals in order to improve their performance
- They have the opportunity to introduce new free resources on the market to streamline the process

Construction Firms

- They have a commercial showcase that allows them to clearly display the free slots so they can be chosen for the most optimal job for their needs
- They are followed up punctually, limiting the likelihood of errors or unnecessary processes.
- They have the opportunity to analyze the construction processes of other companies to improve their own

Public Administration

- It has a total view of all the projects in progress, the figures involved and the results of the completed works, so there is total transparency on compliance with the regulations
- It assists professionals and civilians in understanding regulations and flapping legislation
- Create a marketplace where the meeting between supply and demand is clear and transparent, limiting cases of speculation
- It has a detailed report of the construction phases with which to resolve any dispute that may arise
- It would have the possibility of having an updated and technologically advanced database of the properties present in the area created with the enormous potential that this entails

Basis of the Creation of the Platform

It can be challenging and time-consuming to develop a collaborative web platform for exchanging, consulting, and analyzing the technical, economic, and management knowledge of a construction project, so it's needed a precise order to proceed in this sense. Even if the aim of this thesis is not the development of the platform itself, here are some contribution to briefly outline the route, starting from the following points:

- Specify the platform's objectives and scope: What ought the platform to accomplish? Who is going to use it? What kinds of data are required to be included?
- Pick a stack of technologies: To construct a web platform, a variety of tools and technologies are accessible. Utilizing a content management system (CMS) like WordPress or Drupal or creating the platform from the ground up using a framework like Ruby on Rails or Django are two possibilities to take into account.
- Design the user interface: Consider the needs of users and how they will interact with the platform. Will they be able to upload and share documents, collaborate in real-time, or view project data in interactive visualizations?
- Build the platform: starting the developing the platform will involve writing code, setting up a database, and configuring servers.
- Test and debug: Before launching the platform, it's important to test it thoroughly to make sure it is functioning correctly. This may involve finding and fixing bugs, improving performance, and addressing any security concerns.
- Launch and maintain the platform: Once the platform is ready, it can be launched and the users invited to join. Ongoing maintenance will be required to keep the platform running smoothly, add new features, and address any issues that arise.

Scope And Goals

To guarantee that the platform satisfies the demands of its intended users and produces the anticipated results, the platform's scope and goals should be clearly stated. Here are a few examples of potential goals for the platform:

- Ensure that all stakeholders engaged in a construction project, such as architects, engineers, contractors, and building owners or developers, can work together and communicate effectively.

- Establish a central location where all project-related data, such as plans, specifications, timetables, and progress reports, can be stored.
- Enhance data flow and workflow, minimizing errors and the necessity for manual data entry.
- Encourage industry-wide standards and best practices, which will help projects run more smoothly and more affordably.

The platform have to be used by a variety of stakeholders in the construction industry, including:

- Project owners and developers: These users would have access to all project-related information and would be able to view progress updates and communicate with other stakeholders.
- Architects and engineers: These users would be able to upload and access plans, specifications, and other technical documents.
- Contractors and subcontractors: These users would be able to view project schedules and communicate with other stakeholders.
- Building owners and occupants: These users would be able to view progress updates and communicate with other stakeholders.

The types of information that could be included on the platform would depend on the specific needs of the stakeholders, but could include:

- Project plans and specifications
- Construction schedules and progress updates
- Budget and cost information
- Safety and quality control information
- Communication between stakeholders (notes, messages, etc)
- Reports and best practices.
- Data related to sustainability, energy efficiency, and other aspects of the project that are relevant to the environment.

It's important to note that a platform like this would require a significant investment in terms of development, maintenance, and support, and that it would be important to have a clear plan to ensure that the platform is widely adopted and used effectively.

Technology Stack

Choosing a technology stack for the platform will depend on a number of factors, including the complexity of the platform, the size of the building team, and the skills of developers. Here are a few options to consider [28]:

- LAMP stack: This is a popular technology for building web applications consistsing in Linux as the operating system, Apache as the web server, MySQL as the database, and PHP as the programming language, though this stack is a good choice for small to medium-sized projects and is relatively easy to set up and use.
- MEAN stack: This stack makes use of Node.js as the runtime environment, Express.js as the web framework, MongoDB as the database, and AngularJS as the front-end framework. This stack works well for real-time and single-page apps and is a strong option for creating huge, complicated online applications.
- Ruby on Rails: This is a web application framework that makes use of Rails as the web framework and Ruby as the programming language. It is renowned for its convention over configuration methodology, which facilitates initialization and frees developers to concentrate on developing code. Building web apps that need to manage a lot of data and intricate business logic is an excellent use for this stack.
- Django: This is a web framework built with Python, it's great to work with data-intensive and complex web application. It's often used in scientific computing and data analysis.
- Microservices: This architecture allows to split the application in small services, each one of them with a specific functionality. This allows to work in parallel and handle different technologies for different services.
- Ultimately, the best technology stack for the platform will depend on the specific needs and the skills of development team. It's important to research each option and consider the pros and cons of each one before making a final decision.

Data compatibility and interoperability between the most popular CAD and BIM programs, such AutoCAD and Revit, must be ensured. Users will be able to quickly import and export data from the platform and work with the same data in their favorite program thanks to this. Industry-standard file formats like IFC (Industry Foundation Classes) and BCF (BIM Collaboration Format), which are created

[28] (Shropshire, Landry, & and Presley, 2018)

expressly for compatibility across various BIM software, can be used by the platform to do this.

The platform might also offer an API so that programmers can link their own software to it, further enhancing the platform's compatibility and interoperability.

When choosing a technology stack, it is important to consider the scalability and flexibility of the platform. For example, using a microservices architecture can allow for more efficient scalability and faster deployment of new features. Additionally, using a cloud-based infrastructure can allow for easy access to the platform from anywhere, and can also provide cost-effective scalability. Popular technologies that can be used for building such platform are AWS, Azure, and Google Cloud Platform, with their respective services like Elastic Beanstalk, App Service, and App Engine.

The platform's security and data protection should also be taken into account. To prevent data loss in the event of a crisis, this can involve steps like user authentication and access control, data encryption, and regular backups. The platform should also adhere to all applicable data privacy laws, and privacy should be a top priority.

Design the user interface

When designing the user interface, it's important to think about the different types of users that will be using the platform, and to create an interface that is intuitive and easy to navigate. This can include clear and consistent menus, buttons, and labels, as well as interactive visualizations that allow users to quickly and easily view project data.

Making sure the platform is usable by users with varied levels of expertise, including people who might not have a lot of experience with building or data administration, is a crucial factor. This can be accomplished by delivering detailed guidelines, tutorials, and instructions, as well as a selection of tools and features that are suitable for various user types.

Making sure the platform allows real-time collaboration so that users can work together on the same project wherever they are is another crucial component of user interface design allows people to collaborate in real-time on the same project regardless of their geographical restrictions.

This can include features such as chat, video conferencing, and document sharing, which can help to improve communication and coordination between project members.

Regarding compatibility and interchange of data among the most used cad, bim softwares like autocad or revit it is important to consider the use of open standards like Industry Foundation Classes (IFC) which are widely accepted and supported in the industry. This will enable the integration of data from different platforms and tools

into the platform, allowing users to share and collaborate on information regardless of the software they use.

In order to secure user information and project data from unwanted access or breaches, security and data privacy must also be taken into consideration when developing the platform. To make ensuring the platform is dependable and secure for all users, this can involve steps like user authentication, encryption, and regular backups.

Choosing the most appropriate GUI

When creating the GUI for this platform, several different strategies could be used. One choice might be to create a unique user interface (GUI) for each role that is suited to the requirements and responsibilities of that role. For each user, this might result in a smoother and more natural experience, but it might also necessitate additional development time and resources to build and maintain different interfaces.

Another choice might be to create a universal dashboard that all users can access, but which offers various data visualizations and functionality based on the user's job. From a development perspective, this might be more effective, but for consumers used to a more specialized interface, it might not be as natural.

Combining both strategies could also be a possibility; in this case, a single dashboard would be offered, but with the option to access specific "apps" or parts for each user role. This might offer a harmony of effectiveness and customized functionality. The ideal strategy will ultimately depend on the particular requirements and objectives of the platform, as well as the resources available for its development and upkeep.

It would be important to consider the needs and goals of all the parties involved in the platform in order to determine the most appropriate approach for the GUI. A common dashboard with different apps for each user type could be a good option, as it would allow for a unified platform while still providing tailored experiences for each user group. This would allow for easy navigation and use for all parties involved, while still providing relevant and specific information for each user type. It would also be important to consider the technical abilities and familiarity of the various users, as a more complex GUI may be more difficult for some parties to use. Ultimately, the best approach will depend on the specific needs and goals of the platform and all the parties involved. Ultimately, the best approach will depend on the specific needs and goals of the platform and all the parties involved.

Existing cases

Over the internet, there are several platforms dedicated to optimizing the construction supply chain and the building and construction project process. Building information modeling (BIM) technology is frequently used by these platforms to promote cooperation and communication amongst various stakeholders, including architects, engineers, contractors, and suppliers. Additionally, some platforms provide tools for project management, document management, and real-time collaboration. To choose the platform that would best serve a given set of requirements and objectives, it is critical to thoroughly consider the features and capabilities of several platforms.

There are several platforms that offer solutions for managing construction projects and supply chains. Some include Procore, PlanGrid, CoConstruct, and Buildertrend. These platforms offer features such as project management tools, document management, collaboration tools, and communication tools to help construction teams stay organized and on track.

Some platforms also offer integrations with other software and tools that are commonly used in the construction industry, such as AutoCAD and SketchUp.

In the construction sector, there are many systems that provide some sort of collaboration and data sharing. Several instances include:

Construction professionals may access and exchange project plans, documents, and markups in real-time using PlanGrid, a project management and collaboration platform.

- Procore is a cloud-based platform for managing construction projects that offers capabilities for document management, planning, cost tracking, and collaboration.
- Fieldwire, a platform for managing construction projects that offers capabilities for task management, document management, and team communication.
- CoConstruct is a construction project management program that provides project scheduling, budget monitoring, and communication capabilities. It was created primarily for home builders and remodelers.

These platforms offer a range of features and capabilities, and may be suitable for different types of projects and organizations depending on their specific needs and goals.

Anyway this are apps to be bought and paid for; to have to best response from the market there should be a free collaborative platform in which we all can benefit from datasharing.

Platform appeal to the market

There are numerous strategies to persuade users to use a free platform:

- Make it simple to use: People are more inclined to use a platform if it is simple to use. This entails having an intuitive user interface, understandable directions, and beneficial resources.
- Provide value: Users are more inclined to use a platform if it provides them with something of value, such as access to knowledge, resources, or tools.
- Build a feeling of community: People are more likely to utilize and contribute to a platform if there is a sense of community there. Forums, user groups, and other forms of social interaction can be used for this.
- Market the system: Promote the platform via social media, email marketing, and other marketing platforms to spread awareness and entice consumers to give it a try.
- Encourage use: Take into account providing benefits (such discounts, prizes, or other perks) for frequent platform users. This can boost interest and motivate users to keep using it.

There are several values that this platform can offer to its users:

- Improved efficiency and productivity: By streamlining communication and data sharing between all parties involved in a construction project, the platform can help to reduce the time and effort required to complete tasks, leading to improved efficiency and productivity.
- Enhanced collaboration: The platform can facilitate collaboration between all parties involved in a construction project, allowing for seamless communication and easy sharing of information. This can help to improve the overall quality of the project and reduce the risk of errors or delays.
- Standardization: By providing a common platform for all parties involved in a construction project, the platform can help to standardize processes and data, leading to improved efficiency and reduced risk of errors.
- Improved quality: By providing access to best practices and past project data, the platform can help to improve the overall quality of construction projects.
- Increased transparency: The platform can provide a clear and transparent view of all aspects of a construction project, helping to reduce the risk of misunderstandings or miscommunications.
- Cost savings: By improving efficiency and reducing the risk of errors or delays, the platform can help to reduce project costs. Access to a wider

pool of expertise: By providing a platform for collaboration and information sharing, the platform can help to connect construction professionals with a wider pool of expertise and resources, leading to improved project outcomes.

Ensuring PA adoption

The public administration (PA) might be interested in the development and use of this platform in a number different ways:

- Efficiency: The PA can streamline procedures and cut down on the time and resources required for data collection and analysis by adopting a collaborative platform. Cost savings and more effective decision-making may result from this.
- Data integrity: This type of platform can aid in ensuring that data is correct and current, which can be crucial for regulatory purposes. The PA's capacity to decide wisely and guarantee regulatory compliance can be enhanced by this.
- Improved transparency: By providing a central repository for data, the platform can increase transparency and allow stakeholders to see how decisions are being made and what information is being considered. This can help to build trust and improve the PA's reputation.
- Collaboration: By fostering collaboration between different stakeholders, the platform can facilitate communication and encourage a more integrated approach to problem-solving. This can lead to more innovative solutions and better outcomes for the community.

Ultimately is fundamental to ensure that the platform is adopted as a standard over the sector; this is achievable only if the central government approves and incentives the usage and proliferation of the platform.

Feasibility

In order to attain these objectives, the proposed service improvement focused on a competitive strategy, key value chains, representative business processes in the services industry, approaches to process improvement, and cloud computing. The analysis of business process improvement is considered from three perspectives, namely strategic perspective, business process perspective, and technological perspective. [29]

Market Analysis

Finding the size and scope of the platform's prospective market is the first stage in the feasibility investigation. To do this, it is necessary to assess the platform's potential for use and the situation of the construction sector today. This includes identifying the platform's intended users, such as architects, engineers, contractors, and other parties involved in the construction process. It also entails comprehending the current need for such a platform and any prospective rise in demand brought on by its launch.

Technical Feasibility

The second step in the feasibility analysis is to evaluate the technical feasibility of the platform. This includes examining the overall architecture of the platform, the software and hardware requirements, and the level of complexity of the platform. It also requires evaluating the potential for scalability and integration with existing systems.

Financial Feasibility

The third step in the feasibility analysis is to evaluate the financial feasibility of the platform. This includes assessing the cost of development, the potential revenue streams, and the return on investment. It also involves understanding the pricing and pricing model.

[29] (Gai & Steenkamp, 2014)

SWOT

A collection of the results and observation so far encountered can be transcribed as simplified version of a SWOT analysis, thought scientific literature as mentioned the importance of attributing a value, a weight, to each inserted factor of the analysis. As a reference, particularly interesting are AHP [30] and the FAHP-DEMATEL[31] SWOT analysis methodologies .

Strengths

- Efficient collaboration and communication among stakeholders
- Increased transparency in project timelines and costs
- Enhanced accuracy and quality of project data
- Improved project management and decision-making
- Ability to incorporate market trends and best practices
- Potential for cost savings through optimized designs and construction processes

Weaknesses

- Dependence on technology and technical expertise
- Limited adoption and usage by industry professionals may hamper the platform's success
- Technical difficulties or glitches may disrupt project workflows and cause delays
- Security concerns around data privacy and protection may deter users from using the platform
- High development and maintenance costs may make the platform unsustainable in the long run

Opportunities

- Increasing demand for more efficient and collaborative project management tools in the construction industry
- Potential for expansion into new markets or partnerships with other industry players

[30] (Vineet, Puneeta, & Davim., 2022)
[31] (Sharma & Sehrawat., 2020)

- Development of new features or integrations to improve the platform's functionality and appeal
- Growing interest in sustainability and green building practices could lead to increased demand for BIM-based solutions
- Opportunity to leverage AI and machine learning to provide more advanced analytics and insights

Threats

- Competition from other project management platforms or traditional methods of project management
- Slow adoption rate by industry professionals may hinder platform growth and development
- Changing industry regulations or standards may require significant changes to the platform
- Economic downturns or instability in the construction industry could reduce demand for the platform's services
- Technological advances or disruptions may render the platform obsolete or less competitive.

Risk Analysis

Identifying and evaluating potential hazards and dangers in order to determine any potential negative outcomes from such risks is known as risk analysis. Some potential dangers for a collaborative web platform using BIM are as follows [32]:

- Data Security: Data security is one of the main issues with any web platform. Potential hazards including data breaches, cyberattacks, and illegal access to sensitive information should be taken into account during a risk analysis.
- Technical Problems: Problems with the platform's technical infrastructure, such as server outages, software flaws, and system failures, can have an adverse effect on users.
- User Adoption: For a collaborative platform to be successful, it needs to have a large user base. The potential hindrances to user adoption, such as lack of knowledge, insufficient training, or opposition, should be taken into account in a risk analysis.

[32] (Alali & Yeh, 2012)

- Integration Problems: For the platform to work properly, it may need to integrate with other programs or systems. The functioning and usability of the platform may be impacted by integration concerns, such as compatibility or interoperability problems.
- Legal Compliance: Considering legal compliance requirements, such as data privacy laws or intellectual property rules, depends on the nature of the platform.
- Economic considerations: Economic considerations, such as shifting market dynamics, pricing strategies, or finance, may have an impact on the platform's viability.

A risk analysis should identify and prioritize these potential risks, assess the likelihood and potential impact of each risk, and develop a plan to mitigate or manage the risks. This process helps to ensure that the platform can operate effectively, efficiently, and securely, while minimizing the potential negative consequences of any identified risks.

Data Security

Potential risks to data security should be taken into account in a risk analysis for the web platform, including:

- Data breaches: To acquire unauthorized access to sensitive data, such as user information, project plans, and financial data, hackers and other bad actors may try to compromise the platform's security safeguards.
- Cyberattacks: The platform may be susceptible to a range of cyberattacks, including malware, phishing, and distributed denial of service (DDoS) attacks. The platform and its users may suffer serious consequences as a result of these attacks.
- Unauthorized access: Unauthorized users may try to get access to the platform by taking advantage of security flaws such weak passwords, unprotected networks, and unencrypted data.

The platform should put in place a number of security measures, including:

- Encryption: To protect sensitive data, including user and financial information, the platform should employ encryption.
- Access control: To guarantee that only authorized users have access to sensitive data, the platform should incorporate access control procedures.

- Regular security audits and testing can help find platform vulnerabilities and confirm that security precautions are operating as intended.
- Education and awareness: Platform users should receive security best practice training, including how to create secure passwords and steer clear of phishing scams.

Disaster recovery and business continuity: The platform should have a disaster recovery and business continuity plan in place to ensure that data can be recovered and the platform can be restored in the event of a security breach or other disaster [33].

Technical issues

The platform may be significantly at danger from technical problems. Hardware failure, software defects, security flaws, and system crashes are only a few examples of technical problems. These problems may result in system sluggishness or downtime, which would be bad for the user experience and the platform's reputation.

To mitigate this risk, it's important to have a robust technical infrastructure in place, including reliable hardware and software systems, regular software updates and security patches, and proactive monitoring and maintenance to identify and address potential issues before they cause problems. It's also important to have a dedicated support team in place to provide prompt assistance and resolution to any technical issues that arise.

User Adoption

A collaborative platform's success depends heavily on user uptake. It won't work if users are unwilling to utilize the platform consistently and adopt it. Potential obstacles to user adoption should be taken into account in a risk analysis, including:

- Lack of awareness: If users are not aware of the benefits of the platform or how to use it, they may be less likely to adopt it. It's important to provide adequate training and education to users.
- Resistance to change: Some users may be resistant to change and may prefer to continue using their current methods of communication and collaboration. It's important to understand and address these concerns to encourage adoption.

[33] (Chang & Ramachandran, 2016)

- Usability issues: If the platform is difficult to use or has a poor user experience, users may be less likely to adopt it. Usability testing and feedback from users can help identify and address these issues.
- Compatibility with existing tools and systems: If the platform is not compatible with existing tools and systems used by users, it may be more difficult for them to adopt it. Integration with existing tools and systems can help reduce this barrier.
- Security and privacy concerns: Users may be hesitant to adopt a platform if they have concerns about the security and privacy of their data. It's important to address these concerns and ensure that the platform has appropriate security measures in place.

Costs/Benefits Analisys

The use of cloud computing services appears to offer significant cost advantages. The most frequently mentioned advantages include investment and operating costs saving, high elasticity of services as well as increased flexibility of certain business processes. On the other hand, the adoption of cloud computing in enterprise environments is non-trivial. Understanding the organizational benefits and drawbacks is far from straightforward. The adoption of cloud computing results in a considerable amount of organizational change that will affect employees. The aim of this contribution is to conduct and describe the evaluation model of cloud computing that would be applicable in business practice for evaluating the effectiveness of such investments. The target users of this model are primarily people in companies with decision-making power in the investment field. The appropriate starting point based on the multi-criteria evaluation was the cost–benefit analysis (CBA) approach for cloud computing (CC). A multi-method approach (systematic literature review, analysis of real cloud computing services, expert interview, case study) was applied in order to develop and evaluate the formal model. We found that our model fits the practical requirements and supports decision-making in cloud computing.[34]

Cost-benefit analysis is a technique used to compare the costs and benefits of a project or decision to determine whether the benefits outweigh the costs. In the case of a collaborative web platform for the construction industry, some potential costs and benefits could include:

[34] (Maresova, Sobeslav, & Krejcar, 2017)

- Development and implementation costs
- Ongoing maintenance and support costs
- Costs associated with user training and adoption

Development and implementation costs are the costs associated with creating and launching the collaborative web platform. These costs can include expenses related to software development, hiring developers and other staff, purchasing hardware and software, and marketing the platform to potential users.

Development costs can vary depending on the complexity of the platform and the development team's experience and location. For example, developing a BIM-based collaborative web platform may require specialized expertise and a more significant investment in technology and hardware than a simpler web platform.

Implementation costs can include expenses related to training users, integrating the platform with existing systems and workflows, and ongoing support and maintenance.

A cost-benefit analysis would weigh these development and implementation costs against the potential benefits of the platform, such as increased efficiency, improved communication, and reduced costs in the long term.

In addition to the development and implementation costs, a cost-benefit analysis should also consider ongoing maintenance and support costs. These can include:

- Infrastructure costs: The platform will require servers, storage, and other hardware components to operate. These will need to be maintained and upgraded over time.
- Software licensing costs: Depending on the software used to develop the platform, there may be licensing fees associated with using it.
- Personnel costs: The platform will require ongoing support and maintenance, which may require additional personnel or contracted services.
- Training costs: To ensure effective use of the platform, users may require training, which can be an additional cost.
- Upgrades and enhancements: Over time, the platform may need to be upgraded or enhanced to keep up with changing technology or user needs. This will require additional development and implementation costs.

All of these ongoing costs should be factored into the cost-benefit analysis to determine the long-term viability and profitability of the platform.

One of the costs associated with implementing a collaborative platform is user training and adoption. This includes the cost of providing training to users on how to use the platform and any new workflows that come with it. In addition, the cost of any necessary support and troubleshooting resources should be taken into account.

The cost of user training and adoption can vary depending on the complexity of the platform and the size of the user base. However, investing in effective user training and adoption can lead to higher user satisfaction and increased adoption rates, which can ultimately lead to greater benefits for the organization.

Benefits

- Increased efficiency and productivity: A collaborative web platform can streamline the project management process, allowing for more efficient communication and coordination between stakeholders. This can reduce the time and effort required to complete tasks, resulting in increased productivity.
- Improved communication and collaboration between stakeholders: A collaborative web platform can facilitate communication and collaboration between stakeholders who may be geographically dispersed or work for different organizations. This can reduce communication barriers and improve collaboration, leading to better project outcomes.
- Reduced errors and rework: By facilitating communication and collaboration, a collaborative web platform can reduce errors and rework. This is because stakeholders can share information in real-time, reducing the likelihood of misunderstandings and mistakes.
- Improved project outcomes: A collaborative web platform can help ensure that projects are completed on-time and on-budget by providing stakeholders with a clear view of the project's status and progress. This can help identify potential issues early on, allowing for prompt resolution and improved project outcomes.
- Increased transparency and accountability: A collaborative web platform can increase transparency and accountability by providing stakeholders with a clear view of the project's status and progress. This can help identify potential issues early on, allowing for prompt resolution and improved project outcomes.

Access to market trends and insights: A collaborative web platform can provide stakeholders with access to market trends and insights, such as new technologies, techniques, and best practices. This can help stakeholders stay up-to-date on industry developments, allowing for more informed decision-making. To conduct a cost-benefit analysis, you would need to estimate the costs and benefits associated with the project and compare them to determine whether the benefits outweigh the costs.

If the benefits outweigh the costs, the project would be considered a good investment. However, if the costs outweigh the benefits, the project may not be worth pursuing. It's important to note that cost-benefit analysis is not a perfect tool and involves some degree of uncertainty and subjectivity in estimating costs and benefits.

Conclusions

This dissertation focused on the purpose of trying to implement a tool on those every day's minor – and not so – issues and uncertainties that cause a continuous fragmentation of work procedures and flows.

As the size of disorganization is widely spread across the Construction Industry with deep roots on its major stakeholders, it handed up suggesting a new methodology more than a tool itself because the problematics weren't much due to errors as they were on the model of project development and construction supply chain data flow.

A systematic change is needed to pursue the improvement in efficiency and productivity of the sector and this change comes with the integrated collaboration among the stakeholders as a common will to ensure technological innovation, quality excellence and a rising culture of knowledge share.

This were the main objectives of the proposed platform as central BIG Data Framework on which the cooperation of the community is added value as it is the experience of the individual user.

The knowledge within the platform grows and develops as it is used, in fact, the more it's used, the more it will provide added value; this means is fundamental to ensure the adoption and engagement of a platform to the individual users, as much as to the community. Is important, therefo, to offer individuals applications and tools to facilitate and automate their task, besides and beyond the advantages to the community.

Matter of fact, the implementation of this kind of central heavy data cluster could be, potentially, very expensive, thought the size and economic importance of the CI is that significative to a global level, that every percentage of improvement of the efficiency and productivity can rise large amounts of resources saving.

Anyway, no matter what are the results and the implications of this platform adoption, this thesis – as many others have done even better – has shown that there are plenty of solutions, technological innovation, methodological approaches that can help the AEC sector to grow and improve; there are not any left excuses to don't embrace the change!